Application No.: 1485/21

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Scientific abstract

**Theoretical Study on the Mechanics, Patterns, and Factors Controlling 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 impoundment is usually of a higher magnitude. Basic processes related to reservoir-induced seismicity (RIS) produced by water level fluctuations have been known for some time and are well documented in the scientific literature. RIS depends on a complex interaction between the water body and various tectonic, geological and hydrological factors. Although high-resolution seismic and water level monitoring has often been performed in the field to explore RIS, this has not yet provided a comprehensive understanding of any mechanism essential to RIS. Moreover, differences in RIS arising from the tectonic earthquake sequences in the same region and their controls also seem uncertain. This project aims:to study RIS in different faulting environments; to evaluate the importance of areal strain rates in RIS; to identify the specific characteristics of RIS sequences and clarify how they differ from tectonic sequences covering the same areas; and to define the factors controlling them, in terms 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, to apply to earthquake simulations.

In this project, I hypothesize that characteristics of RIS, including its foreshock-aftershock pattern, which was identified in observations corresponding to type II of Mogi’s model, and its high b-value in the Gutenberg-Richter frequency-magnitude relationship, may be connected to the presence and migration of fluids. Here, a heterogeneity in mechanical rock properties is enhanced by a heterogeneity in fault transport properties. A weak aftershock-main shock magnitude dependence, as recorded in some observations, could stem from the gradual arrival of a fluid front and a gradual decrease in fault strength, governed by the degree of heterogeneity. In addition, it is anticipated that the modelled RIS events will be more frequent in regions with a higher tectonic strain rate, affected by tectonic and RIS-induced stress accumulations and by a pore pressure-induced drop in local fault strength. This hypothesis will also be applied to an initial analysis of recent seismicity (2013 and 2018 sequences) in the vicinity of Lake Kinneret, Israel. These sequences differ from the earlier seismic patterns in the region, which are connected to the dominant strike-slip motion at the Dead Sea fault.

The proposed investigation will enhance our understanding of an essential RIS mechanism, and of RIS characteristics and controls. This project has particular signficance for seismic hazard mitigation with respect to earthquake prediction, and for the optimization of water level fluctuations in artificial reservoirs and lakes to avoid triggering RIS.