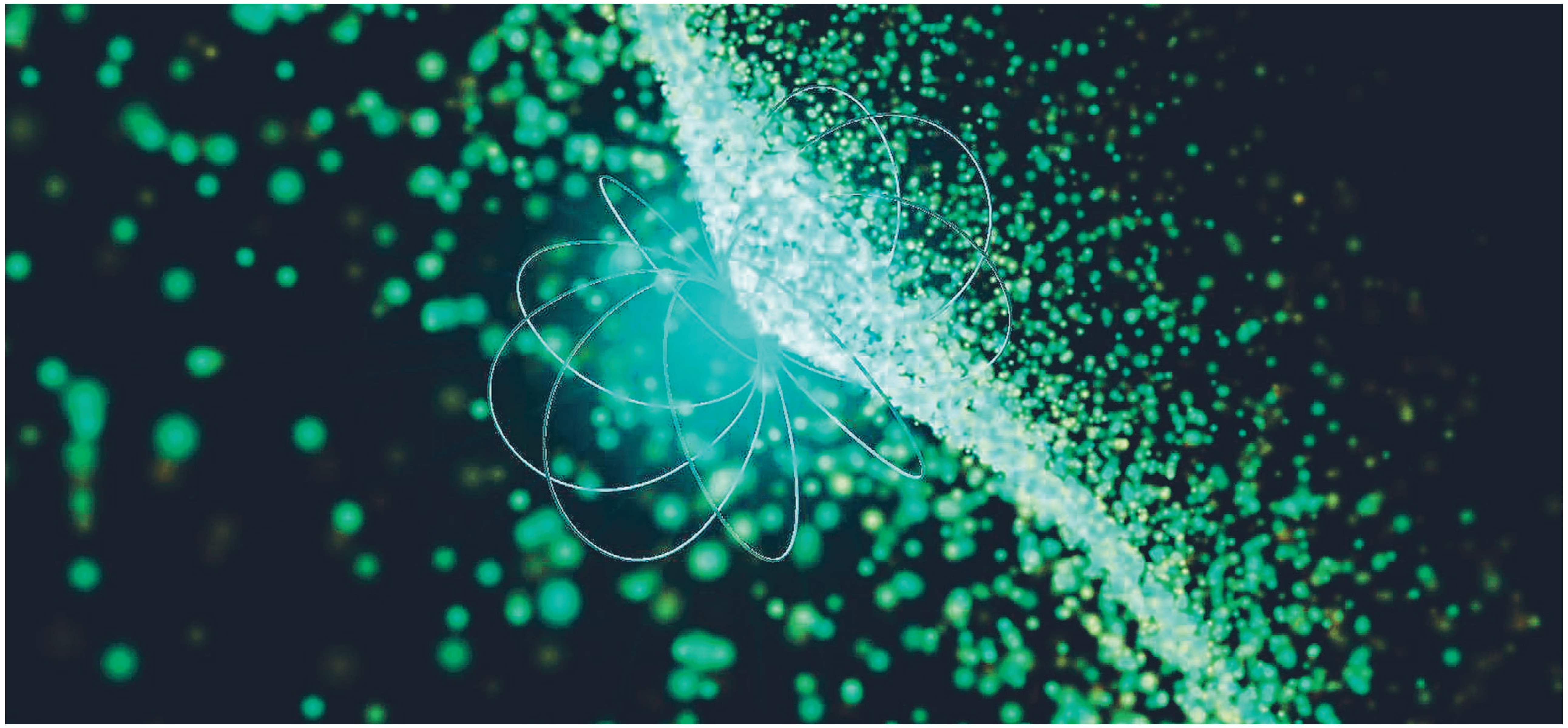
# Monsters of the sky

Studying dead stars can help us understand life on Earth, **Nyssa Skilton** writes



A dead star spins around its own axis deep in space. It has shrunk over millions of years of evolution as gravity sucked the star in on itself. The remnant is a dense ball with a radius of just 10km and weighing more than the sun. It's like a sugar cube that weighs the same as a mountain.

The dead star, called a magnetar, is a highly magnetised star, producing a magnetic field 1000 trillion times larger than that of the Earth. The magnetic field slows the star's rotation, straining its outer crust until it cracks and vibrates with seismic waves. A giant flash of energy escapes and spreads across galaxies. Australian National University theoretical astrophysicist Lilia Ferrario is working to unravel the mysteries behind these great magnetars, or ''monsters of the sky''.

''There are only about a dozen of these objects that are known in the galaxy,'' Ferrario says. ''I study where they come from, where the magnetic fields come from and what kind of star you have to have to die and give birth to this kind of monster.''

Ferrario, using mathematical simulations, is slowly building knowledge on how such phenomena exist.

