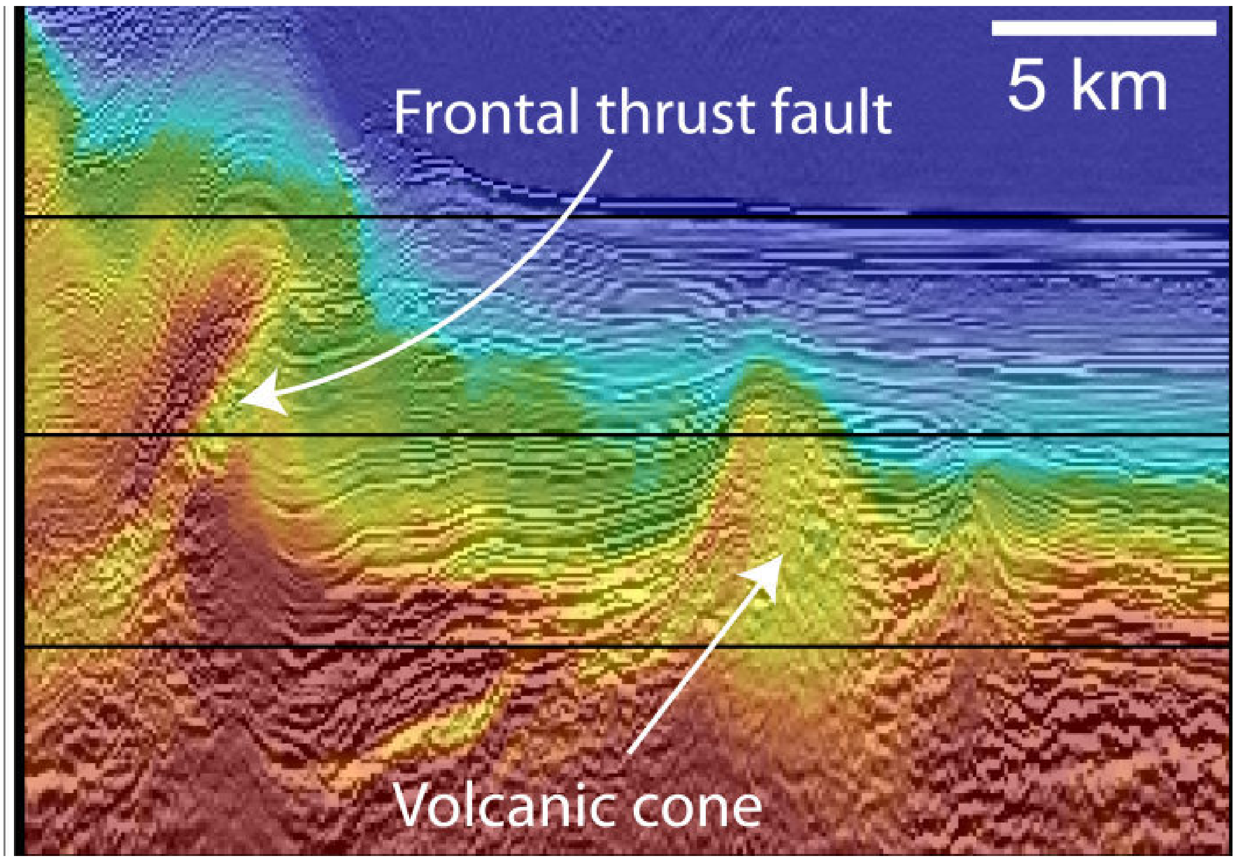
'Treasure trove' of quake clues could be unearthed by wavy new technique

September 24 2019, by Caroline Brogan



Credit: Imperial College London

Geologists have improved upon methods to map seabed rocks, helping us better understand underwater earthquakes and the tsunamis they can cause.

Their technique combines traditional 'acoustic mapping' with a newer method called 'full waveform inversion'. They found their new method enhanced their view of rocks along a fault line—a break in the Earth's crust—off the east coast of New Zealand's North Island.

