Thermal self-regulation of continental strength

ROBERTO F. WEINBERG[1], KLAUS REGENAUER-LIEB[2]
AND GIDEON ROSENBAUM[3]

[1]School of Geosciences, Monash University, Melbourne, Victoria, Australia 3800 (Roberto.Weinberg@sci.monash.edu.au)
[2]School of Earth and Geographical Sciences, The University of Western Australia, Perth, Western Australia 6009, and CSIRO Exploration & Mining, Kensington, Western Australia 6151, Australia (klaus@cyllene.uwa.edu.au)
[3]School of Earth Sciences, The University of Queensland, Brisbane, Queensland 4072, Australia (g.rosenbaum@uq.edu.au)

The strength of the lithosphere is the integrated force required to cause deformation at a given rate. It has previously been assumed that continents subject to deformation are weaker when they are hotter. We argue that it is not the steady-state heat flow of continents that control their strength, but dynamic feedback effects, triggered by shear heating and thermal expansion. These effects localize strain into weak shear zones which control the dynamic strength of continents. Here we present numerical results showing that a cold and strong continent is substantially weakened by development of intensely localized shear zones. In contrast, weakening effects are less efficient in an initially warmer continent where shear zones are more diffuse. This leads to self-organization of the dissipative structures, i.e. the width, length, distribution and heat generation of shear zones. As a result, regardless of initial temperature profiles and crustal thicknesses, all modelled continents yield similar dynamic strengths that follow similar temporal evolution defining a lithospheric strength attractor. An important implication is that even cold and deeply-rooted Archaean cratons may be vulnerable to deformation as evidenced by a number of cratons that were rifted apart during the break-up of Gondwana.

Constraining timescales of ore-formation by numerical simulations of magmatic-hydrothermal systems

P. WEIS[1]*, D. COUMOU[2], T. DRIESNER[1], S. GEIGER[3],
I. STEINBERGER[1], G. GRÜN[1] AND C.A. HEINRICH[1]

[1]ETH Zurich, Department of Earth Sciences, Switzerland (*correspondence: philipp.weis@erdw.ethz.ch)
[2]Potsdam Institute for Climate Impact Research, Germany
[3]Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, UK

Fluid flow in magmatic-hydrothermal systems is strongly influenced by the properties of salt water. Within the pressure and temperature range of most ore-forming geological settings these vary non-linearly by orders of magnitude, and fluids can phase separate [1]. This complexity can have a large impact on fluid evolution and migration and, consequently, on timescales of ore-forming systems. Capturing these non-linearities is challenging for any modelling approach and numerical simulations often use simplifying assumptions. However, recent studies implementing more realistic fluid properties have demonstrated their immediate impact on the transient behaviour of magmatic-hydrothermal systems [2,3]. Mid-ocean-ridge systems have been shown to develop into a mass and energy flux optimizing interplay of up- and downflow and an efficient metal-leaching process that might be able to form a massive sulfide deposit in less than 10^3 years [4].

Silicic magmas carry several percents of volatiles which are released upon crystallization or depressurization. Our modelling approaches of subduction-related ore-forming systems depend on conceptual models prescribing magma emplacement, fluid exsolution from magmas and its injection into vein systems. First simulations constrain the timescale of a single magmatic event assuming a stagnant magma chamber exsolving fluid by crystallization to 10^4 to 10^5 years. Initial simulations assuming higher fluid injection rates from an inferred convecting chamber might confirm an expulsive behaviour, as recently discussed for the timescale of alteration and ore deposition of less than 10^3 years [5]. These generic simulations will be followed by site-specific studies on the Bingham Canyon porphyry deposit [6] and the active submarine system at Brothers volcano [7].

[1] Driesner (2007) *Geoch. & Cosm. Acta* **71**, 4902-4919. [2] Jupp and Schultz (2000) *Nature* **403**, 880-883. [3] Coumou *et al.* (2009) *JGR*, in press. [4] Coumou *et al.* (2008) *Science* **321**, 1825-1828. [5] Cathles & Shannon (2007) *EPSL* **262**, 92-108. [6] Steinberger *et al.* (2009) *GCA*, this volume. [7] Grün *et al.* (2009) *GCA*, this volume.