3-D Faulting and Magmatism at Mid-Ocean Ridges

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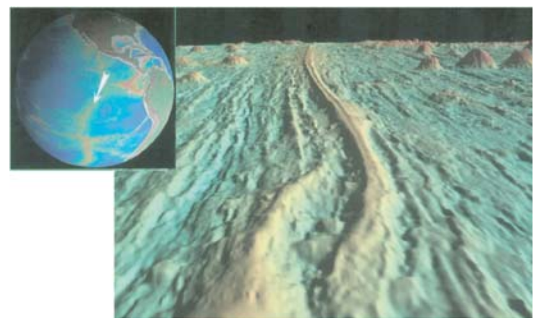
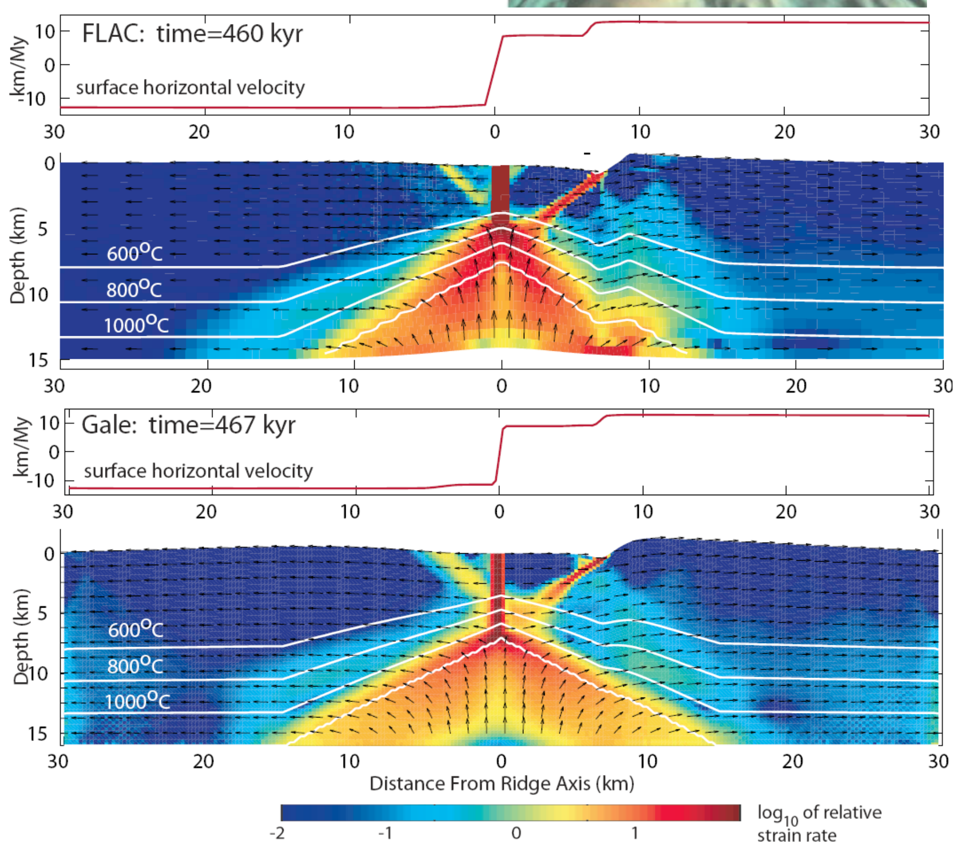
Faulting and magmatism at mid-ocean ridges influences the geometry of the plate boundary, shapes the topography of the axial zone, and creates seafloor fabric that covers two-thirds of the Earth's surface. The tectonomagmatic cycle at ridges creates a situation in which extension is accommodated partly by magmatic intrusions and partly by faulting. Magmatism is also heat source that influences the thickness of the brittle lithosphere out of which faults grow. Recent geodynamic studies have begun to quantify relationships between observable topographic characteristics and parameters such as the fraction of magmatic vs. tectonic extension and lithospheric thickness[1,2,3]. In so doing, these studies have established a basic understanding of the kinematics of fault migration with plate motion, controls of the stresses on and brittle strength of the lithosphere, and the dynamic processes that determine whether the axis forms a deep valley versus a topographic high.



The above studies were limited to 2D (depth and cross-axis); however, the mid-ocean ridge plate boundary is inherently 3D, with large variations in the 3rd, along-axis direction. The amount of magmatism and lithosphere thickness can vary by many times along individual ridge segments, and spreading itself is disrupted by axial discontinuities in the form of transform faults, overlapping spreading segments, and non-transform offsets.

We have begun a study to quantify the response of faulting and topography to such along axis variations using the CIG-supported finite element code *Gale*. The figure to the right shows example solutions of surface velocity (positive to the right) and strain rate by a different, 2D code (*FLAC*) and *Gale*. Despite fundamental differences in the methods of simulating brittle behavior, the two codes predict similar times and amount of extension at which an active fault (right) begins to die at the expense of a new fault, which is beginning to form on the left plate. We are encouraged by these initial results and will soon be doing calculations 3D. This study is made possible by CIG and in particular by software engineer, Walter Landry, who has provided outstanding support in code development and assistance in adapting *Gale* for simulating faulting and magmatism at mid-ocean ridges.



[1]Buck, W. R., L. L. Lavier, and A. N. B. Poliakov (2005), *Nature*, *434*, 719-723.
[2]Behn, M. D., and G. Ito (2008), *Geochem. Geophys. Geosys.*, *9*, *Q08O10*, doi:10.1029/2008GC001965.
[3]Ito, G., and M. D. Behn (2008), *Geochem. Geophys. Geosys.*, *9*, *Q09O12*, doi:10.1029/2008GC001970.