How to find a meteorite that's fallen to Earth

January 13 2016, by Phil Bland

The November 27 fireball as photographed by the Desert Fireball Network observatory at William Creek, South Australia. Desert Fireball Network

A bright fireball lit up the night sky around Kati Thanda (Lake Eyre South) in South Australia on November 27, 2015.

But how to find the impact site of that meteorite? And how can we know where in the solar system the object came from?

Thankfully, a new meteorite tracking system we've installed in Australia has enabled us to answer these questions, helping us better understand the history and composition of our solar system.

Meteorites are the oldest rocks in existence. They contain a unique physical record of the formation and evolution of the solar system, and the processes that led to terrestrial planets.

They sample hundreds of different heavenly bodies, a compositional diversity that spans the entire inner solar system.

But the most basic piece of data – context – is absent. In almost all cases, meteorite researchers have no idea where their samples came from.

What they need are orbits and the ability to track meteorites back to their place of origin in the solar system. The goal of the Desert Fireball Network is to provide that data.

A network of 'eyes'

This is a project that started in 2012 and since then we've installed a network of 32 automated observatories in remote areas of Australia. They are capable of operating for 12 months without maintenance, storing all imagery collected over that period.

The locations of some of the automated camera stations. Credit: Desert Fireball Network

Although they are high resolution intelligent imaging systems, they cost around A$5,000 each, which is only a fraction of the cost of previous systems. We've completely automated data reduction, so we can potentially scale up the system to arbitrary size without needing hordes of poor PhD students doing manual labour.

And members of the public can contribute by sending in their own reports via a smartphone app that we've developed called Fireballs in the Sky.

Trying to track an object moving at many kilometres a second, from the edge of the Earth's atmosphere to the surface, isn't easy. You have to account for everything from minor distortions in the camera lenses, to the effect of winds blowing the object off course when the light has gone out.

We would only know that it worked when we found a rock on the ground.

One of the automated cameras keeping watch on the sky. Credit: Desert Fireball Network, Curtin University, Author provided

A green flash in the sky

When that fireball lit up the skies above South Australia in November, it was imaged by five Desert Fireball Network automatic observatories. The stations sent alerts to our server in Perth, attaching thumbnails of the fireball image.

With data from just a couple of cameras, we could tell pretty quickly that we had a meteorite on the ground. First, we had to get out to South Australia to pick up additional data from cameras that weren't online, so that we could precisely triangulate the fireball.

We took a light aircraft flight from William Creek, which showed us that there was a feature on the surface that might be where the rock plunged into the mud. Now we had to get out on the lake.

Some of our team set to work pulling together all the data. The more accurately we could pinpoint the fall position, the easier any search would be. Their analysis showed that the object came in at a very steep angle, with a velocity of 50,000km/h, and punched down low in the atmosphere, still visible as a fireball at 18km altitude.

The 1.6kg meteorite close up. Credit: Desert Fireball Network, Curtin University

When it entered the atmosphere, it was about 80kg. At the end of the fireball it had more likely been whittled down to between 2kg and 6kg.

Alongside the effort to work all this out, we were putting together logistics for the trip. We knew we had to get there quickly. There had already been rain. Much more of it and any trace of the rock might be wiped away.

In addition, Kati Thanda has spiritual significance for the Arabana people. We would need their permission before we could go out on the lake. But the Arabana understood the urgency, and gave consent almost immediately. The Arabana guides, Dean Stuart and Dave Strangway, who came with us on the trip were a huge help.

The search is on

We got to the lake shore on December 29. But the lake doesn't have a firm surface; it's thick mud. We had to pick our way out to the fall site – almost at the centre of the lake – trying to find a route that would support a quad bike. Eventually, we found a way in.

Professor Phil Bland and PhD student Robert Howie digging the meteorite out of the mud in the middle of Kati Thanda (Lake Eyre) South. Credit: Jonathan Paxman, Desert Fireball Network

Next day we got to the site, and searched the area, but didn't find any trace of the feature that we'd seen a couple of weeks before from the air. Time was running out. Rain was coming in. We figured we might have just have one more day left.

So we decided to double down: one of our team would fly over the site, while two of us would search on the ground. If they saw anything from the air they would radio, circle the spot, and we could check it immediately.

It was overcast and drizzling as we headed out to the shore, but heavy rain held off long enough for us to get to the fall site. For an hour, the plane just circled.

Then we got a call that they'd seen it. We ran to the spot, and found the last remnant of the feature that our friend had seen a couple of weeks before. The meteorite had punched a deep hole in the mud.

Digging down through that pipe my fingers eventually touched a rock. We'd found our meteorite. The rock is 1.6kg in weight, a bit lighter than we'd expected, and it's probably an ordinary chondrite, the most common type of meteorite. But we need to do some analyses to tell for sure.

An unexpected surprise

We didn't know it when we built the network, but it turns out it can do a lot more than we ever expected. We can track satellites, space debris and rocket launches. We've even tested systems that will let us do fundamental astronomy. And, with a minor upgrade, we'll have a facility that can spot supernovae and optical counterparts to gamma ray bursts.

But it's the potential for planetary research that still gets us excited. Already, we've seen more fireballs than have ever been recorded up to now, giving us a unique window on what's hitting the Earth.

As we recover more rocks, we will gradually build a geological map of the inner solar system. If we can link a meteorite to an asteroid, then we essentially have a sample-return mission to near-Earth asteroids, without the need for spacecraft.

This first rock we've recovered is just the start. In itself, it's a research gold mine. But it also proves that our system works so there should be many more.

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