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Fault growth in a magmatic rift: indicator of the existing magma sources? Case of the Dabbahu-Manda Hararo rift, Afar (Ethiopia)

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The rifting episode that occurred in Dabbahu-Manda-Hararo rift, Afar (Ethiopia), between September 2005 and May 2010 involved 14 dike intrusions. Most previous works were focused on dike injections, while very few on the faulting processes. In this framework, this study aims to better understand the role of faults and the interactions between faulting and magmatism during a rifting episode.
A time space multi-scale analysis has been performed using the faults mapping and ground deformation measurements by SAR interferometry (InSAR). We focus here on the InSAR signal due to slip along faults between dike intrusions in order to consider the brittle deformation in presence of transient deformations of magmatic origin. What triggers slip along faults during inter-diking period ? Post-dike visco-elastic relaxation or magma transfers within the crust ? What does it imply for fault growth ?
To address such questions, we have extracted slip along faults in interferograms spanning inter-diking periods but also on DEM to get the cumulative slip profiles from scarp heights. Fault activity during inter-diking periods is systematically observed where magma transfers occur within the crust. Such areas coincide with the mid-segment magma chamber that is refilling after each dike intrusion, and with the northern segment of the rift that is activated only after the September 2005 initial dike. Faults are probably activated on this segment by the magma discharge coming from the Dabbahu's deep reservoir into the September 2005 dike, as suggested by the geodetic and seismic observations. The temporal evolutions of the ground deformation and the slip along faults show similar trends during the inter-diking time intervals. These similar temporal trends suggest that the magma transfers within the crust trigger the fault activation. Magma movements seem therefore control the fault growth in the Dabbahu-Manda-Hararo rift, as previously suggested by Rowland et al. (2007).
At a smaller scale, we are able to compare the distribution of slip along groups of faults during inter-diking periods with the cumulative slip distribution. Most divergences appear between both distributions for groups of faults located in the northern segment of the rift. A better agreement between the short-term slip distribution and the cumulative one is observed for the faults located in the area of the mid-segment magma chamber. As fault growth seems to be related to magma processes, we suggest that differences between the long and short-term slip distributions are caused by the influence of several magma sources in the northern segment (Dabbahu and Gabho volcanoes and also the mid-segment magma chamber). Such influence of multiple reservoirs is not observed in the rift center where fault growth is mainly controlled by the mid-segment magma reservoir. Therefore the fault growth may be considered as an indicator of the present magmatic sources.