Modeling of the Pohang Earthquake Probability Using the Seismogenic Index

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A strong earthquake of Mw5.5 occurred on 15 November 2017, shortly after finishing borehole fluid injections performed for the geothermal development of the Pohang Enhanced Geothermal System. With a high probability, the earthquake was triggered by these operations. In this work we consider the Pohang Earthquake in the frame of the Seismogenic Index Model. We attempt to estimate the triggering probability of this event as well as a general probability of triggering of arbitrary-magnitude earthquakes at the Pohang site before and after the termination of the fluid injections. A fluid injection in a point of an infinite continuum is taken here as a prototype of the Pohang situation.

The seismogenic index of the Pohang site is approximately between -2 and -1. During the injection operations, one can observe a tendency of the seismogenic index to increase with time. This was possibly an indication of a gradual involvement of seismically more active zones in the stimulated domain. Especially alarming was the event of Mw3.3 on April 15th of 2017. Probably, this event indicated a jump of the seismogenic index to -1. All injection operations in both boreholes should be stopped after this event.

Our estimate of the probability of the Pohang earthquake is approximately 15%. One of decisive factors for this relatively high probability was the low b value. A combination of a low b-value and a rather high seismogenic index made the probability of a hazardous event significant. A termination of all injection operations after the occurrence of the event of M_w3.3 would significantly reduce the probability of an M_w5.5 event down to approximately 3%. An injection termination at M_w2.3 would reduce it down to approximately 1%.

The Pohang earthquake has a clear character of a triggered event. A real-time well developed seismic observation system permitting a precise 3-D event location and a monitoring of the temporal evolution of the geometry of the stimulated volume and of the seismogenic index could potentially help to prevent or to delay the occurrence of such an earthquake.

This paper provides a simplified consideration based on analytical formulations for an effective homogeneous porous medium and monotonic injection operations. Numerical simulations of more realistic injection configurations, an analysis of modeling results along the indicated here directions, further enhanced processing and analysis of seismologic records are required for more
detailed understanding of processes led to the Pohang event.