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Vertical tectonics in the Precambrian orogenic belts: A numerical perspective and application to the Canadian Hearne Craton

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The thermal state and age of the lithosphere are often considered as the main factor controlling the distribution of the structural and metamorphic features orogenic systems (ancient vs. modern tectonics). Hence, within ancient (weak and hot) lithospheres, the deformation appears to be distributed although strain localisation is preferentially found along shear zones in modern (strong and cold lithospheres). However, recent studies challenged this notion by suggesting that both tectonic styles can coexist. In this study, we investigate the effects of far-field stresses on the overall tectonic evolution using a series of 2D visco-elasto-plastic thermo-mechanical numerical models mimicking Precambrian lithospheric conditions. For this, a large range of thermal profiles and shortening rates have been tested. From our parametric study, we determined three modes of deformation that are significantly influenced by the magnitude of the shortening rates: (i) pop-downs/subduction of the upper crustal layers for high shortening rates ($\dot{\epsilon}_{BG} \geq 5 \times 10^{-14}$ s^{-1}) presenting the development of large shear zones, (ii) vertical sedimentary corridors formation, at moderate shortening rates (5×10^{-14} s^{-1} $< \dot{\epsilon}_{BG} \leq 1 \times 10^{-16}$ s^{-1}) producing more diffused vertical and connecting shear zones, and (iii) cusping of the sedimentary cover at slower shortening rates ($\dot{\epsilon}_{BG} \leq 1 \times 10^{-16}$ s^{-1}) which lead to well defined vertical strain patterns. The deformation patterns and features from our models are then compared to key Precambrian field examples, providing further insight into their respective deformation evolutions. In the case for the Canadian Hearne Craton (Western Canadian Shield), we constrain our models by using the available geological and metamorphic data. We determined that the sedimentary cusping mechanism provides the best fit. Our newly generated accumulated finite strain pattern dataset can then be re-interpreted as structural templates to infer capability of fluid circulation responsible for ore deposit genesis prior to the deposition of the Athabasca Basin.