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Scientific abstract –

**Theoretical Study on Mechanics, Patterns, and Controls of Reservoir Induced Seismicity**

Fluids play an important role in all stages of the seismic cycle. Among other kinds of fluid-related anthropogenic seismicity, the seismicity associated with artificial reservoir impoundments is usually characterised by higher magnitudes. Basic processes related to reservoir stimulated seismicity (RSS) produced by water level fluctuations have been known for some time and are well documented in the scientific literature. RSS depends on a complex interaction of the water body with various tectonic, geological, and hydrological factors. Although high-resolution seismic and water level monitoring has often been performed in the field to explore RSS, it still has not provided a comprehensive understanding of the essential RSS mechanism. Moreover, RSS differences from the tectonic earthquake sequences from the same region and its controls also remain uncertain. This project seeks to: study RSS in the different faulting environments; to evaluate the importance of the areal strain rates in RSS; to identify the specific characteristics of RSS sequences and how they differ from the tectonic sequences from the same areas; and to define their controls, in terms of characteristics of water level fluctuations and reservoir size. The analysis will be performed with 3D poro-elasto-plastic numerical modelling extended by incorporating a rate-and-state dependent friction formulation enhanced by the effect of pore pressure, which are applicable to the earthquake simulations.

The hypothesis is that the foreshock–aftershock pattern of RSS identified in observations as corresponding to type II of Mogi’s model, its high b-value in the Guttenberg-Richter frequency–magnitude relation, and its other characteristics, may be connected to the presence and migration of fluids, where a heterogeneity in mechanical rock properties is enhanced by a heterogeneity in the fault transport properties. A weak aftershock–main shock magnitude dependence recorded in some observations could be the result of a gradual arrival of a fluid front and a gradual fault strength decrease, governed by a measure of the heterogeneity. In addition, it is anticipated that modelled RSS events will be more frequent in regions with a higher tectonic strain rate as affected by tectonic and RSS-induced stress accumulations on one hand, and by pore pressure induced local fault strength drop on the other. This paper’s suggested theory will also be applied to an initial analysis of recent seismicity (2013 and 2018 sequences) in the vicinity of Lake Kinneret, Israel, which differs from the earlier seismic patterns in the region connected to the dominant strike-slip motion at the Dead Sea fault.

The proposed investigation will enhance our understanding of an essential RSS mechanism, and of RSS characteristics and controls. This project should have particular significance for seismic hazard mitigation, for earthquake prediction, and for optimisation of the water level fluctuations in artificial reservoirs and lakes to prevent RSS triggering.