What is a “Typical” Mantle Plume?

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Process models for mantle plumes, and indeed arguments for the existence of mantle plumes, are largely based on expected characteristics for these upwelling features. Typically plume models have large heads (>500 km), moderately slender tails (~100 km), uniform compositions (lower to upper mantle/Lherzolite), and high excess temperatures (200 °C or more). Here we present laboratory models of mantle convection with recycled, chemically laminated lithosphere which reveal a diversity in size, composition, temperature and both surface geological and geophysical expressions. Results suggest there is no typical mantle plume, but rather a range in plume classes. Examples from within the different classes can readily explain the diversity in plume surface expressions, from large igneous provinces with associated tails (time progressive island chains), to headless plumes and large (or small) headed plumes with no tails. The traditional large headed, uniform composition, high excess temperature plume was rarely seen in the 25 experiments conducted to date. Laboratory models utilized a glucose syrup (Ra=$10^5 \div 10^6$) for a working fluid. Mixtures of syrup and water were used to introduce density and viscosity contrasts between the ambient fluid and a dyed, chilled and layered slab representing recycled lithosphere. Generally, one layer of the slab was less dense than the ambient fluid (representing Harzburgite) and one layer was denser than the ambient fluid (representing Eclogite). A thermal boundary layer was developed at the base of a 20×20×15 cm tank by uniform basal heating. Interaction between the slab layers and fluid within the thermal boundary layer had a strong influence over the distribution of thermochemical heterogeneity within upwelling plumes. A range of repeatable plume styles emerged from this study. One prominent plume style is characterized by upwellings growing shortly after slabs enter the thermal boundary layer. These plumes are Harzburgite-rich and range from cooler (~100 °C) than ambient mantle to nearly equivalent with background temperature. Two common forms of chemical heterogeneity are seen, one in which these plumes have a thin (~10 km), Eclogite core. Plumes of this type that form from the edge of a slab pile have near perfect bilateral symmetry, containing half Harzburgite and half Lherzolite material from within the thermal boundary layer. Another common style of upwelling is recorded over a range of parameter combinations and occurs well after recycled material has reached and spread within the thermal boundary layer. These are hotter plumes (~200—400 °C excess temperature) with predictable distributions of both slab components (Harzburgite and Eclogite) and ambient thermal boundary layer material (Lherzolite). Length scales of thermochemical heterogeneity range from 1 km to >100 km depending on chemical density contrasts and local processes of instability formation within the basal boundary layer. A number of cases from distinct upwelling classes are digitized and used to drive synthetic melting and seismic models. Results show that more typical “plume-like” patterns can occur, but more commonly cases show extreme spatial and temporal discontinuities in melt production and seismic velocity patterns.

GPU support for sparse matrix calculations in PETSc, with applications to nonlinear Stokes

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Many geophysical phenomena (matle convection, glacier dynamics) are described by nonlinear Stokesian fluids coupled to various thermodynamic quantities. Linearization leads to variable coefficient linear

Stokes systems, which can exhibit poor convergence in absence of effective preconditioners. The emergence of GPU-based architectures offers dramatic hardware acceleration of many scientific computation tasks. Therefore it is natural to try to take advantage of GPU acceleration for many sparse matrix calculations, including Stokes systems. While achieving peak performance on sparse matrices is usually a challenge, we focus on enabling GPU support within one of the most popular sparse linear algebra and PDE library: PETSc (Portable Extensible Toolkit for Scientific computation). In this talk we will discuss our approach to enabling GPU acceleration for sparse matrix calculations, preconditioning, and the implications for Stokes solvers.

WebViz: A web-based collaborative interactive visualization system for largescale data sets

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With larger, faster, and more affordable multi-core and massively parallel computers coming to the market and with the introduction of general purpose GPU computing, the number and size of data sets being produced by the scientific community is on a steep rise. Additionally, with the rise of digital communication technologies, it is more and more common for scientists to engage in international collaborations across large geographical distances. To make sense of the large amount of data now being produced and to make collaboration between scientists easier, a new paradigm for data visualization is necessary. We propose that collaborative visualization tools and a web-based approach to data visualization is an attractive solution [Woodward et al., 2007; Damon et al., 2008; Greensky et al., 2008; McLane et al., 2009].

We have created a web-based application for multi-user collaborative visualization called WebViz. Our web application allows users in geographically disparate locations to simultaneously and collectively visualize large data sets (on the order of gigabytes) over the Internet. Furthermore, by providing data visualization services "in the cloud," users all around the world can leverage our service regardless of their local compute capabilities.

WebViz leverages asynchronous java and XML (AJAX) web development paradigms via the Google Web Toolkit (http://code.google.com/webtoolkit/) to provide remote users with a web portal to LCSE's (http://www.lcse.umn.edu) large-scale interactive visualization system already in place at the University of Minnesota. LCSE's custom hierarchical volume rendering software provides high-resolution visualizations on the order of 15 million pixels and has been employed primarily for visualizing data from simulations in astrophysics, geophysics, and computational fluid dynamics [Porter, 2002; Porter et al., 2002; Greensky et al., 2008; McLane et al., 2009].

In the current version of our WebViz application, we have implemented a new, highly extensible back-end framework built around HTTP "server push" technology. This design allows us to provide a rich collaborative environment and a smooth end-user experience. Furthermore, the web application is almost completely platform independent and is accessible via a variety of devices including netbooks, iPhones, and other web- and javascript-enabled cell phones.

Features in the current version of WebViz include: the ability for (1) users to launch multiple visualizations, (2) a user to invite one or more other users to view their visualization in real-time, (3) users to delegate control aspects of the visualization to others and (4) engage in collaborative chat and instant messaging with other users. These features are all in addition to a full range of visualization functions including 3D camera and object orientation/position manipulation, timestepping control, and custom color/alpha mapping.