MADURA CAVE: A NEW METEORITE FALL DELIVERED FROM AN ATEN ORBIT

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Fall and Recovery: A particularly bright fireball was observed in Western Australia by the Desert Fireball Network (DFN) over the Nullarbor plain on the morning of 20 June 2020 at 6:05 AM local time (Fig. 1). The event lasted 5.5 seconds beginning at an altitude of 75 km and ending at 18.6 km. A kilo-sized main mass was predicted to have survived entry. A two person team from the DFN was dispatched to scout the fall location, near Madura, in order to create training data for an upcoming drone search [1]. The meteorite was found on the afternoon of the first day of scouting (on July 9th, 2020), resting on the dirt road that roughly bisected the fall zone (Fig. 1). This marks the 6th recovered meteorite from the Global Fireball Observatory collaboration [2]. The stone, named Madura Cave (1.072 kg), was the only predicted large mass from this fireball. Based on the light curve of the event, there was a significant fragmentation event around 24 km altitude which likely produced smaller meteorite fragments. These could be searched in the future. The meteorite was classified as an L5 ordinary chondrite (Meteorite Bulletin ID 73645).

Figure 1. left: Madura Cave main mass when found (~11×9×8 cm). right: Fireball as observed from the Forrest airport observatory (~180 km; closest viewpoint).

Initial insights: Madura Cave was delivered on an Aten type orbit (mostly contained within the Earth's orbit). This rare type of delivery orbit -- similar to Bunburra Rockhole [3] -- typically indicates a long (>10 My) dynamical history from a main asteroid belt orbit to the pre-impact orbit. This also points toward an inner main belt origin, and likely pushed towards near-Earth space via the ν6 resonance.

Some other L chondrites with calculated orbits, such as Creston, also seem to originate from the inner main belt [4], and contrary to most L chondrites, do not present Ar-Ar and U-Pb resetting ages around 470 Ma. [4] have therefore suggested the presence of at least two present-day parent bodies for L chondrites: one L asteroid in the inner belt, and another one further out that would be the source of L falls with a ~470 Ma resetting age. The latter proposed parent body would also have been the source for the bombardment that left fossil meteorites found in ~467 Ma sedimentary rock [5]. Upcoming geochronological analyses of Madura Cave should be able to provide important evidence on this L chondrite clan issue.

Ordinary chondrites, even within the same sub-class, have multiple sources and diverse histories [6]. Each new fall observed with orbital history brings another piece to the puzzle.

References: [1] Anderson, S., et al. (2020) Meteoritics and Planetary Science:55 2461-2471. [2] Devillepoix, H. A. R., et al. (2020) Planetary and Space Science:191. [3] Bland, P. A., et al. (2009) Science:325 1525. [4] Jenniskens, P., et al. (2019) Meteoritics and Planetary Science:54 699-720. [5] Schmitz, B., et al. (2001) Earth and Planetary Science Letters:194 1-15. [6] Jenniskens, P. (2020) IAU General Assembly: 9-12.