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Analysis of high-resolution Digital Elevation Model (DEM) of the Afrera Plain (Afar) reveals relationship between magmatism and tectonics in a rift transfer zone

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Continental extension at mature rifts systems focuses along spreading segments where dominant magmatic activity, diking and minor faulting assist plate divergence. Such processes make adjacent spreading segments grow but also interact at zones where the spreading is transferred from one segment to another. A great variety of tectonic structures has been observed at transfer zones, encompassing parallel strike-slip faults (bookshelf faulting) or conjugate systems of en-echelon oblique faults. Transfer zones can also become transform plate boundaries once continental breakup occurs. However, the role of magma in influencing the deformation at rift-rift transfer zones is unclear as direct observations are rare. In this study, we address this open question by exploiting high-resolution Pléiades-1 tri-stereo imagery to produce the first 1 m DEM of the Afrera Plain transfer zone, between the Erta Ale and Tat Ali spreading segments in Northern Afar. This dataset has been used to conduct a detailed structural analysis of both tectonic and magmatic features and explore their geometrical and spatial relationships. We observed different trends and kinematics: Dikes opens with an extension oriented $\sim N65^{\circ}E$, consistent with the regional extension; tectonic features have instead an extensional component with direction varying between $\sim N46^{\circ}E$ and $\sim N68^{\circ}E$. Riedel shears and measurements of fractures opening directions indicate that tectonic deformation occurs along two families of NW-SE- and NS-striking oblique faults having right-lateral and left-lateral components, respectively. At the same time, spatial relationships between faults and lava flows also indicate that magmatic and tectonic activity co-exist in the transfer zone. We explain these observations by two different strain fields acting in the Afrera Plain during magmatic and amagmatic phases. During magmatic phases, dikes open orthogonal to the spreading direction responding to the regional extension. Conversely, during amagmatic phases, the transfer zone is dominated by the interaction between the two spreading segments with counterclockwise rotations of the strain field and shear motions accommodated by conjugate fault systems.