Geophysical Research Abstracts
Vol. 16, EGU2014-16471, 2014
EGU General Assembly 2014
© Author(s) 2014. CC Attribution 3.0 License.

Rifted continental margins: geometric control on crustal architecture and melting

Erik Lundin (1), Tim Redfield (2), and Gwenn Peron-Pinvidic (2)
(1) Statoil ASA, (2) NGU, Geological Survey of Norway

A new model is provided for the distribution of magma-poor and magma-rich rifted margins. The South Atlantic, Central Atlantic, North Atlantic - Arctic (Eurasia Basin), and Red Sea all are magma-rich at their distal ends and magma-poor at their proximal ends (with respect to their poles of rotation). The well-known architectural zonation across fully developed magma-poor margins (limited crustal stretching, hyperextension, exhumed mantle, oceanic crust) is also observed along the lengths of many margins at the super-regional scale. Zones of exhumed mantle, marking magma-poor margin, can be mapped for thousands of kilometers. Likewise can zones of seaward dipping reflectors (SDR) marking magma-rich margins. At this scale, the age of the oceanic crust becomes younger in the direction of the rotation pole, implying that the continents ruptured by rift tip propagation (and rotation pole propagation). Propagation is also manifested by the age of pre-break-up magmatism, break-up unconformity, and margin uplift. Hence, the classic cross-sectional depiction of margin evolution has a third dimension. The degree of melting follows the same pattern. At the distal end of e.g. the South Atlantic, SDR zones are wide and gradually thin toward the rotation pole. Eventually exhumed mantle takes over, marking the transition to the magma-poor margins, which remain to the proximal end of rifting. SDR zones also thin laterally from ca 10-15 km thickness at the continent-ocean boundary (COB) to ca 7 km thick oceanic crust beyond the SDRs. Outcrop data demonstrate that also exhumed mantle contains up to ca 12% melt, infiltrated in the peridotites. Thus, melting is largest at the distal ends near the COB, and decreases both laterally toward the evolving ocean and along strike toward the rift tip. Accepting that continents are rigid to a first order, the linear rate of extension at any given location along an evolving rift and ocean, is governed by the angular rate of opening, the distance to the rotation pole, and the rate of propagation of the pole. For a fixed angular rate, the linear extension rate increases away from the pole. Numerical models reveal that both mantle temperature and rate of extension can govern the degree of melting. However, the above empirical observations suggest that to a first order the rifted margin architecture, including the degree of melting, is governed by the linear rate of extension, which is a direct outcome of geometric rules of plate tectonics. Rapid pole propagation, or a pole jump, will induce a rapid increase in the linear rate. Magma-rich margins seem to form when continents break at a high extension/strain rate caused by rapid propagation; this occurs at the distal end of a rupturing plate. Our testable model questions the common ad hoc introduction of mantle plumes to explain "excess" melting along magma-rich margins. This does not rule out that mantle heterogeneities may exist, but such heterogeneities appear second order when it comes to generating magma-rich margins.