

can't — this is a major step forward", he says.

The first challenge will be to transform a commercially available superconductor into a large, high-performance electromagnet, which could take around three years, says Martin Greenwald, deputy director of MIT's Plasma Science and Fusion Center. Within the next decade, the team hopes to develop a prototype reactor that can generate more energy

than it consumes. Then, they hope to develop a 200-megawatt pilot power plant that can export electricity to the grid.

Stewart Prager, former director of the Princeton Plasma Physics Laboratory in New Jersey, says it's good news that the MIT proposal is attracting private capital. But he warns that private investment won't be enough to make up for stagnant budgets in the US fusion

programme. "This funding for MIT is terrific, but there's just no way you are going to get the private sector to take on the full brunt of the fusion programme," Prager says.

For their part, MIT researchers hope that their work will generate more government interest in fusion research. "If we can change that narrative, we can potentially reinvigorate the rest of the programme," Greenwald says. ■

## SEISMOLOGY

# Drillers probe risk of big quakes in New Zealand

*A major expedition is investigating the enigmatic sea-floor fault zone.*

BY ALEXANDRA WITZE

**A**n international team of geoscientists has launched a fully fledged onslaught to understand New Zealand's biggest earthquake and tsunami hazard.

On 11 March, the *JOIDES Resolution* drill ship began a two-month expedition to bore deep into the Hikurangi subduction zone off the east coast of New Zealand's North Island. There, the Pacific plate of Earth's crust dives, or subducts, beneath the Australian plate. The grinding of these geological titans has the potential to unleash a magnitude-9 earthquake and accompanying tsunami.

The drilling effort is part of a broader project to better understand the danger of the Hikurangi. "It's a major earthquake and tsunami hazard to the largest population centres, and it's not very well understood," says Laura Wallace, a geophysicist at the GNS Science research institute in Lower Hutt, New Zealand, and co-chief scientist on the upcoming cruise. The expedition will also give researchers the chance to probe the fault's role in a type of enigmatic slow-motion earthquake.

Whatever the scientists find will help to inform their understanding of seismic processes in other parts of the world with similar geologic settings, says Susan Schwartz, a geophysicist at the University of California, Santa Cruz.

Work kicked off in October, when researchers sprinkled nearly 300 seismometers in a dense array near the town of Gisborne on the North Island. Around the same time, two research vessels — the US *Marcus Langseth* and New Zealand's *Tangaroa* — deployed seismometers on the sea floor and blasted sound waves into the ocean crust to study its structure. Then, in December, the *JOIDES*



The Kaikoura earthquake in 2016 caused extensive damage on New Zealand's South Island.

*Resolution* did some initial drilling at three sites off the coast near Gisborne, to prepare for the bigger expedition that kicked off this week.

## ANATOMY OF A DANGER ZONE

Together, the studies aim to build a detailed picture of the guts of the subduction zone. It is perhaps the largest geophysical-research effort in New Zealand's history, says Stuart Henrys, a geophysicist at GNS Science who led the deployment of the land seismometers. The governments of New Zealand, the United States, the United Kingdom and Japan are helping to fund research on the fault over five years.

One thrust of the work is to determine whether, and how often, the Hikurangi might

rupture in quakes as large as magnitude 8 or 9. A section of the fault offshore near Wellington is geologically locked and does not move, whereas a more northern part, near Gisborne, moves slowly. The seismic studies should help to illuminate the behaviour of rocks on either side of the fault and how that influences earthquake risk in both regions, Henrys says.

Another big question is the role of 'slow-slip' events akin to slow-motion earthquakes, in which the action unfolds over weeks or months, rather than seconds or minutes. Geologists aren't sure how slow-slip events influence the risk of larger quakes along a fault, but the Hikurangi is a natural laboratory for exploring that, Wallace says. Researchers ▶

► can access it relatively easily because, offshore of Gisborne, the subduction zone experiences the shallowest slow slip in the world, just a few kilometres below the sea floor.

#### DRILLING FOR ANSWERS

The Hikurangi usually sees slow-slip events once every year or two — including an episode triggered in November 2016 by the magnitude-7.8 Kaikoura quake on the South Island (L. M. Wallace *et al.* *Nature Geosci.* **10**, 765–770; 2017). “It basically lit up the subduction zone in slow slip,” says Wallace. What scientists learn about slow slip at the Hikurangi could

help them to better understand earthquakes in other slow-slip regions, including those off the coasts of Costa Rica, Mexico and Japan.

