Ending 30 years of hurt: The Winchcombe meteorite fall

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Meteorite hunting is a lot like football (soccer)… just run with us on this. Success requires skill, a cracking team, a whole lot of luck… and historically England (and the UK) are not very good at it… we were just unlucky… the (fire)ball always seems to miss the goal! While around the world meteorite fall recoveries are becoming more and more frequent, in the UK, as the famous English football anthem by the band the Lightning Seeds attests, it's been '30 years of hurt' since our last meteorite fall: The Glatton meteorite of 1991 that landed in Arthur Pettifor's back garden as he was tending to his onions[1]. However, approximately three meteorites over 100 g should fall on the UK each year[2]; so right now, the UK is batting way below its average (yes we know that's cricket not soccer…).

Recovering meteorites that have been seen to fall is incredibly important for planetary science. Even better is when the fireball (the bright light trail left behind as the rock passes through Earth's atmosphere) is caught on camera. These images allow us to triangulate where the meteorite landed and quickly search for any visiting space rocks before they get contaminated by Earths environment, and calculate its orbit to link these special rocks back to their parent asteroid[3,4].

Over the last few decades researchers and amateur astronomers around the world have developed automated camera networks to image fireballs alongside sophisticated models to figure out if a meteorite survived, where it landed and where it came from in space. The UK has become a melting pot of fireball camera networks all using a variety of equipment from narrow angle CCTV cameras to DSLRs and industrial cameras equipped with 360° 'all sky' lenses. There are six active networks: Network for Meteor Triangulation and Orbit Determination (NEMETODE), the UK Meteor Observation Network (UKMON), the UK Fireball Network/Global Fireball Observatory (UKFN/GFO)[3], System for Capture of Asteroid and Meteorite Paths/Fireball Recovery and InterPlanetary Observation Network (SCAMP/FRIPON)[2], the Global Meteor Network and AllSky7. Even better, since 2018 all these networks work together and share data under the umbrella of the *UK Fireball Alliance* or *UKFAll*[6] (Figure 1). We were ready for the big one, we just needed something to fall out of the sky on top of us. Enter spring 2021 and the amazing story of the Winchcombe fall event….[7]

Sunday

On the 28th February 2021 at 21:54 a bright seven second fireball was observed across the UK and Northern Europe. Social media feeds alerted us about the fireball. We checked our cameras and fired off a quick message to our international colleagues at the GFO and FRIPON to check if anything survived to the ground.

Monday

We woke up to a barrage of the best kind of emails you'd ever want to receive: 16 separate UKFAll observatories caught the fireball (Figure 2); ~1000 members of the public reported seeing it and heard a sonic boom; the object's orbit originated in the asteroid belt; video footage showed fragmentation of the fireball suggesting there was a good chance that meteorites survived. The game was afoot.

Now under normal circumstances we'd already be in cars rushing to the fall site as well as lighting the beacons to tell UKFAll's army of citizen science volunteers to mobilise. However, these are not normal times, we faced two problems, 1: COVID, the UK was under a national lockdown so getting people to the area was not going to be easy. 2: we didn't have a well constrained dark flight model yet (the meteorites journey from when the light of the fireball goes out, sending the rock into freefall where it is blown about by the wind, to it landing on the ground). This meant our initial estimate of where the rock had landed was a 280 square kilometer area (Figure 3), a bit too big to search by foot, and a far cry from our usual search areas that are typically no bigger than 10 square kilometers.

While we were waiting for a more refined search area, we alerted the media with our 'approximate' fall location to see if any lucky locals had come across any new rocks that looked black and shiny (the typical appearance of a freshly fallen meteorite that has had its surface melted as it passed through the atmosphere). UKFAll had a set of pre-prepared press releases for just this occasion so we had the story out the door by 8 am. The next thing we knew various members of UKFAll were on national television and radio talking about 'what to do if you think you have found a meteorite and who to contact'[8].

Simultaneously to our media efforts, but unbeknownst to us, most of the meteorite was already sitting in a clean plastic bag in the Wilcock family home in the small town of Winchcombe. The daughter of the family Hannah had heard a loud cracking sound outside their home at about 22:00 the previous evening, but didn't see anything unusual when she looked out of the window that night. The next morning, however, the whole family had found a splatter of dust and black rocky fragments on their driveway. Their initial thought was: who's been lobbing lumps of coal into peoples' gardens? However, their son Daniel had seen the news and told them about the possible meteorite fall in the area. Realizing its potential importance, they bagged the debris and sent in a photo of what they had found to UKMON (Figure 4). The speedy action of the Wilcock family was amazing and meant that around 300 g of the meteorite spent less than 12 hours on the ground before it was collected, with no rain having fallen (see, it does stop sometimes!). This meteorite is about as fresh as you can get and is comparable to the material brought back by asteroid sample return missions like Hayabusa2 and OSIRIS-REx, especially with the fireball data giving us its orbit. But we're getting ahead of ourselves.

