Monitoring dyke injection and strain field evolution using shear-wave splitting.

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Magma storage and dyke injection in the shallow crust is a fundamental process in rifting and volcanic environments. The dyking will tend to align with directions of maximum compressive stress, and the associated aligned fracturing and melt migration provides a very effective means of generating seismic anisotropy. Observations of shear-wave splitting provide one of the most unambiguous indicators of such anisotropy. As such, shear-wave splitting can be used to monitor the evolving strain field in volcanic and rifting environments. Here we apply lessons learned from monitoring fracture propagation during the hydraulic stimulation of tight-gas reservoirs. In a number of experiments we observe spatial and temporal variations in shear-wave splitting magnitude and orientation. We invert shear-wave observations for fracture properties, including the tangential and normal compliance, the ratio of which is a good indicator of fluid flow and permeability. Frequency dependent affects can be also used to indicate the length scales of the causative cracks or fractures. We apply these insights to microseismic data recently acquired across the volcanically active Afar triple junction in Ethiopia. The pattern of S-wave splitting in Afar is best explained by anisotropy from deformation-related structures, with the dramatic change in splitting parameters into the rift axis from the increased density of dyke-induced faulting combined with a contribution from oriented melt pockets near volcanic centres. The results help in our understanding of the role of melt in strain accommodation in rifting and volcanic environments.