Quaking in Wellington

Chris Rowan explains how ancient magnets can help predict earthquakes in New Zealand.

Most earthquakes occur at the boundaries of tectonic plates. Off the east coast of the North Island, New Zealand, a large undersea trench marks where the Pacific plate is being pushed underneath the Australian plate – a subduction zone, just like the one near Indonesia that was responsible for the Boxing Day tsunami. Although many of the earthquakes here are confined to the trench, about half of the overall motion at the boundary is accommodated by a complex network of faults on the island itself, including one that runs through the capital, Wellington. But which faults are most likely to move?

We can accurately measure how fast the plates are moving relative to each other at plate boundaries, and this tells us how much energy is being stored up as the plates grind against each other – energy that must eventually be released in earthquakes. Nonetheless, predicting the location and size of an individual quake is extremely difficult. Sometimes plate boundaries are well defined, with all motion occurring on one or two very large faults. But, as in New Zealand, boundaries are often broad zones, tens or even hundreds of kilometres wide, containing a large number of smaller faults. In these cases, we need to find out which faults are taking up the strain. Where deformation is spread over a large number of faults, frequent small earthquakes are likely. If deformation is restricted to a few faults, less frequent, but larger and more destructive earthquakes can occur. Understanding the past is the key to predicting the future: the faults most at risk are those which have moved the most in the last few millions of years. We can identify these by looking at how the alignment of magnetic particles in rocks has changed over the millennia.

Our trusty drill, adapted from a chainsaw and still just as noisy, in action. Cooling water must be pumped through the diamond-tipped bit to prevent it overheating.

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Under the bemused gaze of tourists, dog walkers and farmers, my colleagues and I drilled hundreds of core samples from fine-grained sedimentary rocks, particularly mudstones, all along the east coast. These rocks contain magnetic minerals that, as they are being deposited, act like miniature compasses and align with magnetic north. As the rocks solidify, the particles become trapped in this alignment.

A typical core. The marks tell us the original orientation of our samples, vital if we want to tell the direction the magnets within were actually pointing.

But the magnetic particles in our samples from the North Island do not point north. Instead, over a region 400km long and 100km wide, they point east. The originally north-facing coastal region has rotated 90° clockwise in the last 20 million years, spinning the rocks, and their tiny magnets, with it. The movement is caused by the Australian plate riding over the Pacific plate much faster in the north of New Zealand than in the south, forcing a rotation hinged about the slower-moving southern region. Geologists have noticed similar rotations in California, Greece, and other plate boundary zones.

Because the magnetic minerals are out of alignment by the same amount across such a large area, we know the whole region is moving as a single rigid block, with most movement on a few large faults at its edges. So earthquakes are likely to be bigger, but once we've accurately mapped out the boundaries of this block, we'll have a much better idea of where they're going to happen.

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