Geodetic Constraints on Continental Rifting Along the Red Sea


1 MIT; 2 KACST, Riyadh, Kingdom of Saudi Arabia; 3 Marmara Research Center, Gebze, Turkey; 4 National Earthquake Center, Damascus, Syria; 5 National Seismological Observation Center, Dahmar, Yemen; 6 Kuwait University, Kuwait City, Kuwait; 7 Hashemite University, Zarqa, Jordan; 8 NRIAG, Helwan, Egypt; 9 Asmara University, Asmara, Eritrea

We are using GPS to monitor and quantify patterns and rates of tectonic and magmatic deformation associated with active rifting of the continental lithosphere and the transition to sea floor spreading in the Red Sea. Broad-scale motions of the Nubian and Arabian plates indicate coherent plate motion with internal deformation below the current resolution of our measurements (~ 1 mm/yr). The GPS-determined Euler vector for Arabia-Nubia is indistinguishable from the geologic Euler vector determined from marine magnetic anomalies (~ 3 Ma average), and Arabia-Eurasia relative motion from GPS is equal within uncertainties to relative motion determined from plate reconstructions. These observations indicate that Arabia plate motion has remained constant (~10%) during the past ~25 Ma when Arabia separated from Nubia. GPS survey profiles extending from the Red Sea coast in KSA show no resolvable motion relative to the Arabian Plate. This and the approximate agreement between broad-scale GPS rates of extension (i.e., determined from relative plate motions) and those determined from magnetic anomalies along the Red Sea rift imply that spreading in the Red Sea is primarily confined to the central rift (~10%). Extrapolating the GPS velocities back in time indicates that the Red Sea rift initiated around 25 Ma BP more or less simultaneously from the Gulf of Suez to the Afar Triple Junction, and that rifting transferred from the Gulf of Suez to predominantly left-lateral strike-slip faulting along the Gulf of Aqaba and Dead Sea fault system around 11 Ma BP.

Figure: Topographic/bathymetric map of the Red Sea region with GPS velocities and 95% confidence ellipses – black vectors show motions with respect to Nubia, and blue vectors with respect to Arabia. Red lines crossing the Red Sea basin are estimates of total extension in the direction of present-day opening. Assuming that Arabia motion has been at a constant velocity since initiation of rifting, we estimate that rifting occurred roughly simultaneously along strike from the Suez to the Afar Triple junction ~ 25 Ma BP. From the width of the Gulfs of Suez and Aqaba, we estimate that rifting transferred from the Suez to Aqaba ~ 11 Ma BP.