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Advancing the Particle-In-Cell Scheme to an Adaptive, Unstructured Computational Framework

Christopher Mathews (1), Rhodri Davies (1), Cian Wilson (2), and Stephan Kramer (3)

(1) The Research School of Earth Sciences, The Australian National University, Canberra, Australia, (2) Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington DC, USA, (3) Department of Earth Science and Engineering, Imperial College, London, UK

A growing number of geochemical observations point towards the existence of distinct geochemical "reservoirs" within the mantle, some of which have survived for over 4 Byr of planetary evolution. Depending on their volume and material properties (e.g. density, viscosity), these reservoirs could play a significant role in governing mantle dynamics. To test whether or not this is the case, it is desirable to simulate thermochemical mantle convection rather than convection driven purely by temperature variations.

Fluidity, a multi-purpose, finite-element, control-volume, adaptive, unstructured mesh computational modelling framework, has the ability to simulate thermochemical convection, through the use of a multi-material control volume scheme. This mass-conserving control volume scheme successfully passes several common thermochemical benchmarks, but it is limited in its general applicability. As an alternative method, a particle-in-cell scheme has been implemented into the Fluidity framework. The implementation of such a scheme into an unstructured, adaptive framework has not yet been achieved within the geodynamics community and, thus, has some inherent challenges. Examples include the transfer of particle properties to an unstructured mesh, and the redistribution of particles in accordance with the dynamically load-balanced mesh in parallel. This presentation will summarise these challenges and how they have been overcome, demonstrate the validation of the newly implemented particle-in-cell scheme, and include comparisons of this scheme with the previous multi-material, control-volume framework.