What are cratons made of?

C.M. COOPER*

School of Earth & Environmental Sciences, Washington State University, P.O. Box 644430, Pullman, WA 99164-4430 (*correspondence: cmcooper@wsu.edu)

Just as in nursery rhymes, cratons come with a list of defining qualities – high Mg #s, low seismic anomalies, neutral buoyancy, highly undeformable, thick and old lithopshere. But how did these unique features with specific come into existence? What was the original material that cratons were made of? Can the dynamics associated with the formation & longetivity of cratons provide insight into early Earth continental lithosphere?

Cratons have been proposed to have formed either due to interactions with a mantle upwelling (large degree of melting initiated by a plume) or downwelling (thrust stacking or amalgamation of material in a subduction related process). While both formation processes can satisfy some, but not all of craton requirement list, both geochemical and seismological evidence strongly point to a thrust-stacking origin. If this formation hypothesis is true, then it can place specific constraints on the initial craton material based on the dynamic requirements for the physical process – specifically, whatever cratons were made of must have been highly deformable during their origin and then switch to a high undeformable material for the duration of their existence.

In this presentation, I will step through the results from numerical modeling and theoretical scalings that demonstrate the conditions under which cratons can be formed and stabilized via thrust stacking of some material. I will then couple the dynamic constraints with observables to winnow down the potential culprits of proto-cratonic lithosphere in hopes of answering – what are cratons made of?

Petrological & geophysical processes far from equilibrium: Fluctuations, bifurcations, criticality, time and texture

REID F. COOPER

Brown University, Department of Geological Sciences, Providence, RI 02912 USA (reid_cooper@brown.edu)

Equilibrium thermodynamics is the heart of education in petrology and geochemistry (phase diagrams rule!), and very often the heart of research as well. The Earth, however, is evolving: it is far from equilibrium as evidenced, e.g. by convection in the mantle (not to mention by the presence of life!). Petrological processes—degassing and crystallization of magmas and weathering as examples—and geophysical processes—earthquakes and rock plasticity—are often the result of very large driving potentials ($\Delta_r G$) and even larger driving forces (d [$\Delta_r G$]/dx and/or d [$\Delta_r G$]/dt). The large potentials/forces open-up reaction possibilities—spatiotemporal dissipative structures, i.e., reaction textures and temporal power laws associated with criticality—often unavailable to systems in processes (e.g. melting) that cannot be overdriven. I'll illustrate some of these ideas with research pursued in my group in the areas of deep undercooling of silicate melts, magma redox dynamics, crystallographic preferred orientation in plasticity and seismic wave attenuation. Societies also demonstrate patterns, which, too, are dissipative structures: ideas and the efforts to implement them have consequences; it is not just energy that flows. *Elements* resulted from modifying some rules of our interaction and now affects how we pursue geo-chemical science together.