

Can we use electrical conductivity to help understand the earthquake-induced stress-cycle in the ductile region beneath the Alpine Fault, New Zealand?

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SUMMARY

In the Southern Alps (New Zealand), 3D inversion modelling of MT data and micro-earthquake data from a closely spaced array of seismometers shows that a dipping electrically conductive zone is located immediately below the seismogenic region of the crust at the down-dip projection of the Alpine Fault. There is a remarkable correlation between the spatial extent of the conductor and surface strain-rates derived from GPS data suggesting the conductive zone is a consequence of the ongoing ductile deformation. The conductivity image shows a strong resemblance to model calculations of accumulated (ductile) creep between major Alpine Fault earthquakes. The simplest interpretation of these correlations is that the conductive zone is produced by ongoing deformation connecting small amounts of conductive aqueous-fluid at the mineral grain-boundaries.

However, the mechanism by which the enhanced conductivity is produced at mid-crustal depths is poorly understood. Based on observations of the fault rocks being exhumed along the Alpine Fault we think that the most plausible mechanism is pressure-solution-creep associated with the latter stages of fault rock mylonitization. The strain-induced dissolution-precipitation chemistry at the grain boundaries would provide additional charge carriers enhancing the conductivity of the grain boundary fluid and explain the correlation between the conductivity and the surface strain rate.

Since creep depends on differential stress, the question that arises is whether it would be possible to turn the conductivity image into a stress image. This will only be possible if we understand of the mechanisms producing the conductivity and deformation. Laboratory-based studies of the electrical properties of materials undergoing ductile deformation at mid-crustal temperatures and pressures are needed to develop this understanding. Determining the relationship between the conductance and creep rate would allow the stress state of the ductile region to be assessed and help us understand the Alpine Fault's earthquake cycle.

Keywords: Magnetotellurics, Seismology, Surface strain-rate, Ductile deformation, Rock conductivity
