THE LOST METEORITES OF ANTARCTICA PROJECT: A NEW UK-LED ANTARCTIC METEORITE RECOVERY PROGRAMME.

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Introduction: Meteorites provide us with invaluable material evidence of how the Solar System formed and evolved through time. In particular, iron-based meteorites provide material originating from the complex planetary bodies, providing insights to the number, diversity, evolution and destruction of protoplanets that existed in the early Solar System [1-2]. The most prosperous places to find meteorites is Antarctica, which has contributed over 66% of the world's classified meteorite samples [4-6]. This large proportion is due to Antarctica's ice dynamics and high katabatic winds, which produce highly concentrated localised Meteorite Stranding Zones (MSZs).

Crucially most Antarctic meteorite recovery missions have followed similar collection protocols [7-12], focusing their search efforts upon finding material located on the ice surface (a rare few samples have been recovered from within the ice [13,14]). The consequence of this surface search approach appears to have been an under representation of iron-based meteorites in the world's body of curated samples: 0.7% from Antarctica compared to 5.5% from the rest of the world [5].

Recent laboratory and mathematical modelling work by Evatt et al. [15] hypothesised that 'missing' iron-bearing meteorites are likely to lie hidden a few cm below the surface out of sight of surface searches. We proposed that this under-representation of iron-rich meteorites might be the result of the Sun's rays penetrating the ice in MSZs during the summer months and warming of the thermally conductive iron-rich meteorites (i.e., iron meteorites, pallasite group, mesosiderersites etc.) more than stony iron-poorer types (i.e., iron-poor achondrites, L and LL chondrites). The ice melting process allows the more iron-rich meteorites to effectively sink into the upwelling ice, meaning that they don't easily emerge onto the surface to be spotted by collection teams. We suggest, therefore, that there may be a sparse layer of iron-rich meteorites trapped buried at depths of up to ~30-50 cm within the Antarctic ice meteorite stranding zones [15].

The Lost Meteorites of Antarctica Project: is funded by the Leverhulme Trust with support from the British Antarctic Survey (BAS) to explore new Meteorite Stranding Zones in Antarctica for meteorites that are encapsulated within ice [16]. The exploration activity involves several methods: (i) investigation of ice flow regimes in Antarctica to pinpoint suitable exploration sites; (ii) develop more sophisticated models to predict burial depths of different meteorite types in different field settings, (iii) developing technology to identify ice trapped meteorites and tune and ruggedise this technology to understand sensitivities to different meteorite groups (Fig. 1); (iv) collect surface located meteorites to determine productiveness of field settings; ultimately (v) collect sub-surface meteorites and classify them to test the Evatt et al. [15] missing iron meteorite hypothesis.

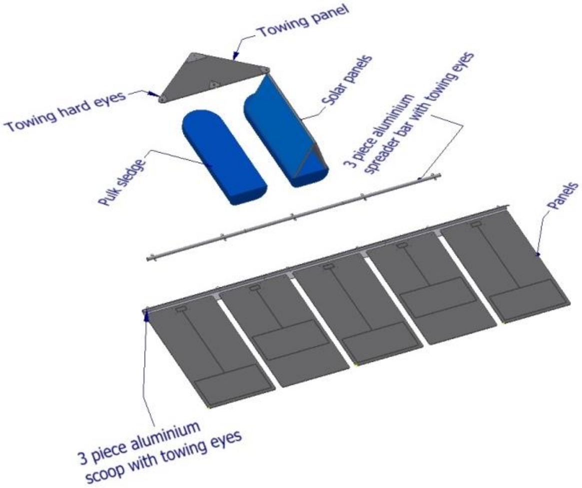

Figure 1. CAD design of the five panel metal detector array and snowmobile tow assembly Credit: Scott Polfrey (BAS).

Metal detector array coil design: A pulse induction metal detector has been designed and built at University of Manchester in conjunction with BAS. The coil panels are built from sections of polythene sled (a similar polythene sled system is used by BAS to transport fuel). The copper coil wire is encapsulated in the sled material using polyurethane resin. For a system design we aim to detect a 30 mm diameter ~100 g iron-rich meteorite at 300 mm depth (minimum target).

