Geophysical Research Abstracts
Vol. 19, EGU2017-10223-1, 2017
EGU General Assembly 2017

Can multi-scale calibrations allow MT-derived resistivities to be used to probe the structure of the deep crust?

Virginia Toy (1), Marco Billia (1), Richard Easingwood (1), Martina Kirilova (1), Emma Kluge (1), Katrina Sauer (1), Rupert Sutherland (2), Nicholas Timms (3), John Townend (2), and the DFDP-1 and DFDP-2 Scientists Team

(1) Department of Geology, University of Otago, Dunedin, New Zealand (virginia.toy@otago.ac.nz), (2) SGEES, Victoria University, Wellington, New Zealand (rupert.sutherland@vuw.ac.nz), (3) Curtin University, Perth, Australia (n.timms@curtin.edu.au)

Our current knowledge of microstructural and mechanical controls on rock resistivity is such that identical magnetotelluric (MT) anomalies could result from a highly mineralized but extinct shear zone, or from an unmineralized, fluid saturated, active shear zone. In pursuit of the ability to interpret the structure and activity (rather than just the presence) of buried geological structures from electromagnetic data, we are investigating correlations between rock structure and electrical properties of ductile shear zone rocks recovered from the active Alpine Fault Zone, New Zealand.

Multi-scale measurements of resistivity exist for this zone: its ductile portions have anomalously high electrical conductivity identified in MT models constructed as part of the South Island Geophysical Transect (SIGHT). Additionally wireline resistivities were measured in situ to $\sim$820 m depth during the recent Deep Fault Drilling Project (DFDP-2), and resisistivity of hand samples has been measured at laboratory conditions [Kluge et al., Abstract EGU2017-10139].

In exhumed and borehole samples, the distributions and arrangements of conductivity carriers – graphite, amorphous carbon, and grain boundary pores that would have contained brines or other conductive fluids at depth, have been characterised. These vary systematically according to the total ductile shear strain they have accommodated [Kirilova et al., Abstract EGU2017-5773; Sauer et al., Abstract EGU2017-10485]. Transmission electron microscopy analyses of grain boundaries also indicate that they contain carbon.

The next phases of our investigation involve: (i) construction of crustal fluid composition models by quantitative microstructural and compositional/mineralogical mapping of fluid remnants and their solid residues and calibration of these using in situ measurements of fluid composition in DFDP-2 at depths to $\sim$820 m; (ii) calculation of resistivities for real microstructures based on electrical properties of the individual component minerals and fluids – for microstructures fully characterised in three-dimensions; (iii) measurement of the effects of dynamic linking of phases during ductile creep of solid rock on complex resistivity of DFDP samples at a range of realistic crustal temperatures and pressures. A particular challenge in this study is to determine appropriate scaling relationships of electrical properties among samples, boreholes, and MT models because dielectric constants of minerals depend on frequency of the imposed current, which varies with scale and, consequently, measurement method. We invite discussion of strategies to overcome this.