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Repeated dyke injections trigger creep pulses on normal faults: Example of the 2005-2010 rifting episode in the Manda Hararo rift, Afar (Ethiopia) using Interferometric Synthetic Aperture Radar.

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A major rifting episode began in September 2005 in Afar with a first intrusion of a 65-km-long mega-dyke, followed by 13 smaller dykes from June 2006 to May 2010. Between these numerous injections, transient deformation was observed above the magma chamber at the rift center suggesting that a crustal magma reservoir refills between the dyke intrusions to feed the subsequent dyke.
The floor of the Manda Hararo rift is intensely dissected by normal faults and fissures, which have been mapped using optical images (SPOT & QUICKBIRD images), together with SAR interferograms and coherence images. A detailed analysis of SAR interferograms at full resolution in the inner part of the rift reveals that creep pulses affect these faults between the dyke intrusions. We focus here on this InSAR signal associated with creeping faults in order to study the magmato tectonic interactions and the tectonic extension along spreading segments. In particular we wish to answer the following questions: Is the fault activity observed at the surface triggered by the magmatic intrusions at depth? Is the amount of extension accommodated by magmatic dilatation correlated with the intensity of fault slips during inter-dyking periods? Is the tectonic deformation triggered by the dilation of the crustal magma reservoir ? How do faults grow and interact over the whole rifting period?

Using the current database consisting of more than 150 ENVISAT SAR acquisitions along 4 different tracks, we extract slip along faults on full-resolution unwrapped interferograms spanning inter-dyking periods. The horizontal and vertical profiles are then estimated by combining ascending and descending tracks covering the same time periods.
The spatial distribution of active faults suggests a control by the magma transfers within the crust. In particular, above the area affected by the inflation/deflation of the crustal magma chamber in the center of the rift, the faults seem to be activated mainly in response to the refilling of this main magma chamber. Slips on faults are also observed in the Northern segment of the rift, south of the Dabbahu volcano, during 6 months after the September 2005 mega-dyke. Together with geodetic and seismic data, these observations suggest the discharge of the Dabbahu reservoir into the mega-dyke.

At a smaller scale, we investigate the fault growth and the interactions within a fault population for 3 inter-dyking periods. The slip patterns are well-preserved through a complete inter-diking period. Most of the slip minima locations are correlated with changes in the faults strikes or with relay zones of connecting faults. Furthermore we observe a first order similarity in shape between the patterns of these slip pulses and the long-term deformation given by the scarp heights, suggesting that the long-term tectonic deformation within the rift is mainly controlled by the magmatic activity.