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First Recovery From The Desert Fireball Network: Bunburra Rockhole, a Brecciated Achondrite Delivered From An Aten-Type Orbit

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Abstract

We report on the progress of the Desert Fireball Network, in Western Australia, and analysis of the first sample recovered by the network; a meteorite named Bunburra Rockhole. Initial analysis of Bunburra Rockhole show that it is a brecciated basaltic achondrite. Orbital data based on the trajectory recorded by the Network cameras indicate that it has an unusual Aten-type orbit. We will present more detailed analysis of both the meteorite chemistry and the implications of its orbit. This recovered sample provides a validation of the basic premise of our project: the meteorite was found on our first organized search, indicating that an expanded future Desert Fireball Network in the Nullarbor will be capable of delivering dozens of meteorites with orbits over the lifetime of the project.

The Desert Fireball Network

Meteorites provide us with the only surviving physical record of the formation of our Solar System. But they are also unique - as geological materials - in that they come with virtually no spatial context to aid us in interpreting that record. There is a profound disconnect with possible asteroid parent bodies; we have no sample-return material; and orbital information for meteorite falls is largely absent. Although a primary motive behind fireball camera networks was the recovery of meteorites with orbital data [1], only four samples have been obtained. The reason for this low recovery rate relates to field areas: any vegetation makes looking for small meteorites extremely difficult. Our solution was to place a network in an area that has proved eminently suitable for locating meteorites: the Nullarbor Region of Australia. The aim of the Desert Fireball Network (DFN) is to deliver numbers of samples with precise orbits, providing a spatial context to aid in interpreting meteorite composition.

The current embryonic Desert Fireball Network consists of four observatories. During the past two years we recorded more than one hundred fireballs. Five of the recorded fireballs were observed well enough to be triangulated, and also had a computed terminal mass larger than 100 grams, two of which were in areas suitable for systematic searching. The first organized search for a Desert Fireball Network fall took place in October 2008. Two fragments, totalling 324 grams, were recovered within 100m of the projected ground track.

The First sample recovered; Bunurra Rockhole

Bunburra Rockhole is brecciated and contains numerous clasts. BSE images reveal three lithologies delineated by grain size (Figure 1). Mineralogy in all lithologies is similar, comprising pyroxene, plagioclase, and silica, with minor

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amounts of chromite, sulphide, and ilmenite. Pyroxene is Fe-rich and ranges from Ca-rich to Ca-poor ($Fs_{26.7}$ $Wo_{44.0}$ to $Fs_{63.6}$ $Wo_{2.3}$). Exsolution lamellae are apparent in all lithologies, but are most prominent in the medium-grained areas. Plagioclase ranges in composition from An_{85} to An_{91}. The Fe-rich composition of the pyroxenes indicates that Bunburra Rockhole is a basaltic achondrite. We will discuss in detail the current ongoing work to investigate the major and trace element chemistry, and their isotopic composition.

Orbital trajectory information:

This first DFN meteorite was delivered from an extremely unusual orbit. It is the first achondrite with an orbit, and the first meteorite with an orbit from the southern hemisphere. The fireball is designated DN200707; the meteorite, Bunburra Rockhole. The beginning of the fireball lightcurve for event DN200707 occurred at 19h13m53.2s±0.1s (UT) on July 20th 2007 [2]. The object had an initial velocity of 13.40km/s; semimajor axis (AU): 0.851 ± 0.002; argument of perihelion (°): 209.9 ± 0.2; eccentricity: 0.245 ± 0.003; longitude of ascending node (°): 297.59525 ± 0.00010; perihelion distance (AU): 0.643 ± 0.004; inclination (°): 9.07 ± 0.17; aphelion distance (AU): 1.05997 ± 0.00014; period (years): 0.786 ± 0.003. All angular elements are given in J2000 equinox. This is one of the most precise orbits ever determined for a meteorite, but it is exceptional for another reason. It is an Aten-type orbit. Aten asteroids are near-Earth objects which have semi-major axes <1AU. In the case of DN200707, virtually the entire orbit was contained within the Earth's orbit (see Figure 1). An orbital analysis was performed using the parameters defined above. The orbit is relatively chaotic, with a number of previous close approaches with Earth and Venus. Approaches as close as 0.04AU to Venus are possible; the most recent Venusian encounter occurred in September 2001. A search on the asteroid catalogue for objects with similar orbital elements resulted in several cases. However, given the relatively chaotic nature of these orbits it is rather unlikely that these objects are genetically related to our meteorite. Detailed orbital integration analysis is currently ongoing to investigate the probable history and likely ultimate origin within the solar system; we will discuss these results in more detail.

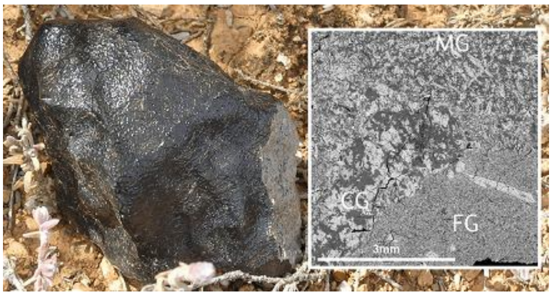

Figure 1: Bunburra Rockhole at the recovery site, and (inset) a BSE image showing lithologies (FG=fine grained; MG=medium grained; CG=coarse-grained).

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