2017 Geodynamics Seminar

Origin and Evolution of Oceanic Ridge-Transform Patterns and Triple Junctions: a numerical modeling prospective

Taras Gerya

Institute of Geophysics
Department of Earth Sciences
ETH-Zurich

Tuesday, March 14, 2017
1:30 - 2:30 p.m.
Clark Lab 507, Quissett Campus, WHOI

Talk Summary

Characteristic pattern of mid-ocean ridges sectioned by transform faults stand as inherent feature of terrestrial plate tectonics. A fundamental unresolved problem is how this pattern has formed and why it is maintained. Here, we study numerically the processes of triple junctions formation from uni-directional lithospheric extension. According to the numerical experiments, ridge-transform oceanic spreading patterns can form gradually in two ways: (1) during mature spreading by rotation of oblique ridge sections caused by asymmetric plate accretion and (2) during transition from rifting to spreading by rotation of proto-transform linkage structures formed between individual offset spreading centers. It is demonstrated on the basis of simple analyses that the ridge-transform system is a long-term plate growth pattern that is generally different from an initial plate rifting pattern. Geometry of the ridge-transform system is governed by geometrical requirements (180o rotational symmetry for open space occupation) for simultaneous accretion and displacement of new plate material within two offset spreading centers connected by a sustaining rheologically weak transform fault. According to these requirements, the characteristic spreading-parallel orientation of oceanic transform faults is the only thermomechanically consistent steady state orientation. Results of numerical experiments compare well with both incipient (Woodlark Basin) and mature (Mid-Atlantic Ridge) ridge-transform spreading systems observed in nature.

Ridge-ridge-ridge triple junctions are another remarkable feature of global plate tectonics but their nucleation and evolution remains debatable. Here, we study numerically the processes of triple junctions formation from multi-directional lithospheric extension. We document two major classes of junctions: (i) transient quadruple and triple plate rifting junctions are formed by the initial plate fragmentation and gradually converted into (ii) stable triple oceanic spreading junctions controlled by the accretion of new lithosphere. Quadruple junctions break into two diverging triple oceanic spreading junctions connected by a linear spreading center lengthening with time. This process gradually decreases length of deforming boundaries between four diverging rigid plates and thus integral mechanical resistance of these boundaries to the spreading. Geometry of triple oceanic spreading junctions varies from asymmetrical T-junctions to ideal 120o junctions. Structure of oceanic spreading junctions includes two crucial tectonic elements: oceanic ridges (i.e. plate boundaries) and intra-plate ranges dividing lithospheric sections accreted from different ridges. The geometrical steady state is achieved on the timescale of several million years. We propose a new simple geometrical theory of a migrating steady state triple junction, which describes its structure and migration vector as a function of three plate velocity vectors. Predictions from the numerical models and geometrical theory find some good analogies in nature but more systematic cross-disciplinary work is needed in the future.