People first became aware of the existence of magnetars in 1979 after one of the stars let out a flash from a galaxy orbiting our own, called the Large Magellanic Cloud. The flash, comprising extremely energetic pulses of light called soft gamma rays, swamped several spacecraft circling the Earth. Some of these crafts were satellites patrolling the skies to police an international treaty that banned nuclear tests in space.

Ferrario says the burst created some panic, particularly among United States Defence personnel.

''All of a sudden this radiation came from nowhere and zapped all these spacecraft,'' she says.

''All the detectors on all the spacecraft, they all went right off the scale. They basically shut down and turned away from the source of radiation and they survived, only just, but they survived. It was so intense that it affected the outer atmosphere of the Earth as well and disrupted radio communications worldwide.''

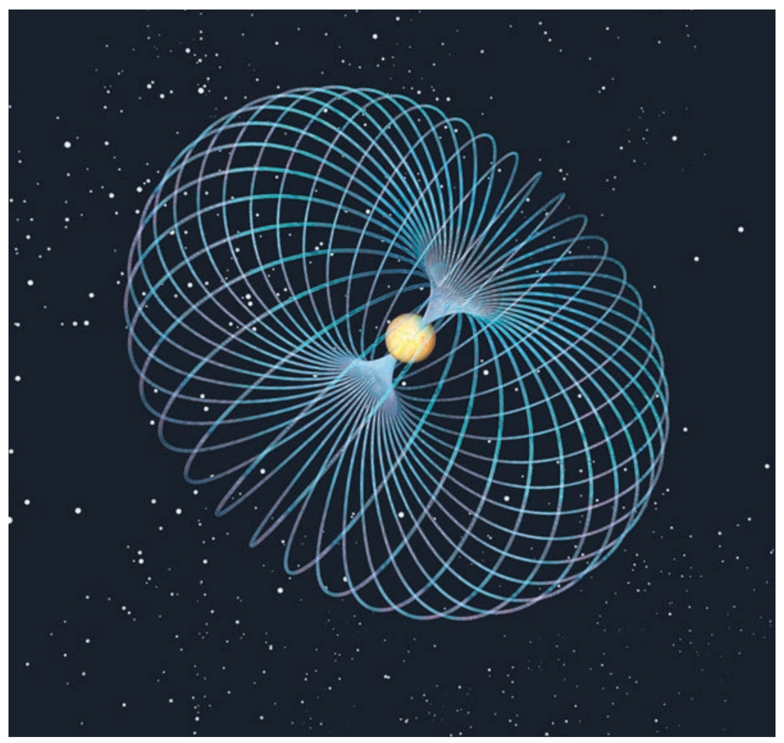
The burst was just one-fifth of a second long, but contained as much energy as the sun releases in 1000 years. Weaker pulses in clear eight-second intervals followed the original burst for 200 seconds.

Astronomers discovered much later that this period of eight seconds was the period of rotation of the neutron star that caused the flash. ''All that happened is we had a star quake from an object which in radius is only 10 km and is located 1700 quadrillion kilometres away from us,'' Ferrario says. ''So imagine if it had been a bit closer.''

A dead star is one that has run out of the nuclear fuel which feeds its survival. But if the star has a mass up to eight times greater than the mass of our sun, the gravity will be so strong that the star collapses in on itself, forming a tightly packed ''white dwarf''.

Stars of even greater mass, between eight and 25 times that of the sun, are subject to even stronger forces of gravity and these form neutron stars. Any larger, and what's left after the star's death is a black hole, a region of space where the gravitational force is so strong that nothing can escape from it. Ferrario is particularly interested in these stellar remnants and has been studying them for about 20 years. She studied at the University of Bologna in Italy before travelling to Australia to complete her PhD at the ANU. Now the sky is her laboratory.

Ferrario says what she and other scientists learn in space can help to build understanding about the



physical nature of what surrounds us here on Earth.

''Everything we see in the sky, in stars, and particularly objects like white dwarfs, neutron stars and black holes, is not something that we can study on Earth. The state of matter is beyond anything that you can create in a terrestrial lab,'' she says. ''They should help us to make advances in physics that otherwise wouldn't be possible.''

On Earth, physicists can create magnetic fields with strengths of about 10 million gauss. A magnetar is characterised by a magnetic field as high as 1000 trillion gauss.

Physicists create such fields using a magnet, surrounded by explosives in a mine. They detonate the explosives, which compress the magnetic field and intensify its strength for a small fraction of a second. Laboratories around the world carry out this experiment, including the US Los Alamos laboratory in New Mexico and a nuclear weapons laboratory in Sarov, Russia.

Ferrario says the only way to test theories on much stronger magnetic fields is to study what exists in space. ''Physicists knew about atomic transition in very strong magnetic fields, but then it is only astrophysicists like myself who have been able to test their theory against observations and guide in a sense the physicists to understand what's going on.

