Three-Dimensional Modelling of stress-induced anisotropy with application to Mount Asama, Japan

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In order to investigate the link between observed temporal changes in anisotropy and volcanic activity in the crust, we have developed a three dimensional forward model to simulate shear wave splitting (SWS) in seismic rays. Anisotropy is expressed in shear waves when wave velocity is dependent on its polarisation, splitting the wave as one polarisation travels at a higher velocity than its orthogonal counterpart. Fast wave polarisation and delay time between fast and slow shear wave components can be measured to give an idea of the strength and orientation of anisotropy along the ray path. At volcanoes, changes in anisotropy are attributed to changing stress conditions as magma moves through the crust (e.g. Savage *et al.* "Stress magnitude and its temporal variation at Mt. Asama Volcano, Japan, from seismic anisotropy and GPS").

We have combined finite element stress modelling with the 3D analytical solution for stress induced elastic anisotropy developed by Gurevich *et al.* in order to produce synthetic SWS. This approach is based on the hypothesis that microcracks (i.e. pore scale fractures and discontinuities) oriented perpendicular to the maximum compressive stress are closed preferentially, inducing anisotropy in the rock mass. We find that stress changes produced by the dyke at Mount Asama, an andesitic volcano in central Japan, determined for an eruption in 2004 are only of significance within its immediate vicinity when regional stresses are nearly isotropic. Small differential stresses and resulting low values of anisotropy indicate that a pure dry crack closure model for changing anisotropy may be overly simplistic. Current implementations of this stress effect suggest that realistic crack compliance ratios cannot explain the large values of anisotropy measured. The following hypotheses are suggested:

1. The cracks are fluid filled and hydraulically connected.
2. New crack distributions are formed due to the stresses.
3. The cracks that do exist change the relative content of fluid versus gasses.
4. Background anisotropy due to mineral alignment or structure is overprinted by crack-induced anisotropy in such a way that small changes in the crack-induced anisotropy are amplified by the method we are using to measure anisotropy. ♠