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Electrical properties of schist and mylonite from the South Island, New Zealand: Exploring the source of the Southern Alps Anomalous Conductor

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The Southern Alps Electrical Conductor (SAC), identified from magnetotelluric surveys of the South Island Geophysical Transect (SIGHT) in the South Island, New Zealand, has high electrical conductivity relative to surrounding lithology (0.1 to 1 S/m between 5 and 25 km depth). This phenomenon is spatially coincident with shear zones of the Alpine Fault transform boundary and a region of anomalously low seismic velocity. It has been suggested these geophysical anomalies indicate dynamically linked fluids or graphite networks at depth, but this is unconfirmed.

The convergent component of deformation within the Southern Alps orogen exhumes the lower crust. Because of this, we have been able to examine the relationship between electric properties, porosities, and mineral arrangement of hanging wall rock samples across metamorphic and strain gradients approaching the Alpine Fault. These allow us to constrain the roc properties which yield the source of the Southern Alps Electrical Conductor.

We measured the electrical properties of 7 hand samples at the USGS Rock Physics Lab in Menlo Park, California. Complex resistivity of samples under confining pressure was measured up to 200 MPa, with a saturating brine of 0.1 M KCl. Laboratory measurements were then converted to complex conductivity. Mylonite conductivities were also averaged at each confining pressure and extrapolated to Alpine Fault conditions at depth (using fluid conductivity, geothermal gradient and effective confining pressure) to find projected in situ values between 0 and 9.4 km depth.

Porosity ranges from 1.2 to 5.4% for hanging wall metamorphic schists and 1.0 to 1.9% for Alpine Fault Zone mylonites. Schist porosity substantially decreases with increasing proximity to the Alpine Fault, but mylonite porosity exhibits no systematic trend.

Conductivity at 5 MPa effective confining pressure and 20 Hz ranges from 9.70x10-5 to 2.23x10-3 S/m for schists and 1.48x10-3 to 4.33x10-3 S/m for mylonites. Schist conductivity decreases towards the Alpine Fault, likely due to decreases in porosity. Conversely, mylonite conductivity increases towards the Alpine Fault. The latter trend cannot be systematically related to porosity, but may reflect another factor.

Projected mylonite conductivities were found to increase from 1.0x10-4 to 1.33x10-2 S/m between equivalent pressures of 0 and 3 km depth and then decrease to 1.0x10-2 S/m at a pressure equivalent to 9.4 km depth. These projected values are less than the expected conductivities found by MT surveys. To explain this inconsistency, we propose that either the input fluid compositions are incorrect or that we have not accounted for a factor such as grain boundary surface conductance or conductive graphite films.