Tighert: A new eucrite meteorite fall from Morocco

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The fall of the Tighert meteorite took place in the night of 9 July 2014 at 22^h30^m. The bolide traveled from North-West to South-East and experienced several fragmentation events along its atmospheric trajectory. Eyewitnesses in several localities of the Guelmim-Es-Semara (Tata, Tirhert, Foum El Hisn, Douar Imougadir, Taghjijt, Assa, etc.) saw the bolide and heard audible detonations a few minutes later. Immediately after the fireball event the authorities of the area organized a field search to check for possible security problems. Detailed mineralogical and petrological examination of the meteorite have revealed that it is comparable to an eucrite "magmatic" meteorite that comes from the asteroid belt, exactly Vesta-4.

1 Introduction

Observed meteorite falls are interesting for several reasons. Material from observed falls has not been subjected to terrestrial weathering, making the find a better candidate for scientific studies. Historically, observed falls were the most compelling evidence supporting the extraterrestrial origin of meteorites. Furthermore, observed fall discoveries are a better representative sample of the meteorites' types which fall to Earth.

During the last eighty years, thirteen meteorite falls were recorded in Morocco, of which ten are well documented, named Douar Mghila, Oued el Hadjar, Itqiy, Zag, Bensour, Oum Dreyga, Benguerir, Tamdakht, Tissint and Aoussred. It represents only 0.011 % of the Moroccan declared meteorites (or equivalently, 0.1 fall per year per 71085 km^2) (Ibhi, 2013a and 2013b). All those objects have been watched by eyewitnesses and all last Moroccan falls have been recovered by hunters that spend much time searching meteorites especially in the desert.

On Wednesday, July 9, 2014 at 22^h30^m, a stone meteorite shower occurred in the region of Foum Lhisen. This was the second wide-area meteorite shower in the Tata province following the martian Tissint meteorite shower in 2011. The first meteorites were recovered the following day close to the road between Foum El Hisn and Assa city. Thousands of people moved to the site from surrounding cities and villages to search. The fall area is ~20 km^2 and is elliptical in shape. The major axis of the ellipse is ~7 km from North-West to South-East.

In this article, the first observations and field data will be presented as preliminary mineralogical and chemical characteristics of this new meteorite.

2 Collecting observations

Eyewitnesses reported that they saw a brilliant light that shot across the night sky. It seemed to be brighter than an electric welding light. The nomads reported that it was at first yellow, and then turned red-green before it split into many parts. Then, they saw innumerable falling sparks. After 10 s, the fireball exploded, producing a sharp peal of thunder, which resonated about 5 s. A few moments later, the sound disappeared, fragments of the meteorite fell accompanied by whistling noises. The fireball was seen by people from cities and villages more than 300 km around the fall site. No deaths or injuries happened by the fall.

Figure 1 – Many of the nomadic people in the region converged to assist in recovering the fresh samples before valuable information was lost to weathering. Initial searches by nomads, converging in the direction of the bolide, produced the first few fragments (photo, Meteor center).

Thousands of people moved to the site from surrounding cities and villages to search (Figure 1), the first meteorites were recovered the following day close to the road between Foum El Hisn and Assa Near the Tighert village (Figure 2). Most of the specimens found were quickly identified as meteorites because they exhibited a prominent fusion crust covering part of their surface. The largest recorded mass

was about 1100 g, with an estimated total mass of 15 kg. Most pieces are covered by a very shiny, glassy black fusion crust with translucent patches.

Figure 2 – The Tighert village (Photo, Meteor center).

3 The Tighert meteorite

The fragment provided to researchers at the University of Agadir (UIZ) was approximately 25 mm in diameter and about 10 mm thick. The measurement of the magnetic susceptibility on this fragment, showed that Log χ (10^{-9} m^3/kg) is about 2.7 and the density of 2.77. This value corresponds well to the confidence interval of the eucrite meteorites in the alignment chart given by Folco et al. (2006), revealing in this way, that it is a "magmatic" meteorite that comes from the asteroid belt, exactly asteroid Vesta-4. The isotopic analysis of oxygen of acid-washed subsamples by laser fluorination done by Ziegler K. of the Institute of Meteoritics, New Mexico University (Meteoritical Bulletin, 2014, no. 103, in preparation) confirmed that this meteorite is a unbrecciated eucrite and the name "Tighert" has been approved by the Meteorite Nomenclature Committee of the Meteoritical Society.

Eucrites consist of basaltic rock from the crust of Vesta-4 or a similar parent body. They are mostly composed of Ca-poor pyroxene, augite or pigeonite, and Ca-rich plagioclase. Based on differences in chemical composition and features of the component crystals, they are subdivided into several groups (Mittlefehldt et al., 1998). The unbrecciated eucrites (Tighret meteorite type, Figure 3) are important to understand the lithological diversity on their parent body, which is especially relevant with the ongoing DAWN mission to Vesta (Mayne et al., 2009). Unbrecciated eucrites are also important to understand the early planet differentiation mechanisms, where unbrecciated eucrites may be free from the influence of post crystallization impact additions (Jasmeet et al., 2013).

