News Item: Recovery of the Winchcombe Meteorite: A triumph for collaboration and citizen science

By: Mike Lambert interviewing Jim Rowe, Coordinator of The UK Fireball Alliance (UKFAll)

When you suddenly hear a lot of banging and drilling coming from over the garden fence, you're bound to wonder what your neighbours are up to. Back in 2016, it turned out that my next-door neighbour, Jim Rowe, was installing his first meteor camera on his chimney. And now, five years later, Jim and his collaborators have had their persistence rewarded with the recovery of the Winchcombe meteorite: one of the most important events of its kind in the UK for over 400 years, and something that might have some international space agencies scratching their heads and wondering about the cost-effectiveness of their sample-recovery missions.

ML: *Jim, what prompted you to install that first meteor camera?*

JR: I suppose meteorites are where my interest in Geology meets my interest in Astronomy – added to which, there's the sheer dramatic appeal of the event – when a rock from space hits the Earth's atmosphere. Ever since I was a kid, I've been fascinated by the idea of trying to recover a freshly fallen meteorite.

But the real spark came in March 2016, when there was lots of media coverage of a huge fireball over the UK. I Googled '*why are there no fireball networks in the UK?*' and discovered there were in fact several. Richard Kacerek of the UK Meteor

Figure 2: THe Winchcombe fireball as seen from Maidenhead Berkshire - Credit Márton M. via IMO.net

Figure 1: Next door in Whetstone; Jim's house with the FRIPON camera at top and UKMON and NEMETODE cameras further down the chimney

Observation Network (UKMON) pointed me towards their resources for building a camera and gave me huge support when the one I built didn't work first time.

By May 2016, it worked with both the UKMON and NEMETODE meteor networks and I started seeing some really interesting events.

ML: *How does a meteor camera work?*

JR: It's usually based on a digital video camera. It takes pictures of the sky all night: either 25 or 30 frames per second, depending on the system. A computer compares these frames – looking out for any changes – and keeps a record of just those excerpts from the night sky when something's happening. Some of the more sophisticated systems can analyse the images and only retain those that are meteors. But the one I first set up caught absolutely everything.

ML: *I remember you saying you'd got a great shot of one of our local tawny owls.*

JR: Yes, owls, bats, moths, and lots of planes. But I also caught lots of meteors, including a couple of really good, bright fireballs, one of which dropped a meteorite in the North

Sea early in 2020.

ML: *Why do you need a network of these meteor cameras?*
JR: If you only have one camera, then all you get is a photo of a line against the night sky. You can see exactly where the meteor was relative to the stars – but that's all. However, if you can observe it from two different locations, then you'll see different stars in the background. And – because the meteor is only about 80km up, whereas the stars are infinitely distant – you can do some good geometry on it. You can work out its trajectory, accurate to tens of metres. You can get its speed and its rate of deceleration. You can even look at fragmentation events and the changes in deceleration after those events. And, if you've got good enough camera data, you can individually track multiple fragments.

Also, once you've got the exact trajectory and the initial speed, then you know what it was doing just before it entered Earth's atmosphere. And that means you can calculate the original orbit of the meteoroid, which tells you where it came from in the solar system.

ML: *Hang on. What's the difference between a meteor, a meteorite and a meteoroid?*
JR: Basically, a meteoroid is the name of the object when its orbiting in space. It creates a bright meteor when it enters Earth's atmosphere. And the fragments of rock that reach the surface are meteorites.

ML: *So, putting it simply, if you combine data from two or more cameras, then you can calculate where the object came from in space and where it's likely to land?*
JR: That's right. And, if you can quickly recover that meteorite and get it to a laboratory before it becomes contaminated, then, potentially, it's comparable to material from a sample-return mission to an asteroid.

ML: *You mean it would be as good as something a space mission brings back from an asteroid?*
JR: Yes, almost – but at a fraction of the cost!

