Geophysical Research Abstracts,
Vol. 11, EGU2009-6511, 2009
EGU General Assembly 2009

Colliding channels and the internal dynamics of gneiss domes

DL Whitney (1), C Teyssier (1), and P Rey (2)

(1) University of Minnesota, Geology and Geophysics, Minneapolis, United States (dwhitney@umn.edu), (2) University of Sydney, School of Geosciences, Australia

Thick orogenic crust contains a low-viscosity layer, likely partially molten, that can flow in a channel located between the Moho and upper crust. Exhumed channel crust commonly occurs in gneiss domes. 2D numerical modeling of orogenic collapse provides insight into the dynamic behavior of this low-viscosity layer, its internal structure, its relation to upper crust deformation and boundary conditions, and the relation between channels and domes. We use Ellipsis, a particle in cell finite element code, to solve the governing equations of momentum, mass, and energy in incompressible flow (Moresi et al., 2003, J. Comput. Phys. 184), and incorporate viscosity and density drops that simulate partial melting. Two types of experiments have been conducted: (1) extension of uniformly thick crust, and (2) extension to contraction of a transition between thick crust (plateau) and foreland.

Extension of thick crust produces a metamorphic core complex by localization of extension in the upper crust, boudinage of the viscous mid-crust, and upward flow of lower crust. Upward flow draws material from the low-viscosity channel, resulting in the convergence and collision of channel material in the core complex. A thin vertical zone where the channels collide undergoes very high strain and separates two lobes (subdomes) of channel flow. Within these two lobes, particle (and P-T) trajectories are complex owing to partial overturning resembling convection cells.

Slow extension to slow contraction of a plateau-foreland system results in similar behavior of the upper crust and viscous mid-crust because the potential energy of the plateau crust dominates the dynamics of the system, irrespective of boundary conditions. In these cases, the channel has a tendency to internally convect in cells on 50 km wavelength, even though the density drop is only a few percent. Fast extension results in upward flow of the channel in a metamorphic core complex, as in the case of extension of thick crust. The difference is in the direction of flow as a function of time. In the first increments, channel flow is dominated by foreland-directed horizontal laminar flow in an attempt to minimize the difference in gravitational potential energy between plateau and foreland. However, as soon as extension begins in the upper crust, channel flow is diverted upward as the core complex instability amplifies. At this point, return flow from the foreland toward the core complex leads to colliding channels and the development of nappe-like structures with complex structures and P-T paths.