''So the humble white dwarf, those objects high up in the sky, told us that everything was correct. We tested physics against what nature is showing us in the sky.''

The work may one day help to master nuclear fusion, but there is still a world of questions to answer. For one, where do these extraordinary magnetic fields come from? Ferrario has confirmed the types of stars that give birth to magnetars in their deaths are giant stars up to 40 times the mass of our sun. The gravity from such a star should have engulfed it to form a black hole, but for some unknown reason it didn't.

So Ferrario compared the magnetars to other giant ultra-magnetic stars in our galaxy.

She found their magnetic fields appear to be present throughout the stars' lives.

When the stars collapse, and become neutron stars, their magnetic field is compressed and enhanced. The result is the formation of a neutron star with a particularly strong magnetic field. Ferrario says these magnetars, with their monstrous fields and violent flaring events, may shed light on other violent phenomena in the universe such as the mysterious gamma-ray bursts. One day scientists may be able to use them as standard candles to investigate the expansion and death of our universe.

In several billion years, the Earth's own star, the sun, will begin to die. The nuclear fuel it feeds on will run out and gravity will take over. In its dying convulsions, the sun will engulf the Earth, but they will be too small to leave a significant mark in the sky. ''I've always dreamt about unravelling the mysteries of stars and the universe,'' Ferrario says. I just want to know what happens out there and where the universe is heading – how it's going to die, how it was born, what is up there and how things work. I just want to know, I've always wanted to know.''

## CSIRO SCIENCE CLUB

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**1.** What are we? We capture light, and yet we don't. We reflect the rays of the sun, and yet we don't. Without us the world is grey and dull.
**2.** Each of the planets have at least one Moon, except for which two?
**3.** How many satellites have been destroyed by a meteor?
**4.** Which planet boasts the largest known volcano in our solar system?
**5.** What does DEWHA, the acronym for an Australian Government department, stand for?

**Answers**

**1.** Colours. **2.** Venus and Mercury. **3.** One, the European Space Agency's Olympus in 1993. **4.** Mars (the volcano is called Olympus Mons). **5.** Department of the Environment, Water, Heritage and the Arts.

Left: A magnetar spraying energy during a star quake. To see a rotating flaring magnetar, visit: www.rkm.com.au/Interactive/GAMES/magnetar.html

Far left: This artist's impression represents a magnetar in a quiescent state. When these neutron stars are in a quiescent state they still emit high energy radiation, but nothing anywhere near as violent as what happens during their star quakes. The wires emanating from the star are the stellar magnetic field lines which form the so-called "magnetosphere" (the shape of a magnetosphere looks a bit like a doughnut).

Illustrations: Russell Kightley Media www.rkm.com.au

Inset: Australian National University theoretical astrophysicist Lilia Ferrario.

Photo: Melissa Adams

## NYSSA SKILTON BYTE SIZE

DNA fingerprinting has revealed baby orange clownfish have remarkable homing abilities. Nemo's dad may not be the only one to have a nose for direction. Scientists from the Australian Centre of Excellence for Coral Reef Studies and their international partners have discovered some baby clownfish are swept out to sea as hatchlings, travelling as far as 35km from the reef where they spawned. The scientists, using the clownfish parents' DNA to identify where their children came from, show about 40 per cent of baby clownfish that settle in a marine reserve are those that returned home. They say their findings illustrate the importance of marine protected areas in conserving breeding stock.

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The experiences of others can direct you to the path of happiness, according to US psychologists. A study from researchers at Harvard University and the University of Virginia suggests that rather than closing our eyes and imagining the future, we should examine the experiences of those who have already been there. In one experiment, women predicted how much they would enjoy a speed date. The women who learned about a previous woman's experience did a much better job of predicting their own enjoyment of the speed date than those who studied the man's profile and photograph. The study has appeared in the journal *Science*.

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Dog bones have revealed signs of early agricultural practices in East Asia. Archaeologists from the Carnegie Institution in Washington DC analysed the bones, which came from an archaeological site in a region of north-west China, considered to be a possible early centre of East Asian agriculture. Chemical traces within the dog bones suggest a diet high in millet, a grain that wild dogs are unlikely to eat in large quantities, but was a staple of early agricultural societies in north-west China. The authors, reporting in *Proceedings of the National Academy of Sciences*, say if the dogs were consuming that amount of millet, their human masters were likely to be doing the same.

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Australian astronomers have discovered a rare, high-density dwarf galaxy, which may help scientists better understand how galaxies and their clusters evolve. The dwarf galaxy is far brighter and more massive than the clusters of stars that usually surround galaxies, and was born in the very early stages of the formation of the universe. The discovery, made by a team of researchers at Swinburne University in Melbourne and from the United States, was published in *Monthly Notices of the Royal Astronomical Society*.