ML: *So, thinking back to 2016, when you installed your first camera, were there the systems in place to achieve all this?*

Figure 4: The "alert area" sent to the media on the morning after the fall. At 280 sq km it was much larger than the calculated strewn field and was intended to provide a focus for media activity and public awareness. Credit SCAMP/FRIPON & UKFAll

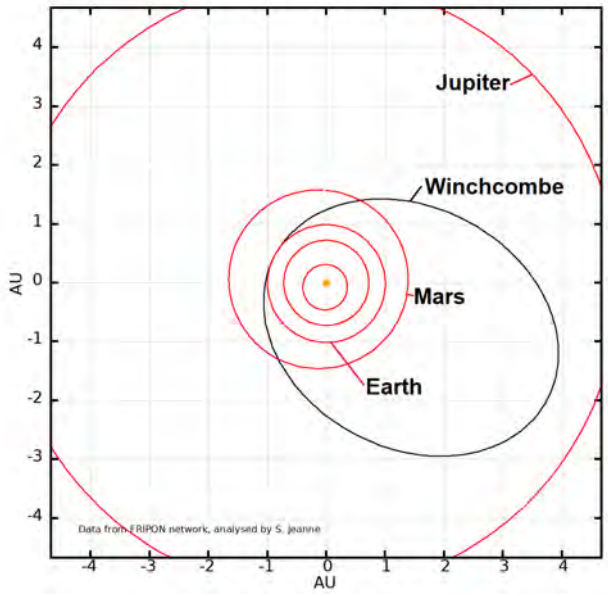

Figure 3: The pre-impact orbit of the Winchcombe meteoroid, as calculated by FRIPON in the hours after the fall. The meteoroid orbitte as far out as Jupiter. Its orbit only just intersected with that of the Earth. Credit SCAMP/FRIPON

JR: Not really. The existing networks were oriented more towards observing meteors than recovering meteorites. When the French FRIPON network was established in 2016 for the purpose of meteorite recovery, I set up the UK arm of that project. So, I put a FRIPON cameras on my own house in Whetstone, plus other cameras in Manchester, Cardiff and Canterbury. That's been very successful at tracking potential fall events. However, in 2018, when camera data showed a meteorite might have landed in Devon, our attempts to recover it were a bit of a shambles. And that's when we got organised and set up The UK Fireball Alliance (UKFAll).

ML: *What's the purpose of UKFAll?*
JR: After what happened in Devon, we realised we needed to develop a much more rapid response. The cameras were doing their job but, if we wanted to quickly recover a pristine meteorite, then we needed better 'strewn field' calculations, agreement about how volunteers could help in the search and decisions about how to use and recruit local and national news media.

Via UKFAll it's also been possible to align the work of the individual camera networks – of which there are now six – with that of the UK planetary science community. UKFAll is a collaboration between the networks and those institutions which take an interest in non-Earth geology: like the Natural History Museum (NHM) and the Universities of Manchester, Glasgow and Plymouth. We wanted to make sure that any meteorites reached these institutions quickly and free from contamination.

We also wanted to work with the existing system of national repositories, where any recovered material would be held. So, in England that's the NHM; in Northern Ireland it's the Armagh Observatory; in Wales it's the National Museum Cardiff; and in Scotland it's the Hunterian at the University of Glasgow.

ML: *And I remember, early last year, you were busy developing some important software?*

Figure 5: A close up of the "alert area" with Winchcombe at its centre. Credit UKFAll

JR: Yes – one of my projects in the first lockdown was to improve communication between the various camera networks all of whom were recording their observations in different ways. In collaboration with a student from Trinity College, Dublin, we came up with some software, which means that most of the networks – whether they're based in France, Canada or Australia – can now use observations from completely different and previously incompatible cameras from the other networks.

ML: *So, that brings us up to 28 February this year. Take me through what happened that night.*

JR: The first I knew was just after 10:00pm, when I received an email from Ray Taylor of the NEMETODE meteor network, who's based in Skirlaugh, near Hull. He'd been standing outside – just witnessed an unbelievably bright fireball – and wanted to know if anyone else had seen it.

ML: *How bright can a meteor like this be?*

JR: Ones that drop meteorites will often be brighter than the moon and, occasionally, they're so bright that, for a second or two, they'll turn the sky blue and you can see all the colours in the surrounding landscape. Added to which, they're often accompanied by a widespread sonic boom. They're truly spectacular natural events – so that people who witness one will often be retelling the story 50 years later.

ML: *What did you do, after getting Ray's email?*

JR: I immediately logged into the FRIPON server in Marseille and saw that the event had been recorded by cameras in Manchester, Honiton and Cardiff. I realised – if it had been captured by stations so far apart – we were dealing with a huge event. But, because it takes a while for the camera networks to do the maths, I decided to get some sleep before what I knew was going to be a very busy day.

