

EGU2020-19758

<https://doi.org/10.5194/egusphere-egu2020-19758>

EGU General Assembly 2020

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Deformation Regimes in Cratons Caused by Gravitational Instabilities

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Most cratonic lithospheres are stable entities that have not been deformed since their formation in the Archean. In contrast, geological and geophysical inferences showed that North China and Wyoming Cratons have been deformed/destroyed under specific geodynamic circumstances (e.g. metasomatization, slab dehydration). For instance, lithospheric roots are densified-destabilized and they may eventually sink into the mantle. Here, numerical experiments are used to investigate how high-density anomalies/eclogite in the lower crust that is varying in size, density and geometry may control the lithospheric removal process. Based on a large set of parametric numerical calculations, we first classified the lithospheric removal style (e.g. localized, non-localized, high degree, and pierce through). In the case where the eclogite blocks attached to the lower crust, two different conditions develop; localized deformation and non-localized deformation occur due to the small-scale convection. Two new different removal mechanisms are evolved after the eclogite becomes detached from the lower crust; (i) pierce through mechanism subsequent to localized deformation and (ii) high-degree deformation following non-localized deformation. While the width of the eclogite block causes high-degree deformation, it is observed that with increasing thickness it leads to the formation of viscous drips. Experimental results indicate that eclogite block(s) under the cratons may still be there while creating small wavelength MOHO depth variations.