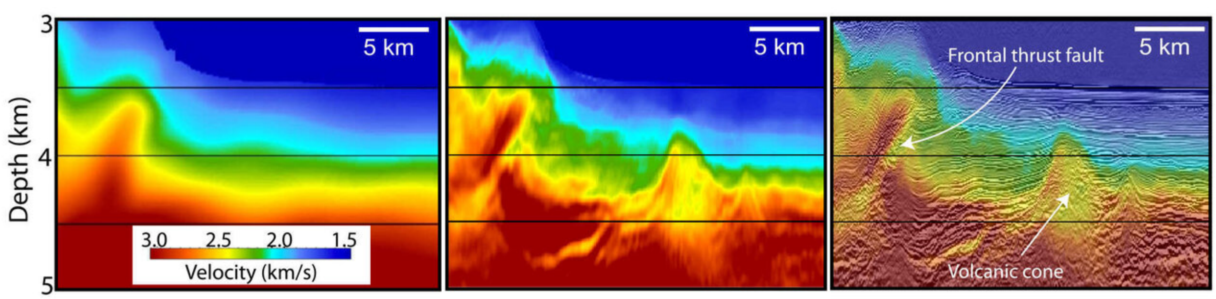
The researchers hope that their clearer view of the rocks around these fault lines—whose movements can trigger earthquakes and subsequent tsunamis—will help them better understand why such events happen.

Lead author Melissa Gray, from Imperial College London's Department of Earth Science and Engineering, said: "We can now scan underwater rocks to see their properties in greater detail. Hopefully this will help us to better work out how earthquakes and tsunamis happen."

"Treasure Trove"

Just off the North Island coast of New Zealand, the edge of the Pacific tectonic plate ducks underneath the edge of the Australian plate—an area known as the Hikurangi subduction zone.

Subduction refers to when two plates move against each other, building pressure that eventually triggers one plate suddenly 'slipping' beneath the other. This sudden slipping can cause earthquakes, which in turn trigger tsunamis if they happen underwater.



Ultrasound images of the subduction zone, before (L) and after (middle & R) 2D waveform inversion was used. Credit: Imperial College London

However, subduction can also cause silent quakes known as 'slow slip' events, which release the same amount of energy as a typical earthquake, but over a much longer amount of time.

Slow slip events often go unnoticed and cause no damage, but the authors of this new report say studying them could constitute a "treasure trove" of information. Melissa said: "Our new way of studying slow slip events could unveil a treasure trove of clues about how larger, more devastating quakes happen."

Ultrasound images of the subduction zone, before (L) and after (middle & R) 2-D waveform inversion was used. The 'after' photos show the zone in much finer, higher resolution detail.

Quake quandary

Current rock mapping techniques use sound waves to build pictures of what rocks look like many kilometres below ground, as well as revealing how porous and hard they are and how much fluid and gas they are likely to contain. This information helps scientists assess how rocks might behave when stress builds up, and how much shaking there would be in an earthquake.

Now Melissa, together with Imperial's Dr. Rebecca Bell and Professor Joanna Morgan, have plugged current sound wave information into an imaging technique called full waveform inversion.

