



## **The effect of pre-tectonic reaction and annealing extent on behaviour during subsequent deformation: Insights from paired shear zones in the lower crust of Fiordland, New Zealand**

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The effect of pre-tectonic reaction and annealing extent on the rheology of lower crustal rocks during a subsequent deformation event was studied using field and detailed microstructural analyses combined with numerical simulations to examine. In the studied rocks (Pembroke granulite, South Island, New Zealand) granulite facies two-pyroxene-pargasite orthogneiss partially to completely reacted to garnet bearing granulite either side of felsic dykes. The metamorphic reaction not only changed the abundance of phases but also their shape and grain size distribution. The reaction is most advanced close to the dykes, whereas further away the reaction is incomplete. As a consequence, grain size and the abundance of the rheologically hard phase garnet decreases away from the felsic dykes. Aspect ratios of mafic clusters which may include garnet decrease from high in the host, to near equidimensional close to the dyke. Post-reaction deformation localized in those areas that experienced minor to moderate reaction extent producing two spaced “paired” shear zones within the garnet-bearing reaction zone at either side of the felsic dykes. Our study shows how rock flow properties are governed by the pre-deformation history of a rock in terms of reaction and coupled annealing extent. If the grain size is sufficiently reduced by metamorphic reaction, deformation localizes in the partially finer grained rock domains, where deformation dominantly occurs by grain size sensitive deformation flow. Even if the reaction produces a nominally stronger phase (e.g. garnet) than the reactants, a local switch in dominant deformation behaviour from a grain size insensitive to a grain size sensitive in reaction induced fine-grained portions of the rock may occur and result in significant strain localization.