European Seismological Commission
36th General Assembly
2-7 September 2018
Valletta - Malta
ESC2018-S21-213

UNDERSTANDING SEISMIC AND VOLCANIC PRECURSORS THROUGH SHEAR-WAVE SPLITTING: CURRENT KNOWLEDGE AND PROSPECTS

Kaviris George* (1), Papadimitriou Panayotis (2), Kapetanidis Vasilis (2), Voulgaris Nicholas (2), Spingos Ioannis (2), Millas Christos (1), Fountoulakis Ioannis (1), Karakonstantis Andreas (3), Makropoulos Kostantinos (3), Bozionelos Georgios (4), Lekkas Efthimis (2)

(1)Section Of Geophysics-Geothermics, Department Of Geology And Geoenvirionment, Panepistimiopolis 15784, (2)National And Kapodistrian University Of Athens, (3)Section of Geophysics-Geothermics, Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, (4)Department Of Geosciences, University Of Malta

* gkaviris@geol.uoa.gr

Shear-wave splitting (SWS) occurs when a S-wave enters an anisotropic medium and splits into two components, travelling with different velocities, the Sfast and Sslow. The time difference between the arrivals of the two is commonly referred to as time-delay or time lag td and has been utilized as a diagnostic tool of the stress regime in tectonic and volcanic areas. While stress builds up, fluid-filled microcracks in the upper crust are undergoing changes that affect td. Shortly before the event, the increase of stress stops and a significant drop occurs, due to microcracks coalescing to form the fault plane. These variations represent the stress accumulation and release in the medium.

A “stress-forecast” of an impending M=5.0 earthquake in Iceland was achieved by Crampin et al. (1999), approximately two weeks prior to its occurrence, by analyzing shear-wave splitting and observing the temporal variations of normalized (per the hypocentral distance) time-delays tn. Similar observations have been reported by various research teams since then, but always in hindsight. Concerning volcanic eruptions, an additional phenomenon of shear-wave splitting can be considered as a precursor, i.e. the 90° flip of the polarization direction before an event.

Shear-wave splitting as a robust tool for earthquake prediction is facing certain obstacles. The method is highly dependent on the occurrence of intense seismicity in the vicinity of the station, given that a significant number of recordings will be rejected due to selecting suitable data and, while feasible, manual shear-wave splitting analysis is time-consuming. Automatic methods have been widely applied but require even stricter selection criteria, which leads to even less usable results. In addition, SWS studies have observed significant scattering of time-delays, attributed to high pore-fluid pressure, which could contaminate data showing fluctuations of time-delays due to a stress cycle linked to an event. In Greece, such phenomena have been observed in both tectonic and volcanic environments. In the Western Gulf of Corinth, tn have been linked with the occurrence of significant (Mw > 3.5) earthquakes during the seismic swarm of 2013. In the island of Santorini, a period of increased volcanic activity during 2011 – 2012 was not accompanied by a significant volcanic event. No 90° flips of the polarization direction were derived from shear-wave splitting. Nevertheless, tn exhibited gradual increase and sudden drop, related to the major Mw = 5.1 and 5.2 events which took place about 40 km SW of Santorini.

Shear-wave splitting can be combined with other techniques that study precursor phenomena. Variations of VP/VS ratios and shear-wave velocity obtained from seismic interferometry can complement each other. In addition, development of robust and fast algorithms that can automatically perform shear-wave splitting analysis in big data is important for entrenching seismic anisotropy in the consciousness of researchers studying precursory phenomena. Shear-wave splitting cannot be currently implemented in operational forecasting, but increased interest on the topic can lead to clarifying the source of anisotropy and fully understanding the mechanisms behind stress cycles, rendering the method reliable.

References:

Crampin, S., Volti, T., & Stefánsson, R. (1999). A successfully stress-forecast earthquake. Geophys. J. Int., (138), F1–F5. doi: 10.1046/j.1365-246x.1999.00891.x