An array of typically 5 panels (2 × 1.1 m each) arranged in parallel will be towed behind a skidoo (Fig. 1). The electronic control box system design ensures we have real time signal processing and recognition – the design of this system is a key part of the project development to ensure that it is robust in the harsh Antarctic environment for a 5-6 week field season.

Field search plans: We are making two separate trips to Antarctica for our first season on the ice in 2018-2019. Both field campaigns have different objectives, but come together to lay the groundwork for our main field expedition in 2019-2020.

Meteorite reconnaissance: In Antarctic austral 2018 summer (Dec-18 to Feb-19) we aim to visit several icefields south of the Recovery Glacier in the Shackleton Mountain region, and in the northern most part of Argentina mountain chain (Fig. 2). Four weeks of field work will involve searching and collecting any meteorite samples that are found on the ice surface. The recovered meteorites will be returned to the UK for curation, and will provide vital information about which ice fields are productive search areas. Outcomes of this first field campaign will be presented at the 2019 LPSC meeting.

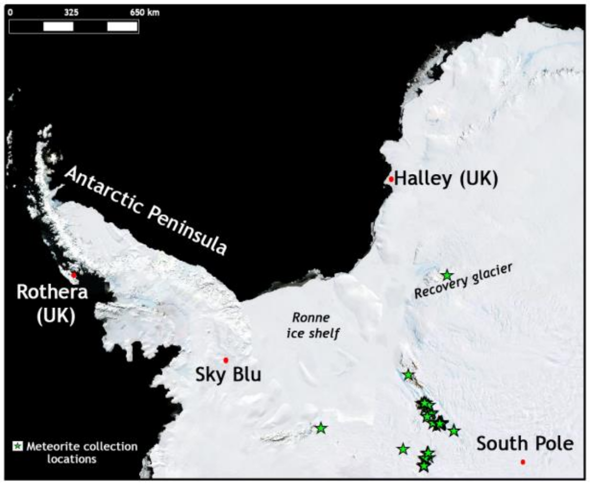

Figure 2. 2018 Austral summer BAS field campaigns will head to the Sky Blu ice runway and Recovery Glacier region. The green stars represent locations of previously collected Antarctic meteorites by systematic search teams and serendipitous discoveries (data from [3]).

Field equipment testing: Initial testing of individual metal detector panels was conducted in Svalbard in March 2018 where lessons were learnt about the electronic processing and ease of drag of the panel setup.

A second in field campaign will take place at the Antarctic Sky Blu ice runway in Jan-2019. This will aims to finalise the configuration of the electronics to detect metal objects buried at different depths in the ice, test the signal processing algorithms at appropriate skidoo speeds and the ruggedness of the full 5 panel detector array system. We will also develop best practice extraction methods of meteorites trapped within ice so not to damage them during the recovery process.

Future field campaign: We will use knowledge gained from this first field season to plan which blue ice field site to return to in Dec-2019 for a scaled-up sub-surface meteorite search campaign involving deploying two five panel detector arrays running parallel to each other. Using a large multi-science approach, we have estimated that on average (considering ice speed, wind speed, temperatures, meteorite size etc. [15]) that there may be 0.17 (0.12, 0.24) detectable iron-rich meteorites per 1 km^2 of blue ice (brackets denote a standard error range). Therefore, considering our expected skidoo ground speed of ~15 km/hour, two five-panel arrays with a width 5.5 m, and working in two eight hour shifts per day, we can (theoretically) search ~2.4 km^2 per day. In theory this therefore equates to an expected recovery rate of around 2.9 (2, 4.1) iron-rich meteorites per week, under the assumption that the meteorites have sunken into the ice and they are sufficiently shallow so as to be detectable. However, we are fully conscious that this is a very upper bound, as weather, technical issues, terrain and human fatigue will all serve to heavily reduce the rate down. In addition, this figure will clearly be strongly influenced by what is actually returned during the first field season; despite our modelling, we can only collect what has actually fallen.

The classification of surface samples recovered in the first season will be compared to the types recovered in the second sub-surface search season. This analysis will resolve which types of meteorites have emerged at the surface per icefield area enabling us to statistically test the Evatt et al. [15] hypothesis and further explore meteorite englacial transport mechanisms and Antarctic ice-flow dynamics.

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