Illuminating Alpine Fault Earthquake Risks and Revealing Geothermal Resources

A collaboration with Victoria University of Wellington geophysicists is revealing information to help us understand and prepare for future earthquakes. The team have also discovered a reservoir of geothermal heat beneath the South Island's West Coast, a result published last year in the world's top scientific journal *Nature*. By sending ultra-short laser pulses down an optical fibre inserted into New Zealand's Alpine Fault, the team are revealing information that informs earthquake models and warning systems. This innovative use of laser technology resulted from a collaboration made possible by CoRE funding.

The project, which received Marsden funding last year, combines the laser and optics expertise of DWC science team leader, Neil Broderick and DWC Principal Investigator Kasper Van Wijk from The University of Auckland with the geological expertise of Victoria University of Wellington Professors John Townend and Rupert Sutherland.

The story began in 2014 when a multi-national team of about 200 scientists, led by John and Rupert, congregated in Whataroa, a small town on the South Island's West Coast. Their mission was to drill hole a kilometre down to the Alpine Fault, to collect samples and measurements and set up a long term observatory inside the fault zone. The project has the

The Alpine Fault in the South Island of New Zealand seen here as a diagonal line on the land surface from near Franz Josef in the south *(left, front)* to Blenheim in the north *(middle, top)*. Dodd-Walls Centre Deputy Director, Neil Broderick, has been using laser light to measure temperature and fault dynamics at depth inside the fault. *Photo credit: used with permission from NASA-Johnson Space Center, Image Science and Analysis Group, photo taken from the International Space Station.*

attention of the international community because it fills a knowledge gap in understanding the conditions at a fault in the late stages of its cycle when a large earthquake is due. This drilling project provides a unique point of observation as the pressure builds.

“One of the really nice things they left behind in the hole,” said Neil, “was an optical fibre cable.”

Rupert and John contacted the Dodd Walls Centre to find out how to make the most of this fibre and Neil jumped at the opportunity. Neil is an expert at understanding how laser light travels through optical fibres, in particular when pressure or tension in the fibre forces the laser light to stop following the usual rules of physics and when non-linear effects emerge. In these cases, which are predominant in the intense conditions in the alpine fault, more complex theory is required and Neil and his students are the perfect people to understand what’s happening.

Kasper has a foot in both camps. He understands both optics and geophysics. He is an expert on rocks and vibrational modes of the Earth so he can help analyse the data. Rupert and John are involved in analysing the data and connecting it to the geology.

The team uses fibre laser technology developed in their Auckland labs. These lightweight and portable lasers deliver ultra-short pulses of intense laser light that travel down the fibre and reflect back at points of pressure or tension. By analysing the reflected light the team can deduce pressure, vibrations and temperature all the way down the fibre.

“The results are amazing,” Neil says. “ In most parts of the Earth the temperature gets about five degrees hotter every hundred meters. Our results show around ten times that. We think this is because it is a large, deep and very young fault. As the mountains are being pushed up, they generate heat and they are still cooling down from that.”

Discovering these unexpected resources of geothermal energy under the West Coast could be significant for the local economy and tourism industry as they could be used in thermal pools and attractions.

The project is a win-win for everyone concerned. Neil and Kasper are gaining an incredible insight into a new field. Rupert, John and the international geological community are getting invaluable data to inform their understanding of earthquakes.

The techniques being developed have potential future use for monitoring the structural stability of roads and buildings.

If it wasn’t for the collaborative culture of the Dodd-Walls Centre the project could not have got off the ground.

To begin with, the publicity of having a Centre of Research Excellence helped alert Rupert and John to the expertise available.

“People know that if you want something done with light, you come to the Dodd-Walls Centre,” Neil pointed out. ”So it grew out of that really. It’s a beacon.”

Once the match had been made, the team spent a year doing research and getting preliminary data before they were awarded Marsden Funding. Without the support of the CoRE it would have been impossible to bridge this gap from a good idea to an internationally recognised Marsden funded project.

The team is now delivering compelling results as well as training students with ideal skills for New Zealand’s high tech industry. A Ph.D. student recently began work and a student who recently completed a masters degree on the project has been snapped up by local company Coherent Solutions who specialise in test and measurement equipment for optical communications.

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May 2018