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Detachment depth revealed by rollover deformation: an integrated approach at Mount Etna.

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Flank instability is common at volcanoes, even though the subsurface structures, including the depth to a detachment fault, remain poorly constrained. Here, we use a multidisciplinary approach, applicable to most volcanoes, to evaluate the detachment depth of the unstable NE flank of Mt. Etna. InSAR observations of Mount Etna during 1995-2008 show a trapdoor subsidence of the upper NE flank, with a maximum deformation against the NE Rift. The trapdoor tilt was highest in magnitude in 2002-2004, contemporaneous with the maximum rates of eastward slip along the east flank. We explain this deformation as due to a general eastward displacement of the flank, activating a rotational detachment and forming a rollover anticline, the head of which is against the NE Rift. Established 2D rollover construction models, constrained by morphological and structural data, suggest that the east-dipping detachment below the upper NE flank lies at around 4 km below the surface. This depth is consistent with seismicity that clusters above 2-3 km below sea level. Therefore, the episodically unstable NE flank lies above an east-dipping rotational detachment confined by the NE Rift and Pernicana Fault. Our approach, which combines short-term (InSAR) and long-term (geological) observations, constrains the 3D geometry and kinematics of part of the unstable flank of Etna and may be applicable and effective to understand the deeper structure of volcanoes undergoing flank instability or unrest.