When I got back to the computer at 05:40 there was data from FRIPON and from the Desert Fireball Network in Australia, both with calculations of the trajectory, plus a note from the American Meteor Society in the US with reports of a sonic boom. So, I emailed everyone in UKFAll to let them know that we were in for a big day, and began updating our pre-prepared press releases, including a map showing the area in Gloucestershire where the meteorite had probably landed. The press releases were picked up by the media in mid-morning and my role then was to direct media enquiries and deal with reports from the public.

ML: *Did Covid restrictions affect your plan?*

JR: We couldn't deploy our 250-or-so volunteers to help in the search. But, in other ways, luck was on our side.

Dr Ashley King of the NHM gave an early interview on the BBC and Richard Kacerek of UKMON did the same on Sky. On the map I'd made for the media, I'd marked the patch of Gloucestershire we were interested in with a red polygon. When the Wilcock family discovered the meteorite on their drive, a family member, who'd seen the TV broadcast and our map, told them what to do. First, they took a photograph of it. Then, using a clean Waitrose freezer bag, they picked up the material without actually touching it.

ML: *Like you would a dog poo?*

JR: I'm not sure I'd have used that image – but, yes, exactly!.

ML: So, tell us about the meteorite itself.

JR: About 500g of material has been recovered. That's about 300g from the Wilcocks' driveway, 150g from a beautiful, almost-intact stone found by Mira Ihasz of the University of Glasgow team in a sheep field and the balance from three or four other sites near Winchcombe.

It's something called a Carbonaceous Chondrite – a particularly rare and interesting form of meteorite. More than 60,000 meteorites are known but only 1,206 have ever been

Figure 6: Members of the planetary science community obtained Covid sign-offs then converged on the area, searching open areas in the strewn field and responding to reports of fragments. Credit Dr. Katherine Joy, University of Manchester

Figure 7: One of the meteorite fragments recovered by the University of Glasgow team from a sheep field near Winchcombe. Credit Dr Luke Daly

recovered after being seen to fall: and of those, just 51 were Carbonaceous Chondrites. They're the leftovers of planetary formation. They've never been part of a planet or compacted by strong gravity, which means they've remained more or less unchanged for the past 4.6 billion years. Carbonaceous Chondrites are high in hydrated minerals – and, from isotopic analysis of the hydrogen in their water content, you can tell interesting things about primeval water and possibly about the origins of water on Earth.

What's really special about this one is that it was recovered so quickly – and particularly before it got rained on. Because Carbonaceous Chondrites have never been compressed by strong gravity, there are massive gaps between grains. So, if they get wet, they quickly get soggy and their chemistry changes.

ML: *Did Carbonaceous Chondrites play a role in Earth's geology?*

JR: It seems likely they did. Just after the formation of the Moon, Earth was a big, molten blob, so hot that a lot of volatiles, like water, would have been lost. So the question becomes: where did our current water come from?

Current thinking is that much of Earth's water and its carbon content derives from later impact by carbonaceous chondrites and comets.

ML: *I've also read that carbonaceous chondrites sometimes contain amino acids.*

JR: Yes – they often do. There are a lot of quite complex organics in there. But that's a bit of a favourite headline for headline writers: that they contain amino acids – 'the building blocks of life' and so on. However, it's a very big step from having amino acids to having life. It makes a cool headline though.

ML: *I'm sorry to have brought our discussion down to such a tabloid level.*

JR: No – I mean it is thought-provoking. It does show that complex organic compounds can form in very different conditions. But it doesn't necessarily mean that this is the direct origin of those complex compounds on Earth.

ML: *What's known about the orbit of this meteor?*

JR. What's unusual about this event is that it was captured by so many camera systems. We know it orbited out almost as far as Jupiter and came in as far as the Earth. So, we caught it when it was near its closest point to the Sun.

Most likely, it began life in the Asteroid Belt, between Mars and Jupiter. But then, sometime in the past 4.6 billion years, its parent body probably collided with another object in the Asteroid Belt and may also have interacted with the gravity of Jupiter and Saturn, which knocked fragments into this more far-ranging orbit. We may get a more precise idea of its history once analysis of its cosmogenic radionuclides are completed.

