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Temporal and Spatial Variation of Anisotropy at Mt. Etna as possible eruption forecasting tool

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Shear wave splitting is the elastic analogue of the well known optical birefringence phenomenon. A shear wave entering into an anisotropic volume, is split into two quasi shear waves, qS1 and qS2, propagating with different velocities and approximately orthogonal polarizations. The splitting parameters are the time delay between qS1 and qS2 wave (hereafter referred to as Td); and the polarization direction of the leading split (qS1) wave (hereafter referred to as Lspd, Linear split polarization direction). The Extensive Dilatancy Anisotropy (EDA) model suggests that the principal source of seismic anisotropy in the crust is composed by stress aligned fluid filled microcracks. In particular, for arrivals within the shear wave window, for seismic foci below about 1 km, Lspd is approximately parallel to the direction of the maximum compressional stress, and Td is controlled by the distribution of densities and aspect ratios of stress-aligned, fluid-saturated, grain-boundary cracks and pore-throats present in almost all rocks at depth. Under changing stress condition, the physical variation of the EDA cracks may be modeled with APE (Anisotropic Poro Elasticity) model, whose deformation mechanism is controlled by the fluid migration by flow or diffusion along pressure gradients between cracks determined by the orientation of the stress field. In the framework of APE, temporal evolution of the splitting parameters define a new class of observation that monitors changes of stress possibly related to impending earthquakes or volcanic eruptions. Mt. Etna experienced several major eruptions in the last 10 years; among them the recent 2001 and 2002 eruptions that are “large” eruptions in term of magma erupted. We measured the splitting parameters at Mt. Etna for the seismicity occurred in the period January - December 2001, including the July eruption, and for the seismicity occurred in the period March 2002 - July 2003, including the October 2002 eruption. We obtained Td through an orthogonal transformation

of Singular Value Decomposition (SVD); Lspd was obtained using a 3D covariance matrix decomposition, projecting the eigenvector related to the largest eigenvalue in the horizontal plane. We found significant variation of both Td (depth normalized) and Lspd several days before the start of both the eruptions. Our observations appear to be in agreement with APE modeling, suggesting that shear wave splitting parameters may define a new class of precursors for the impending eruption at Mt. Etna.