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INTRA-CRATONIC Lithosphe HETEROGENEITIES, FAULTing and Rayleigh-Tylor Instabilities – insight from 3D numerical modelling

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The seismological structure of the Earth's lithosphere is identified to be strongly heterogeneous in terms of thermal and rheological properties. Lithospheric discontinuities (sharp changes in the thermal and/or compositional properties) are thought to be long lived and are mostly correlated with major tectonic boundaries that commonly have been reactivated and are subsequently the foci of magma intrusion and major mineralization. Resent numerical studies have shown that pre-existing weak zones (suture zones, major fault lines) in continental lithosphere act to focus most of the deformation, fluid transfer and melt propagation. The occurrence of such variations may be caused for instance by amalgamation of micro-continents such as is thought to be characteristic of the Yilgarn, Western Australia or parts of South Africa. Theses micro-continents, due to diverse histories may be characterised by various thermal and rheological structures. Here we explore the influence of the rheological heterogeneous on the behaviour of the lithosphere in a compressional, intracratonic regime.

This paper explores the control that 3D lithospheric heterogeneity exerts on the thermal and chemical evolution during deformation subsequent to the development of the heterogeneity, as well as periodicity and lateral distribution of phenomena such as Rayleigh-Taylor instabilities and fluid transport from the mantle through the crust. Exploration of the parameters controlling the 3D distribution of focusing mechanisms iscrucial for understanding the distribution of major ore deposits along mainstructures. Empirical observations in Kalgoorlie area (Western Australia, Yilgarn craton) show that spacing of major gold deposits is approximately 30 km along major lithospheric heterogeneities. This spatial distribution may result from periodic development of Rayleigh-Taylor instabilities along the contact zone, which results in fluid transfer in areas where delamination has occurred. From numerical experiments it appears that the yield strength of the weak zone is one important parameter controlling the spatial distribution of deformation

Our results illustrate that initial structural complexity has a dramatic effect on subsequent faulting and evolution, melting and devolatilisation of the lithosphere. The horizontal and vertical variation in plastic yield stress of the blocks (representing heterogeneously metasomatically altered material) nucleates localised deformation and creates conditions for delamination via Rayleigh-Taylor instabilities, which localise in a quasi-periodic manner along the main structure. Above the site of localised delamination of the mantle lithosphere, a series of deep crustal faults develop that may extend into the upper mantle. These deep structures can act as the pathways for mantle derived $CO2\pm H2O$ fluids and alkaline igneous complexes. A large spectrum of behaviour, including the development of deep sedimentary basins, is observed resulting from minor changes in the orientation and strength of the boundaries between blocks.