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Geometry of a large-scale low-angle mid-crustal thrust (Woodroffe Thrust, Central Australia)

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Young orogens, such as the Alps, mainly expose the upper part of the continental crust and it is not possible to follow large-scale thrusts (e.g. the Glarus Thrust) to great depth in order to study their changing rheological behavior. This knowledge, however, is crucial for determining the overall kinematic and dynamic response during collision, as middle to lower crustal rocks represent the major part of the total crustal section. Information from deeper parts of the continental crust can only be obtained directly by investigating regions where these levels are now exhumed. The Musgrave Ranges in Central Australia is a very well exposed, semi-desert area, in which numerous large-scale shear zones developed during the Petermann Orogeny around 550 Ma. The most prominent structure is the $\sim$400 km long E-W trending Woodroffe Thrust, which placed $\sim$1.2 Ga granulites onto similarly-aged amphibolite and granulite facies gneisses along a generally south-dipping thrust plane with a top-to-north shear sense. Geothermobarometric calculations on the associated mylonites established that the structure developed under mid-crustal conditions (500-650ºC, 0.8-1 GPa). Regional P/T variations in the direction of thrusting are small, but show trends consistent with the south-dipping orientation of the thrust plane, which predicts deeper levels and a higher metamorphic grade in the south than in the north. They imply a very low gradient of only around 3°C/km for a distance of some 30 km in the movement direction of the thrust. Combined with a geothermal gradient on the order of 20°C/km, calculated from four separate P/T estimates from the hanging wall and footwall, this regional gradient indicates that the Woodroffe Thrust was originally shallow-dipping at an average angle of only around 9°. This suggests that upper crustal brittle thrusts do not necessarily steepen into the middle to lower crust, but can define very shallow-dipping, large-scale planar features, with dimensions in the order of hundreds of kilometres. Such a geometry would require the rocks to be weak, but field observations (e.g. large volumes of syn-tectonic pseudotachylyte) argue for strong behaviour, involving alternating fast (seismic) fracturing and slow (aseismic) creep.