The *JOIDES Resolution* expedition aims to drill three holes into the area where the Pacific and Australian plates collide. This is likely to reveal what types of rock lie on either side of the Hikurangi fault, information that would enable researchers to better understand the physical properties of the place where earthquakes are generated.

One target is a thick layer of sediments covering the deep-diving Pacific crust. “Getting our hands on those sediments before they are

subducted will give us important insights into the frictional properties of rocks in the slow-slip zone,” Wallace says. Drillers will need to penetrate to 1.5 kilometres beneath the sea floor for scientists to truly understand this subducting crust and its role in Hikurangi quakes, says Nathan Bangs, a geophysicist at the University of Texas at Austin who led the *Langseth* cruises.

The drill team will install long-term observatories in two of the boreholes, roughly 400 metres beneath the sea floor, to monitor how pressure and temperature change during slow-slip events. ■

#### EVENTS

# Backlash in Brazil against police probe of marijuana researcher

*Investigation of a scientist in São Paulo sparks fear of restrictions to academic freedom.*

BY CLAUDIO ANGELO

A police investigation targeting Brazil’s most prominent marijuana researcher has ignited a wave of protest among scientists. They say that the move by authorities from the state of São Paulo threatens research freedoms at a time when science in the country faces severe problems because of draconian budget cuts.

Police questioned Elisaldo Carlini, a retired professor of psychopharmacology at the Federal University of São Paulo (Unifesp), on 21 February on suspicion of inciting drug crime, according to authorities. They are still investigating the case and have not charged Carlini.

According to documents from Rosemary Porcelli da Silva, the public prosecutor in São Paulo state who requested opening the case against Carlini, she saw “in theory, strong hints of incitement” in a marijuana symposium that he had organized in May last year. One of the proposed guest speakers was the head of the Rastafari church in Brazil, who is still serving prison time under drug trafficking charges and did not participate in the symposium. Marijuana use, production and sale are illegal in Brazil. Da Silva declined to comment on the inquiry.

#### A PIONEER

Carlini, 87, is one of the pioneers of medical-marijuana research. He has investigated the drug since the 1950s, and has published several seminal papers on the anticonvulsive properties of cannabinoids. “Carlini

is an outstanding scientist,” says Raphael Mechoulam, a researcher at the Hebrew University of Jerusalem in Israel whose laboratory first isolated marijuana’s hallucinogenic compound, THC, in 1964.

“Nearly 40 years ago, his group and my group did the first clinical experiment with cannabidiol, a major cannabis compound, on epileptic patients,” Mechoulam says. A treatment that resulted from that work is used by people with epilepsy today.

“In more than 60 years of an academic career, I had never been questioned by law agents — until last month,” says Carlini. He says that last year’s meeting was scientific in nature and had nothing to do with inciting people to take drugs. “It’s a Kafkaian situation. I wonder what they think an old man can do with marijuana.”

On 1 March, researchers, students and staff at Unifesp gathered on campus to express their support for Carlini and to protest against what they perceived to be an attack on the university. As of 12 March, more than 50 scientific societies had signed a petition supporting the scientist. Another petition in defence of Carlini, organized by the Brazilian Society for the Advancement of Science (SBPC) and addressed to the São Paulo state authorities, had more than 34,000 signatures as of 12 March. Among the supporters is

former Brazilian president Fernando Henrique Cardoso, who called the inquiry into Carlini “an unacceptable coercion”.

#### ACADEMIC FREEDOM

SBPC president Ildeu Moreira says that the episode is a step backwards for academic freedom in Brazil, at a time when science there faces drastic funding declines.

Although it is not illegal to study cannabis in Brazil, current legislation makes it difficult. Research institutions cannot cultivate marijuana, and scientists must apply for a special government permit for any experiments with the drug or its components, which can delay their work. Brazil’s food and drug regulatory agency, Anvisa, is examining whether to authorize marijuana’s cultivation for research purposes.

Scientists say that they hope the Carlini case will highlight the difficulty that researchers in Brazil face when studying the medical uses of cannabis. Renato Filev, a neuroscientist at Unifesp, is trying to study whether cannabis can help people with alcoholism, and his animal experiments have shown encouraging results, he says. But clinical trials have been delayed because of the difficulties of getting a permit to bring the drug in from the Netherlands. Universities and ethics committees are afraid of the possibility of controversy or a police investigation, he says.

“I have fought for decades to show that marijuana is a serious plant,” says Carlini. “Dozens of countries have already regulated medical marijuana. The current legislation is a shame to Brazilian science and to Brazil.” ■

**“In more than 60 years of an academic career, I had never been questioned by law agents — until last month.”**