Figure 8: Meteorite fragment recovered from the Wilcock's driveway in Winchcombe. Credit: Trustees of the Natural History Museum

ML: *What other scientific analysis will be carried out on this meteorite?*

JR: There'll be a lot of detailed mineralogy – examining its composition grain by grain. But precisely how the material is analysed and how its distributed between institutions is a matter to be decided by a committee of three scientists: Dr Ashley King of the NHM; Dr Katie Joy of University of Manchester; and Dr Luke Daly of University of Glasgow. It's possible that their decisions will be shaped by the science programme that's already been developed around the Japanese Ryugu sample.

ML: *What's the Japanese Ryugu sample?*

JR: That's the material that a Japanese space mission gathered from an asteroid called *Ryugu*. It scooped up a 5g sample from the asteroid's surface and, on 6th December 2020, delivered it back to Earth, in Western Australia.

So – the point is – a science programme has already been designed for this *Ryugu* sample and, because the Winchcombe Meteorite is of similar quality and composition, that may provide a template for the Winchcombe analysis.

ML: *Are you saying that a whole Japanese space mission recovered just 5g and that you've just got hold of 500g of equivalent material?*

JR: That does seem to be what's happened!

ML: *So, finally, if anyone reading this would like to get involved in the project, what should they do?*

JR: We're definitely looking for more people to get involved. First thing to say is that UKFAll is now affiliated to the Geologists' Association, which was the good idea of Dr Jana Horák of National Museum Wales, one of UKFAll's founding members. Anyone who'd like to find out more can do so at www.ukfall.org.uk.

And, for anyone thinking about installing their own meteor camera, I'd really encourage you to do so. There are some relatively inexpensive options described on this same website.

Editor's note #1: Part of the Winchcombe meteorite is now on public display at the Natural History Museum. Pre-booking for a free ticket to see the first meteorite of its type to ever be recovered in the UK is required.

The 'Winchcombe Meteorite Timeline'

Sunday 28th February 2021

- **21:54** - Fireball
- **22:13** - Ray Taylor of Skirlaugh alerted the NEMETODE e-mail group, having seen it while he was outdoors near Hull, England
- **22:32** – Adam Jeffers of NEMETODE reported a third-party sighting of the fireball from Galway, Ireland
- **22:37** - UKFALL response to NEMETODE, confirming that the FRIPON/SCAMP cameras in Manchester, Cardiff and Honiton had registered the event, which was therefore huge
- **22:41** – Third-party Instagram video circulated within NEMETODE
- **23:03** - First meteor camera video (from Nick James) circulated within NEMETODE

Monday 1st March 2021

- **02:37** - American Meteor Society alerts UKFALL to high number of reports over a wide area, sonic boom reports and termination over land, so the need for a meteorite search
- **03:30** - HD video from AllSky7 camera at Nuneaton sent to UKFALL by American Meteor Society
- **05:41** - Dr Hadrien Devillepoix of Desert Fireball Network (DFN) and Curtin University, Western Australia, commented "*Lots of fragmentation, to a point where it is difficult to pick out the timing on the still images. The GFO camera in Wales is offline, but the other 3 in the area caught it (Lincoln, Mullard/Cambridge and Welwyn). Orbit is pretty cometary. Combined with the unusual amount of fragmentation, I'd say that makes it pretty interesting as we might be looking at a less common type of meteorite.*"
- **06:03** - Converted FRIPON data sent to Hadrien by UKFAll. The FRIPON trajectory solve showed a slow object reaching the low altitude of 30km, so a good chance of survival.
- **06:05** – UKFAll response to American Meteor Society
- **06:12** - Message to all UKFALL team: "*Last night's huge fireball was both seen and heard all over southern England and beyond, and the initial FRIPON and DFN analysis indicates high fragmentation and a likely fall. I'll get press releases and a strewn field together. This is likely already to be national news as it's likely to break the world record for the most-reported meteor, and there are also multiple, excellent videos out there. Possibly looks like a bit of comet, so if anything did survive it could be highly unusual.*"
- **06:53** - First-draft UKFALL press release circulated to members with the message "*Because of lockdown we have the problem of getting anyone into the field. This event was also extremely widely seen and so is a national news story. So, I suspect we should go to national news media. As it's probably on farmland near Cheltenham, let's be less coy about the strewn field than usual. In fact let's just publish it and ask farmers to keep an eye out. Here's a quick first draft. Please amend as you see fit, then let's get it out the door this morning.*

Both Richard Kacerek and Dr Ashley King then did crucial early television work, so the finder knew to photograph it *in situ* and to put the pieces into a plastic bag.