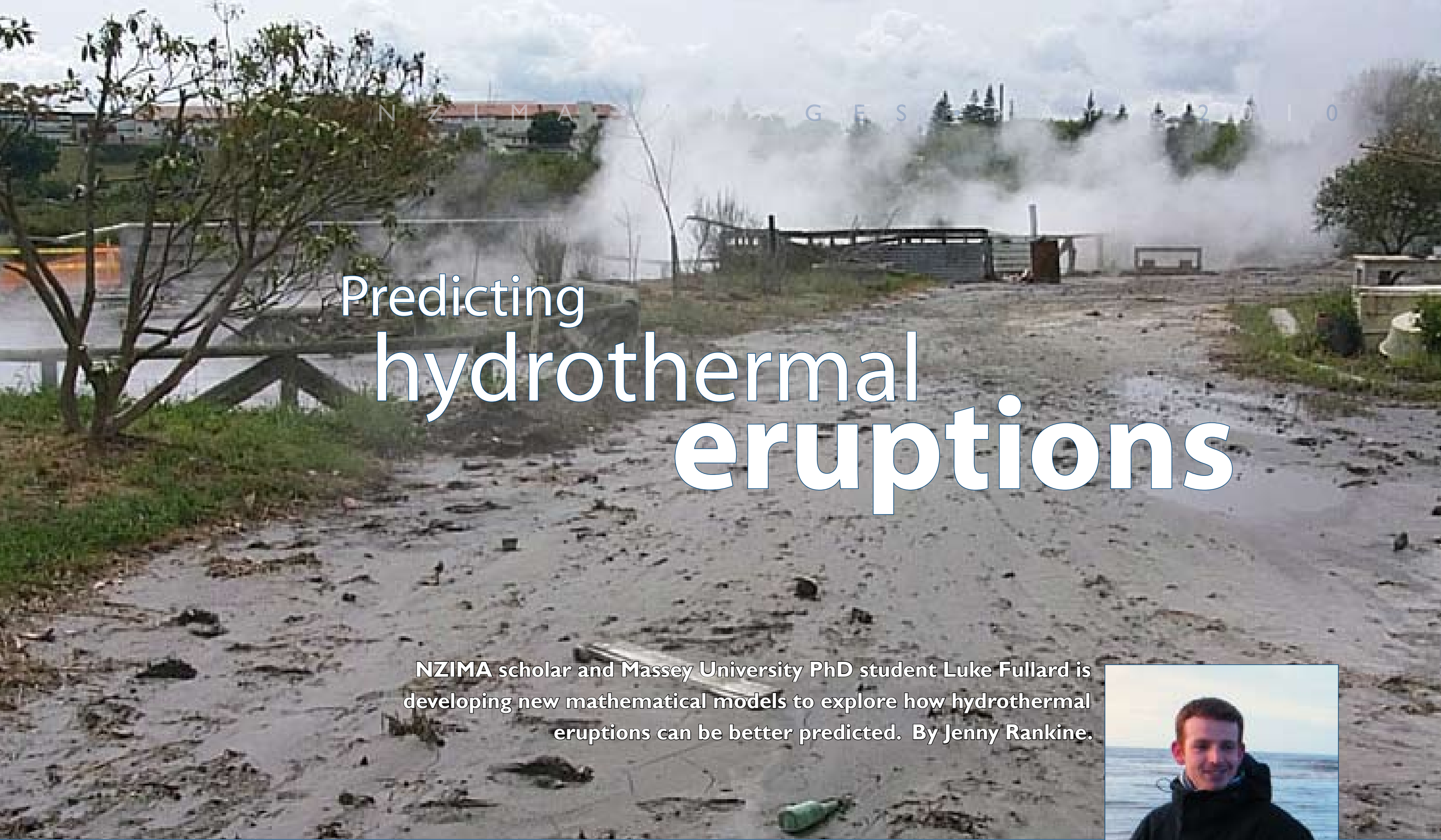

Predicting hydrothermal eruptions

NZIMA scholar and Massey University PhD student Luke Fullard is developing new mathematical models to explore how hydrothermal eruptions can be better predicted. By Jenny Rankine.

The result of a hydrothermal eruption in Rotorua. Photo courtesy GeoNet, www.geonet.org.nz/

Rotorua residents may be familiar with hydrothermal eruptions, as they happen reasonably regularly in the Taupo volcanic zone. These eruptions have occurred in Kuirau Park for more than 100 years, and caused many of its craters. The eruption in 2001 was big enough to shower mud and hot water over the roof of nearby Rotorua Hospital.

Unlike geysers, hydrothermal eruptions occur with little or no warning. They can throw large amounts of water, steam and mud high into the atmosphere, suddenly and fast. They are believed to be triggered by a catastrophic drop in the pressure of geothermal water close to the earth's surface, causing it to boil, lift the ground and form an eruption jet.

Luke Fullard's honours year project developed existing partial differential equations of underground fluid flow for these eruptions from a single vertical dimension to two dimensions.

For his PhD he is focussing on how these eruptions are initiated, and uniting previously separate eruption models for geothermal fluid underground and ejected material above.

"I am using a 'shock-tube' model to see what happens when the high-pressure water is exposed to the lower pressure atmosphere."

"Numerical schemes used to solve these equations used finite difference methods, but they don't work when you have discontinuous data. Usually you have a smooth pressure curve, but we had a big jump in pressure. So we used finite volume methods, which can deal with discontinuities."

Fullard developed a finite volume method for three-phase flows to take account of the actions of water, steam and air in a fractured porous medium.

Each step using the finite volume solver had to tack gravity on at the end. In the steady state case, the two almost exactly cancelled each other but with a slight error, "which is a problem if you're simulating over a long time".

He modified the three middle wave speeds out of the nine speeds in these equations to exactly cancel gravity out to zero. Now he is able to code his data into the maths computer program Matlab.

He will also explore the effect of water in surrounding fields on the eruption, by playing with a "toy problem of pumping water out of a well". He hopes to figure out what initial conditions make these eruptions more likely.

"For example, is there an increased risk if the porosity of the rocks is higher than x, or when a body of water is a certain distance from the surface?"

Fullard's supervisor Tammy Lynch built the first laboratory model of a hydrothermal eruption and used nuclear magnetic resonance techniques to visualise the progression of a boiling front in a porous medium.

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