Tuesday

We were inundated with images of unusual looking rocks that had been sent in to UKMON and the Natural History Museum (NHM). Most were sadly meteorwrongs, but there were a couple that looked promising. However, we must admit several of us were not initially convinced by the unassuming image of a pile of black dust from a driveway in Winchcombe (Figure 4): much like the Wilcocks, we thought it was more likely to be the residue from a BBQ than a space rock! Luckily science is a team effort and lots of eyes were looking at these images including Dr Richard

Greenwood who immediately recognized it for what it was, a meteorite and likely a rare meteorite type known as a carbonaceous chondrite!

Wednesday

Living locally to Winchcombe, Dr Greenwood visited the Wilcock family and confirmed that it really was a freshly-fallen UK meteorite! With this confirmation, plus several other promising looking images sent in by the public, and now that our colleagues at the GFO had run their darkflight model giving us a much smaller, more searchable area, where other meteorite fragments could have fallen. Now was the time to get boots on the ground to try to find the rest of it. There was just the small problem of the national COVID-19 lockdown. A mountain of paperwork and risk assessments later, we received institutional sign off to get a team of around 15 planetary scientists from academic institutions across the UK including Glasgow, Manchester, Plymouth, Imperial College, the NHM and the Open University into the field. We're going on a meteorite hunt! We hope to find a big one!

Thursday-Friday

The search team assembled near Winchcombe on an overcast, but thankfully rain free, spring morning. We had a short briefing, where most of us got our first glimpse of the Winchcombe meteorite to help get our eye in for the coming search, before it got whisked away to the NHM for curation and preliminary analysis. Those of us who had been meteorite hunting before in Antarctica or Australia gave a crash course in searching techniques and we set off. Meteorite hunting, turns out, is the ideal socially distanced activity; using many tried and tested search and rescue techniques, the group lines up ~2 m apart and slowly walks across the landscape scanning the ground in front for shiny black objects (Figure 5). We mark our slow progress with GPS steadily filling in the search area either side of the fall line.

We had ideal searching conditions, overcast meant no long shadows from the sun, and no rain was good for a) not contaminating any meteorites that were out there waiting for us and b) morale. We also received a warm reception from the local landowners who very graciously allowed us onto their property to search safely, for which we are extremely grateful. Now the underlying bedrock of the Cotswolds is oolitic limestone, a bright white rock and about as different from a meteorite as you can be, therefore it was our hope that almost any solid shiny black thing would be what we were after... However, you will not believe how many things lying about in the UK countryside look like the fusion crust of a meteorite, from sheep poop to dewy cobwebs in the morning sun, making the search slow going, as we checked every. single. one.

Saturday

We don't think anyone actually expected anything to come of the search and most of the search team, after covering most of the fall line over two days, headed home on Friday night. The University of Glasgow team, however, decided to stay over the weekend to fill in the final few gaps in our search map. Then the unbelievable happened: early on the Saturday morning Mira Ihasz, a volunteer with the University of Glasgow search team, found a beautiful, completely fusion crusted and mostly intact 160 g piece of the meteorite in a sheep field. Cue pandemonium as we all just screamed and jumped for joy at having achieved what many had thought to be impossible: to search for and recover a meteorite in the UK.

What a week

Several other stones were also found by members of the public from the area bringing the total final mass of the fall to >500 g, most of which were recovered before substantial rainfall. There are many

amazing aspects to the recovery of the Winchcombe meteorite but perhaps the most wonderful is that the Wilcock family as well as the Carrick, Bond, and Godfrey families elected to generously donate all of the material they found or was found on their land to the NHM for scientific research.

The Winchcombe meteorite has now been officially classified as a CM2 carbonaceous chondrite and has energized the UK planetary science community[9]. CM meteorites are really important as they are one of the first rocks to form in our Solar System 4.5 billion years ago and contain a lot of water and organic matter. Therefore, meteorites like Winchcombe that rained down on the early Earth as it formed may have provided the water for our oceans and the organic material to from a nice habitable soup from which life could emerge and evolve. Fragments of Winchcombe have been sent out to every lab in the country for what is set to be one of the most comprehensive studies of a single stone since the fall of the Allende meteorite in 1969. The fragment recovered from the Bond family's field by the University of Glasgow search team is now on display at the NHM.

The whole Winchcombe experience just shows what great things can be achieved when science works as a diverse international effort combining the expertise of academics and citizen scientists to build together something that is greater than the sum of its parts. It is a great first result for UKFAll to build on. Let's make sure it's not another 30 years of hurt until the next one.

References

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