Geophysical Research Abstracts
Vol. 17, EGU2015-7685, 2015
EGU General Assembly 2015

High –Temperature melting in intra-continental settings – insight from numerical modelling

Weronika Gorczyk (1), Bruce Hobbs (2,1), Christopher Gonzalez (1), and Hugh Smithies (3)
(1) Center for Exploration Targeting, University of Western Australia, (2) CSIRO, Australia, (3) Geological Survey of Western Australia

Most of intra-continental melting is associated with interaction of deep mantle plume with mantle lithosphere. Vast amount of mafic/felsic intra-plate intrusions are located along post-collisional lines, where for longer periods of time regional tectonic conditions are more likely to be (weakly) compressional to transpressional, and more rarely extensional. Arrival of the asthenosphere-derived plume would suggest initiation of extension along the weak/post-collision zone. Alternatively, in compressional regime a surprisingly large range of instabilities can develop that lead to melting of the lower crust and mantle lithosphere. Unexpected structural complexity arises which is quite sensitive to the geometry and rheological properties. This has dramatic effects on melting and devolatilisation within the lithosphere and hence in the localisation of and melt emplacement. Melts extracted in theses circumstances lead to emplacement of all variety of magmas: mafic, intermediate and felsic, from wide range of PT conditions.

In order to investigate theses intra-plate sites of deformation, melt production and crustal growth in relation to pre-worked lithospheric crust we performed a series of 2D numerical experiments by using a coupled petrological – thermomechanical numerical model. The model includes, stable mineralogy, aqueous fluid transport, partial melting, melt extraction and melt emplacement in form of extrusive volcanics and intrusive plutons.

As a case study we will present Musgrave Orogeny in Central Australia. The Musgrave Province developed at the nexus of the North, West and South Australian cratons and its Mesoproterozoic evolution incorporates a 100 Ma period of ultra-high temperature (UHT) metamorphism from ca. 1220 to ca. 1120 Ma. This was accompanied by high-temperature A-type granitic magmatism over an 80 Ma period, sourced in part from mantle-derived components and emplaced as a series of pulsed events that also coincide with peaks in UHT metamorphism.

The initial constraint for each model setup is that reasonable geological and physical parameters (e.g., physical rock properties, far field stresses) must account for the most significant geological features of the Musgrave Orogeny, including:

(1) an assumed architecture comprising a recently thinned Proterozoic belt between two (in a 2D scenario) thicker cratonic masses;

(2) the c. 100 Ma total duration of the UHT event, punctuated into c. 10-20 Ma cycles;

(3) the more or less continuous production of charnockitic A-type granites which, based on geochemical and thermal arguments formed from a source that homogenized roughly equal proportions of mantle and residual crustal material.

The three case studies (Model I, Model II and Model III) presented here show an overall similar tectonic/magmatic evolution within the area of interest. Each numerical model replicates parts of the inferred evolution of the Musgrave Orogeny. The results indicate that the most plausible process that introduces ultra-high temperatures >1000°C is mechanical removal of the mantle lithosphere by asymmetric delamination which can be induced by (multiple) episodes of compressional tectonics.