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Science backgrounder, Geothermal energy and micro-earthquakes – 29/8/2012

Small earthquakes are reasonably common in geothermal energy developments worldwide. GNS Science seismologist Dr Steve Sherburn explains that some are naturally occurring and some are caused by human activity. But both types are generally harmless to people and property.

New Zealand is a seismically active country with about 15,000 earthquakes occurring each year and about 250 of these being felt by humans.

The volcanic and geothermal regions of New Zealand's central North Island are also seismically active. The vast majority of the small earthquakes in this area, commonly known as micro-earthquakes, occur naturally, but a small number are triggered by geothermal power production, a phenomenon known as 'induced seismicity'.

Induced seismicity can occur due to a number of causes including heavy engineering and construction works, filling large reservoirs for hydro-electric power generation, mining, oil and gas production, the underground disposal of waste water, and the reinjection of used geothermal fluids at or near geothermal fields.

Most induced micro-earthquakes are too small to be felt by people. However, some will be felt as a rumbling or vibration – similar to that of a heavy truck passing nearby – and others will be clearly detectable as a small earthquake. In New Zealand the filling of Lake Pukaki in 1978 triggered a 4.6 magnitude earthquake – the largest known example of induced seismicity in this country.

Some geothermal fields used for power generation experience micro-earthquake activity and others very little, if any. At some fields this activity is clearly caused by geothermal fluid

re injection, and at others the activity appears to occur naturally. Geothermal induced seismicity is reasonably common worldwide. The Geysers geothermal field in the United States, which is probably the most seismically active field in the world, experiences about 20 earthquakes a year with a magnitude of 3 or more, and 2 or 3 earthquakes a year with a magnitude of 4 or more.

Reinjection of used geothermal fluids back into the earth is industry standard practice for managing and reducing potential adverse environmental effects.

Micro-earthquakes in geothermal fields, including those triggered by power generation, are usually too small to pose a hazard to people and property, though some may be felt nearby.

Geothermal operating companies monitor micro-earthquakes as they can provide information for field management. In addition, the GNS Science-operated GeoNet project has a nationwide, real-time seismic monitoring network that can locate most micro-earthquakes in geothermal fields, either natural or induced, that are large enough to be felt.

Micro-earthquakes triggered by geothermal reinjection commonly occur at between 2km and 4km below the surface, the depth where the fluids are reinjected. At this depth, a micro-earthquake as small as magnitude 2 may be felt nearby, although usually only as a slight vibration.

The largest micro-earthquake in a developed field in New Zealand thought to be associated with geothermal reinjection has been magnitude 3.5, though most are smaller than magnitude 3.

Induced seismicity creating micro-earthquakes has been recorded at Rotokawa and Mokai geothermal fields, in the early stages of reinjection testing at Ngatamariki, and possibly also at Kawerau and part of Wairakei-Tauhara. Ohaaki and Ngawha geothermal fields are not thought to experience any induced seismicity.

Possibly the best understood example of geothermal induced seismicity in New Zealand is at the Rotokawa field, 15km north-east of Taupo. Here there has been an increase in micro-earthquakes in recent years coinciding with additional reinjection activities when a second geothermal power plant at the field came into production. Since 2000 there have been more than 70 micro earthquakes between magnitude 2 and 2.9 at Rotokawa, but only two of magnitude 3 or larger.

Although micro-earthquake activity at Rotokawa has been triggered by geothermal reinjection, the magnitude of the induced activity is similar to nearby naturally occurring

earthquakes and the effects have been minimal with little or no adverse impact on people or damage to property.

FRACKING NOT A FEATURE OF GEOTHERMAL ENERGY DEVELOPMENT

The topic of hydraulic fracturing and its relationship to the geothermal energy industry in New Zealand has recently been raised at public forums and in the media.

There are differences between the drilling and extraction techniques used in the oil and gas exploration industry and those used in the geothermal industry. In New Zealand a geothermal development will often drill to try to intersect a layer of permeable rocks that is naturally present in the underground reservoir. The New Zealand geothermal energy industry does not use the practice of hydraulic fracturing to create permeability.

Induced seismicity at Rotokawa and comparison to natural earthquake activity

This graphic shows all earthquakes in the GNS Science earthquake catalogue that occurred in the volcanic and geothermal regions of the central North Island between January 2000 and June 2012 and were less than 10km deep. The earthquakes shown in red are within 6km of Rotokawa geothermal field; those after 2008 are induced by geothermal power production. The Rotokawa micro-earthquakes are a small part of the overall seismic activity and are smaller than many of the naturally occurring earthquakes.