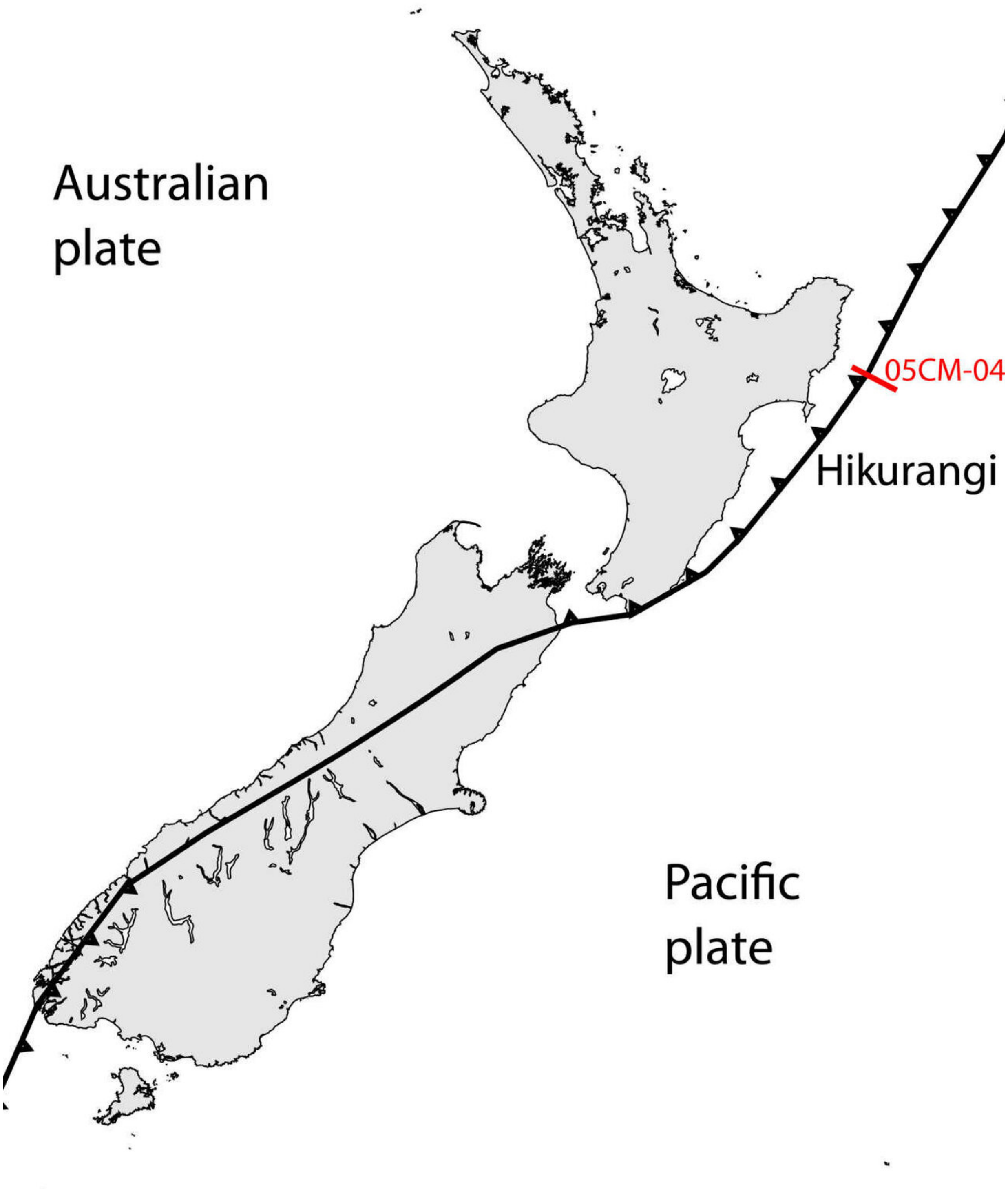


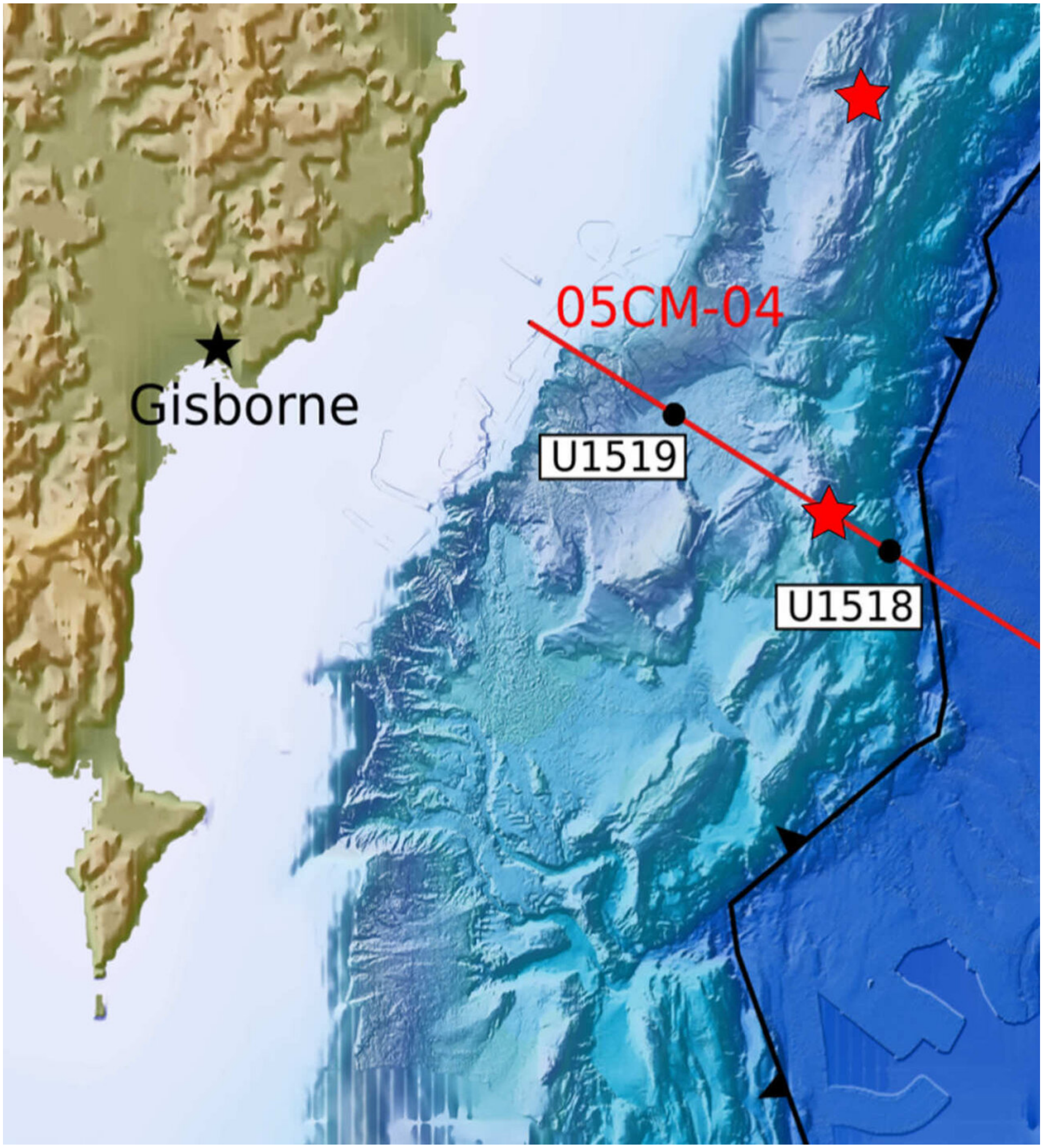
Plate boundary under New Zealand, showing the Hikurangi subduction zone near the North Island. Credit: Imperial College London

This method helped them paint a picture of the Hikurangi fault zone in unprecedented detail (fig.1). They also captured the shallow faults which were responsible for the large Gisborne tsunami in 1947 (fig. 3) - an example of a large tsunami caused by a relatively small slow slip earthquake.

The method builds on the concept of 'acoustic mapping', where sound waves are sent from a boat on the ocean surface down to the seabed and kilometres into the Earth's crust. The amount of time taken for the waves to bounce off different rock layers and back up to the boat—as recorded by underwater microphones being towed behind the boat—tells scientists the distance to the seabed and rock layers, as well as the likely composition of the rocks.

The researchers combined data from acoustic mapping with the full waveform inversion technique. This converted the sound waves into higher resolution, more intricately detailed maps of the seabed and rock beneath.

To check their data were accurate, the authors compared their models of the rock properties mapped by inversion with samples collected from drilling by the International Ocean Discovery Program. They found that the models and real data matched, indicating the technique is accurate and reliable, and can provide more information than current drilling methods.



Locations of Gisborne city on the North Island, the sites of the tsunami-triggering 1947 earthquakes (red stars), and the Hikurangi subduction zone (black line). Credit: Imperial College London

The researchers say this combination of techniques could help governments to produce more accurate hazard maps for earthquakes and tsunamis.

Study co-author Dr. Bell said: "We can use this to study earthquake and tsunami-prone areas around New Zealand and the rest of the world."

Next, they will work to map the very point at which two edges of tectonic plates touch down to depths of 10-15 kilometres.

Dr. Bell added: "Although nobody's seen fault lines like this at such scale before, we still don't know the properties of the Hikurangi plate boundary at the depth where slow slips occur.

"Ultimately, we want to understand why some slips cause devastating earthquakes, while others do not."

More information: Melissa Gray et al, Imaging the Shallow Subsurface Structure of the North Hikurangi Subduction Zone, New Zealand, Using 2-D Full-Waveform Inversion, *Journal of Geophysical Research: Solid Earth* (2019). DOI: 10.1029/2019JB017793

Provided by Imperial College London