■■■

US ecologists say they have answered a question that has been puzzling biologists for more than a century: what determines a lizard's ability to shed its tail? Their answer is venom. Tail-shedding is a common anti-predator defence among lizards. But tail loss carries long-term costs, including slower growth rates and lower social status. The researchers, led by a team at the University of Michigan in Ann Arbor, linked the appendage loss to a venomous snake. They say the lizard's ability to shed a tail within seconds after a potentially fatal bite was a life or death matter. Lizards that lost this capacity were ill-equipped to defend themselves and quickly succumbed to invasive snakes.

# It's time to eat humble pie: latest evidence gives humans a reality check

CHARLEY **LINEWEAVER**

In my most arrogant teenage moments, my mother looked me in the eye and said, ''Pride goeth before a fall.'' Science too, seems to keep reminding us to be humble. The Copernican revolution removed the Earth from the centre of the universe. Astronomers now tell us that the sun is just a typical star in a galactic back of Bourke – and that the Earth may just be a typical terrestrial planet.

Cosmologists tell us that the baryonic matter that makes up all the stars and planets and ourselves is only 4 per cent of the stuff in the universe.

The rest is mysterious, cold, dark matter and dark energy. And now it seems that even our entire universe may be just one of an infinite number of infinite universes. Science seems to have launched humanity on a one-way trip towards anonymity and humility, if not humiliation.

The Darwinian revolution taught us that we are animals – one of several species of great ape. And Richard Dawkins reminds us that we are just the protective wrappers for selfish genes.

Recent DNA studies tell us that salamanders have more genes than we do – and the Freudian revolution taught us that we aren't even aware of most of what is going on in our own minds.

To rub it in, IBM's Deep Blue computer beat the world's best chess player more than a decade ago. Summing up this cascade of scientific dethronements, Stephen Weinberg (Nobel Prize winner for Physics, 1979) wrote: ''The more the universe seems comprehensible, the more it also seems pointless.''

The lesson to be learned, however, is not that the universe is pointless, but that our disappointment is a measure of how inappropriately self-serving our self-image is. One of the healthiest results of science is that it gives our egos a reality check.

In a recent paper, evidence is presented that undermines another form of human vanity: the idea that human-like intelligence is likely to be found across the universe (Lineweaver 2009 www.mso.anu.edu.au/~charley/publications.html). I call this mistaken idea the *Planet of the Apes* hypothesis – after the movie. The hypothesis is widely believed and is often more than just casually endorsed by many scientists. The hypothesis goes like this: human-like intelligence is so generically useful that there is selection pressure on other species to evolve towards bigger brains and human-like intelligence. In our absence (or on other planets), some species will evolve into the ''intelligence niche'' that we currently monopolise (that's what the apes do in the movie).

Carl Sagan has called the occupants of this niche the ''functional equivalent of humans''. This hypothesis could also be called the stupid-things-get-smarter model of evolution. Adherents expect to find the functional equivalents of humans scattered around the universe, wherever life and biological evolution has taken hold. Although the *Planet of the Apes* hypothesis appeals to human vanity, it has failed a series of tests. It disagrees with the best data we have.

A series of long-duration, independent experiments in evolution were set up and left to run. The most straightforward interpretation of the results is that human-like intelligence is not a convergent feature of evolution and that there is no ''intelligence niche'' toward which animal species evolve.

In the absence of humans, other species do not converge on human-like intelligence as a generic solution, or even a specific solution, to life's challenges. These tests have been almost universally ignored. The names of these tests are South America, Australia, North America, Madagascar, India and New Zealand. These islands and continents drifted independently for various time intervals ranging from 50 to 150 million years. The time scale for tripling the size of the human brain in Africa was about 2 to 3 million years. Thus, the experiments ran long enough to test a process that one might expect to take a few million years. In New Zealand, for example, which species are we to imagine is the one that evolved toward human-like intelligence? The kiwi? The tuatara? Obviously neither did. Human-like intelligence did not evolve in New Zealand.

In South America, after 90 million years of independence, no species seems to have evolved towards the ''human-like intelligence niche''.

In Australia, during about 100 million years of independent evolution the brain size of the koala probably decreased and no functional equivalent of humans emerged. I am not saying that other creatures are not smart. Each species seems to have its own unique kind of intelligence, but there seems to be no apparent obligation for it to become more like ours. On several continents and several islands, millions of species evolving over tens or hundreds of millions of years provide no evidence for the *Planet of the Apes* hypothesis.

This evidence needs to be taken seriously since these experiments are among the best data sets we have to scientifically address the question: ''Are we alone?'' So far, the evidence suggests that whatever life forms we find out there, they probably won't be the ''functional equivalent of human beings''.

■ Charley Lineweaver, Research School of Earth Sciences, ANU.