Breccia Mechanics as an Explanation for Extreme Geochemical Micro-Gradients and Fluid Mixing in the Genesis of Iron-Oxide-Cu-Au Deposits

Oliver N.H.S.[1], Williams, P.J. [1], Cleverley, J.S.[1,2], Mark, G. [1], Keys, D.L. [1], Blenkinsop, T.G. [1]

[1] *EGRU, School of Earth & Environmental Sciences, James Cook University, Townsville, Australia*
[2] *CSIRO Division of Exploration & Mining, Kensington, Australia*

Geochemical zonation in the breccia-hosted Ernest Henry iron-oxide-Cu-Au deposit of the Proterozoic Mt Isa Block occurs in an oscillatory fashion at micro-scales and irregular to broadly concentric fashions at broader scales. Oscillatory zoning includes alternations between arsenical- and non-arsenical pyrite with no concomitant variation in S isotopes, and variations in the S, As, and Cl contents of extremely unusual apatites, the latter pattern being mimicked in district-scale breccia pipes. Fluid inclusions analysed to date in the deposit are insufficiently spatially or temporally constrained to confidently point towards fluid mixing, but span a broad range of compositions indicating a very diverse range of fluids was involved in ore genesis, from granite or mantle-derived through to basinal brines (Kendrick et al., 2007). The oscillatory zoning suggests large fluctuations in S and As supply to the sulfides, which could be achieved either by pressure-dependent changes in speciation (e.g. due to fluid pressure pulsing accompanying brecciation) or fluid mixing. Neither process is well modelled by thermodynamic data for As in sulfides or apatite for which the pressure dependence of solubility is poorly constrained. However, mass balance equations and geochemical models can emulate ore assemblages by fluid mixing whereas fluid-rock reactions by sulfidation and carbonatization explain neither the paragenesis nor the zoning patterns. Although the likely difference in viscosity and wetting character between S-rich and S-poor mineralizing fluids would inhibit fluid mixing, the ore assemblage represents the matrix to a milled breccia. We suggest that fluid mixing was achieved by the dynamics accompanying fluidized breccia behaviour, with cyclical pressure changes allowing ingress to two or more fluids and fragment collisions allowing mixing of the fluids in a natural geological ball mill.

The Emergence of Steady-State Plate Tectonics in Dynamic Mantle ~~Models~~

Craig O'Neill[1]

[1] *GEMOC, Department of earth and Planetary Science, Macquarie University, Sydney, NSW, coneill@els.mq.edu.au*

A fundamental criterion for a successful plate tectonic simulation is the reproduction of steady spreading rates and regular plate behaviour. Additional criteria include asymmetric subduction zones, plausible ridge migration and realistic interaction of subducting slabs with the transition zone. However, high Rayleigh number convection is typically erratic and chaotic. The development of plate-like motions require highly viscous surface boundary layers, and a plastic deformation mechanism. However, convection with such ingredients is, under most circumstances, highly time-dependent. Inclusion of mantle phase transitions constrained by mineral physics, most notably an endothermic transition 670km, exacerbates the problem, causing punctuated mantle exchange between the upper and lower mantles. Given the non-linearities in the Earth-system, it is fairly remarkable that anything approximating steady-state behaviour occurs at all.

Part of the resolution of this problem lies in incorporating realistic mantle structures. Previous work has shown that the inclusion of a low viscosity asthenosphere contributes to steady spreading rates by minimizing viscous sublithospheric dissipation. This has the carry-on effect of producing large (Pacific-scale) plate widths, as well as regular spreading rates. Here we show that the interaction of descending slabs into the transition zone exerts a fundamental control on the surface dynamics of plates. The viscosity change at 670km, as well as the buoyancy effect of the phase transition, impede the dynamics of subducting plates, which at the surface results in the reproduction of such features as asymmetric subduction and slab rollback. We suggest many features characteristic of plate tectonics are, at least in part, a function of mantle structure.

A Spectrum of Hadean Geodynamics From Diamond Stability Constraints.

Craig O'Neill[1]

[1] *GEMOC, Department of earth and Planetary Science, Macquarie University, Sydney, NSW, coneill@els.mq.edu.au*

Recent work has shown the coexistence of diamond inclusions in felsic derived zircons. This is problematic, as shallow felsic magma chambers should not be conducive to diamond stability. Most recent examples of diamond inclusions in zircon come from ultra-high pressure massifs in Kazakhstan, where diamond replaced the original