

Postdiking Deformation following the September 2005 Afar Tectono-Magmatic Event

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Magma intrusion through diking is the quantum event of oceanic crustal accretion. Observations in sub-aerial rift zones in Iceland and Afar suggest that diking events, associated with instantaneous localized extension and with shallow, low magnitude, earthquake swarms, typically cluster in a succession of discrete dike intrusions followed by a decadal-scale relaxation strain transient. From 14 September to 4 October 2005, a tectono-magmatic event of unprecedented scale and intensity occurred along the Dabbahu segment of the Afar rift, Ethiopia, with a 60-km long dike intrusion, 162 $5.6 < m_b < 3.9$ earthquakes, and the emplacement of about 2.5 km³ of magma. It is the largest single rifting event on land since the Laki (Iceland) eruption in 1783, and the first to occur in the era of satellite geodesy. This event offers an unprecedented opportunity to directly observe and quantify diking and post-diking processes, critical to past and present magmatic continental rifting and ongoing but not directly accessible at most oceanic spreading centers.

Replying to a request by Ethiopian colleagues for a rapid response effort, we initiated a comprehensive study of crustal deformation associated with the 2005 Afar diking event using GPS, Interferometric Synthetic Aperture Radar (InSAR), seismology, field observations, and numerical modeling. With UNAVCO support, we deployed eight continuous GPS (CGPS) stations in the area of maximum co-diking displacement plus one CGPS station on each of the two volcanoes that mark the northern termination of the dike. Five additional CGPS stations will be added in 2007. We are also performing episodic GPS (EGPS) measurements at a number of sites in the vicinity of the dike and the rest of Afar. Preliminary results from the CGPS stations for the January to March 2006 period show accelerated deformation at most CGPS sites with displacements up to 2 cm horizontally and 11 cm vertically. InSAR results show that five smaller diking events took place between June

2006 and January 2007 along the southern half of the September 2005 dike. InSAR and GPS data between the first and second diking events show inflation and outward motions consistent with the filling of a magma chamber at the northern termination of the future dykes. Overall, magmatic processes are currently dominating the deformation field, suggesting a ready supply of magma below the rift.

This work is funded by NSF (US) and NERC (UK).

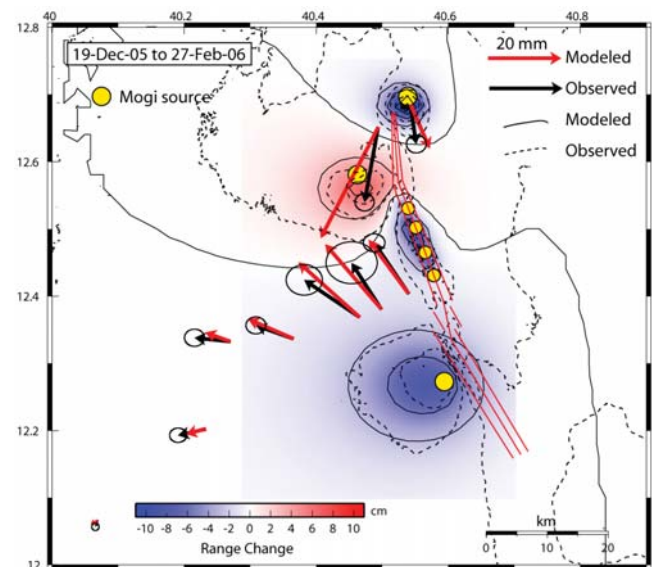


Figure 1. Comparison between model (red arrows and solid black lines) and observations (black arrows and dashed black lines) for the December 2005 to February 2006 period. The model is a joint inversion of GPS and unwrapped InSAR and solves for Mogi sources (volume change) and dyke opening. The deformation field is best matched by Mogi sources than continued dyke opening, indicating that magmatic processes are currently predominant, while a ready supply of magma is available below the rift.