VISCOELASTIC MODELING OF GROUND DEFORMATION DURING THE 1993-1997 INFLATION PERIOD AT ETNA VOLCANO

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We reviewed the ground deformation observed on Etna volcano during the 1993-1997 inflation period by setting up a 3D viscoelastic model. Since 1993 different geodetic measurements (EDM, GPS, SAR and leveling data) identified an inflationary phase characterized by a uniform and continuous expansion of the overall volcano edifice that was not perturbed by eruptive activity. We used the CIG finite element code PyLith for modeling time-dependent ground deformation due to volcanic pressure sources embedded in a viscoelastic medium. Especially in volcanic areas, the presence of heterogeneous materials and high temperatures produce a lower effective viscosity of the Earth's crust that calls for considering the thermal regime of crustal volume surrounding the magmatic sources. We implemented a viscoelastic shell model in which the magmatic source is embedded in an elastic medium and surrounded by a concentric shell of viscoelastic material. It is reasonable to assume that rocks near the inflation source are considerably heated and weakened beyond the brittle-ductile transition temperature, where viscoelastic rheology is more appropriate to describe the mechanical behavior of the surrounding rocks. The computational domain was generated using a digital elevation model of Mt Etna (SRTM data) and a bathymetry model for the off-shore area (GEBCO database from http://www.gebco.net/) using LaGriT (http://lagrit.lanl.gov). To simulate the magmatic inflation we assigned the pressure value on the magmatic source wall. Non-uniform distributions of the Young's modulus and Poisson ratio were estimated using seismic velocity tomography. A viscosity of 10^{16} Pas was assumed for the viscoelastic shell using the generalized Maxwell model. The model permits to evidence that viscoelastic relaxation is responsible for significant time-dependent variations in long-term deformation. The inclusion of the viscoelastic shell enhances the estimates of the deformation field expected at the ground surface over time (Figure). Therefore, the numerical model, including viscoelastic material around the magmatic source, enables to produce deformation comparable with those obtained from elastic model, requiring a significantly lower pressure (Del Negro et al., 2009).

References

Del Negro, C., G., Currenti, D. Scandura, Temperature-dependent viscoelastic modeling of ground deformation: application to Etna volcano during the 1993-1997 inflation period, Physics of the Earth and Planetary Interiors, 172, 3-4, 299-309, 2009.

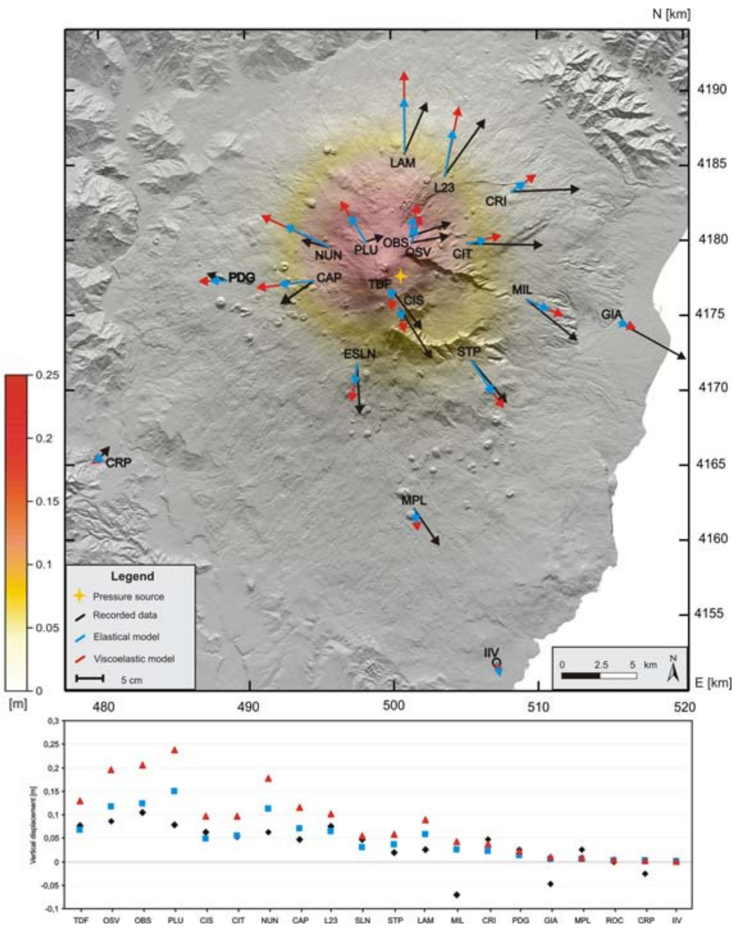

Figure – Comparison between the elastic and viscoelastic solution evaluated 3.5 years later the pressure change occurred.