Figure 3 – Tighert meteorite fragments (a complete piece of the Tighert meteorite showing intact, black fusion crust).

4 Discussion and conclusion

The meteor entered the atmosphere at a very acute angle and disintegrated into a large number of fragments after more than 10 s of flight, throwing numerous fragments into similar tracks ending in an extended zone called the ellipse of the fall (Figure 4). It is estimated that the intense fireball moved horizontally from North-West to South-East, shortly followed by multiple sonic booms. The largest explosion was recorded at a height of approximately 5 km in the West of Tighert. An accurate speed has not been obtained; however, on average, meteors and fireballs move through the atmosphere at speeds up to or greater than 15 km/s.

The strewnfield of Tighert is not yet well studied; it is situated at about 10 km of linear distance to the south of Foum El Hisn city in the region of Guelmim-Es Smara. The mapping of the locations, where the fragments of the meteorite were found, showed us that the fireball exploded into hundreds of fragments that are scattered on a field with a North-West to South-East direction about 7 km long, which is also the flight direction of the meteorite according to the observations of the nomads and which would be the

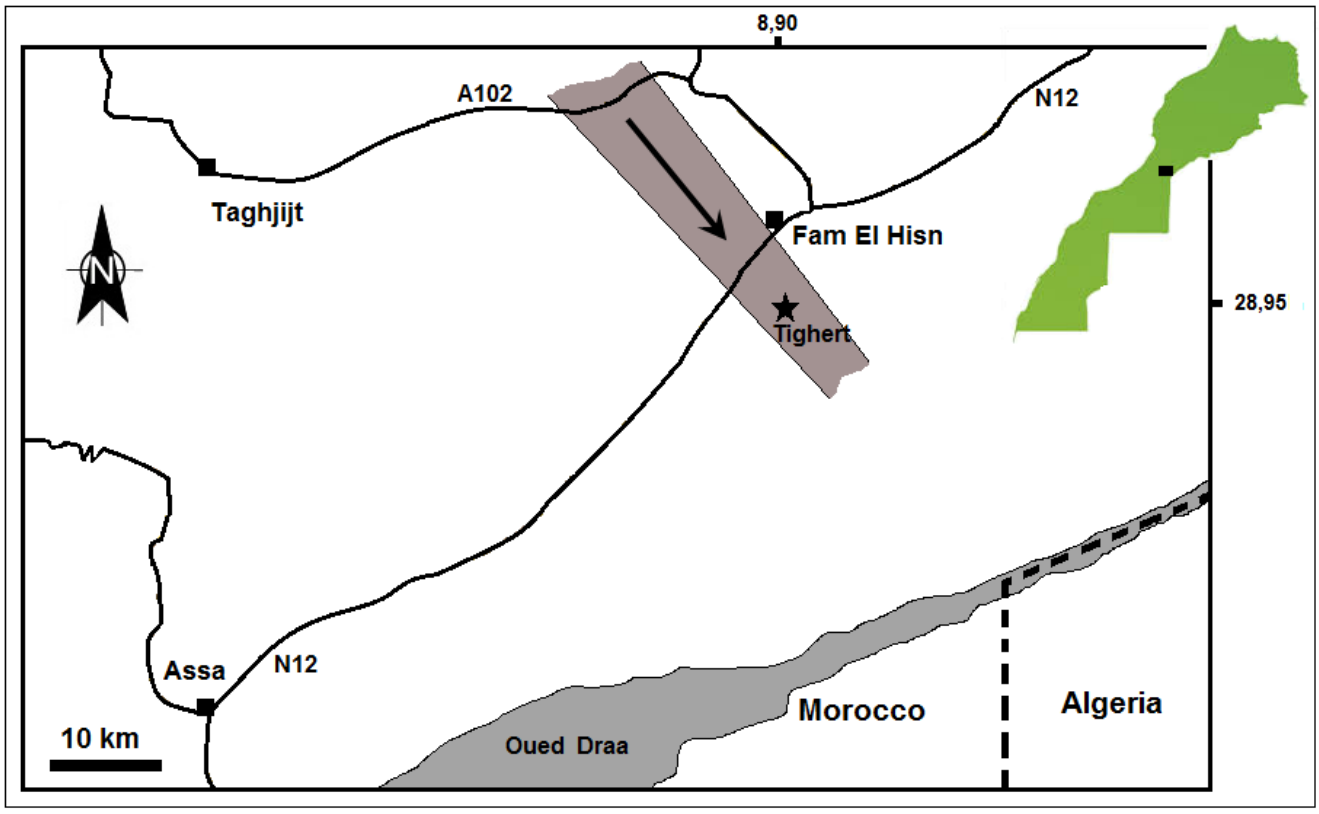

Figure 4 – Estimated flight path of the fireball which resulted in the Tighert meteorite

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direction of the strewn field. The width of the ellipsoid is not yet well defined due to the lack of data, especially in the very steep northern part.

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