MT Traversing the Delamerian and Lachlan Orogens of Victoria to Illuminate Geological Structures, Fossil Fluid Pathways, and Serpentinization

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Three broadband (0.001–2 000 s) magnetotelluric (MT) transects join together to create a 450-km east-west traverse following deep crustal seismic lines across of the Delamerian and Lachlan orogens of southeastern Australia. In 2014, 120 km of new data were collected to fill the prior gap between the 130 km transect to the west, and the 200 km transect to the east.

We have mapped phase tensor ellipses for approximate depths using a period-depth transformation rather than the usual method of mapping for certain periods, which can make interpretation of ellipses difficult as signal penetration depths for different sites can vary considerably depending on subsurface resistivity. These phase tensor ellipse depth slices show changes in upper crustal ellipses (0–10 km), in many cases corresponding to known locations of structural boundaries and faults. Upper mantle ellipses at 50 to 80 km depth show a distinct change in resistivity structure from west to east along the boundary between the Delamerian and Lachlan orogens. The boundary between these orogens is interpreted as a site of subduction, with Proterozoic crust to the west and accreted Cambrian oceanic crust to the east. The ellipses suggest this change is also manifest in the underlying subcontinental lithospheric mantle. A mantle change across the boundary has also been observed as a change in the chemistry of young Newer Volcanic basalts—the Mortlake Discontinuity—which erupted across this region.

Results of three separate 2-D inversions along the profile (due to varying geo-electrical strike) show similar features, with lower-midcrustal conductors mostly changing to resistors at about 10 km to surficial depth, with the exception of cases where these conductors have met permeable large fault systems and have reached the surface. Three of these cases have been uncovered with the new transect of Stepan, including the Escondida, Moyston, and Avoca faults. Interpretation of the cause of the conductors varies along the extensive profile, but mainly involves alteration of mafic-ultramafic rocks of the lower (originally oceanic) crust by fossil fluids, resulting in enhanced magnetic connectivity (and hence increased electrical conductivity) in serpentinized rocks.