New Mars meteorite fall in Morocco: final strewn field

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ABSTRACT

The Tissint fireball is the only fireball to have been observed and reported by numerous witnesses across the south-east of Morocco. The event was extremely valuable to the scientific community; show an extraordinary and rare event and were also the brightest and most comprehensively observed fireball in Morocco's known astronomical history. Since the abstract of A. Ibhi (2011) [1]. In 2012-2013 concerning a number of Martian meteorite fragments found in the region of Tata (Morocco), a number of expeditions have been made to the area. Ibhi has done a great amount of field work. He discovered the strewn field and collected the fragments of this Martian meteorite and many information. Each expedition has had the effect of expanding the size of the strewn field which is now documented to cover more than 70 sq. kilometers. The size of the strewn field is now estimated to be about a 17 km long.

Keywords: fireball; Martian meteorite; Shergottite; Strewn field; Tissint; Morocco

1. INTRODUCTION

A meteoritic body entered the Earth's atmosphere in the south-east skies of Tata, Morocco, On Sunday, July, 18th, 2011 at 2 o'clock in the morning. Its interaction with the atmosphere led to brilliant light flashes accompanied with detonations. The apparent magnitude of the fireball was brighter than -20. A large number of fragments survived the fireball phenomenon. The Saharian nomads living in the surrounding region then came together for searching the debris of this extraterrestrial rock. The first fragment had been discovered at the end of December. About a hundred persons came to the region of Tissint (Tata, Morocco) and about fifty fragments had been collected by the nomads, traders and hunters with some knowledge about extraterrestrial rocks. This extraterrestrial debris became a source of revenue and this explains the trade value of these rocks, which appears to be reached 700 dollars for one gram, to be paid directly in cash in the desert.

Ahmed Sghiwar, a nomad who found a small block of 5 grams in the region, contacted at the beginning of January 2012 the author, Prof. Ibhi Abderrahmane, scientist and collector of meteorites at the Ibn Zohr University in order to inform him about the findings of freshly fallen meteorites in the region of Tata. In 2012-2013 a number of expeditions have been made to the fall area equipped with a modern navigation and detection instruments. The member of this team succeeded in collecting debris of this Martian meteorite and information on the fall.

We present in this paper results of systematic search made over a period of one month to collect the data of this meteorite which has been named as Tissint, where a large number of fragments were found within a seven months of the fall.

2. THE MARTIAN OF TISSINT, COLLECTING OBSERVATIONS

The meteorite of Tissint is the first fall of a Martian meteorite observed in Morocco and the 5th worldwide [2]. Historically, watched falls took place only once in 50 years or more (1815 in France, 1865 in India, 1911 in Egypt and 1962 in Nigeria). This is once in the career of a human being. The following table (Table 1) gives the details of the five falls of Martian meteorites.

Table 1. Date of discovery and classification of Martian meteorite falls

Name	Find Location	Year	Classification	Mass (kg)
Chassigny	Marne, France	1815	Dunite	4
Shergotty	Bihar, India	1865	Basalt	5
Nakhla	Alexandria, Egypt	1911	Clinopyroxenite	10
Zagami	Katsina, Nigeria	1962	Basalt	18
Tissint	Tata, Morocco	2011	Basaltic shergottite	> 12

It is classified as a completely normal olivine-phyric shergottite, with olivine macrocrysts (up to 1.5 mm) and microphenocrysts (up to 0.4 mm) set in a finer groundmass of patchily zoned pyroxene, plagioclase, kelyphite; $An_{61.1-64.3}Or_{0.5-0.4}$, Ti-poor chromite, ilmenite, pyrrhotite and minor merrillite. Both the larger olivine macrocrysts (cores $Fa_{19.4-20.2}$, $FeO/MnO = 42-44$) and smaller olivine microphenocrysts ($Fa_{29.1-30.2}$; $FeO/MnO = 45-46$) exhibit thin ferroan rims ($Fa_{43.2-60.4}$, $FeO/MnO = 50-55$) against the groundmass, and contain spinel-chromite inclusions [3].

The nomads of the region of Tissint (a region in the east of Morocco, situated 60 km to the south east of the town of Tata nearby the Moroccan-Algerian border) became to know that the pieces of rocks collected nearby their camp at the beginning of January 2012 had been in fact Martian meteorites. They started a search for the other pieces of the same fall and indeed other pieces were found in a long drawn-out zone of about 15 km in length. Most fragments have a small size, which is explained by the explosive nature of the bolide. Most fragments were found to have a well developed crust. 16 of the 51 fragments are completely crusted, 11 are partly crusted and 24 fragments have crusts only on a small fraction of the surface area (Fig. 1). In the sands of Oued El Myit and Oued Bou Ifasouan the men and women of the nomads used sieves in order to find debris if not even dust of this extraterrestrial rock.

Fragment is completely crusted.

Fragment is partly crusted.

Crust only on a small fra

Debris of Tissint meteorite.

Fig. 1. Samples of Martian meteorites Tissint (Tata, Morocco).

The bolide broke into parts, when he entered the earth's atmosphere, throwing numerous fragments into similar tracks ending in an extended zone called the ellipse of the fall. Further the nomads and the military reported that it was at first yellow in color, and then turned green before it appeared to split into two parts. One portion appeared to fall in the valley, while another portion was seen to strike a prominent mountain (El Aglab). It is estimated that the bolide entered the Earth's atmosphere at a highly inclined angle southeast of Tata. The fireball detonated at a height of approximately 10 km above the point location 29° 31' N, 7° 36' W close to the Oued Drâa in the Tissint Region. An accurate speed has not been determined, however, on average, meteors and fireball move through the atmosphere at speeds up to and greater than 15 km/s.

3. THE STREWNFIELD OF THE MARTIAN METEORITE OF TISSINT

The strewnfield of Tissint is situated in about 60 km of linear distance to the south-east of Tata in the area of the rural commune of Tissint. It is covered within the topographic map 1: 100.000th of Tata (Fig. 2). The Lambert coordinates are $x = 280\ 800$ and $y = 280\ 100$ and the GPS coordinates are "29° 31' 2881 N; 7° 36' 4472 W".

Fig. 2. Dispersion of Tissint fragments in Qued Drâa. Topographic map 1:100.000th of Morocco.

In fact this fall took place in the heart of a usual prospection area of the Arabic nomads living in the military zone between Morocco and Algeria, which have some knowledge of meteorites and are looking for meteorites for the whole year on their wandering through the desert. In several weeks of a deep search the nomads collected about 12 kg of fragments of the meteorite, some of them not passing 1 gram.

We would take months to explore the entire ellipse of the fall due to the rough ground, the difficulties to access and the overall uneasy conditions. Nevertheless reliable coordinates of most of the falling places had to be got in order to determine the strewn field of the meteorite of Tata, so it had been necessary to move with 4WD cars and sometimes for narrow foot paths even with motorbikes. Additionally the nomads had to be paid for leading the scientists to the places of their findings in order to get their coordinates. Each fragment found was coded and documented with respect to its position in the field.

The position of the fragments could be ascertained conveniently in the 1 x 1 km grid map with respect to local landmarks (Fig. 3). To date a total of nominally 50 fragments weighing about 12 kg have been found. The largest fragment weighed 1100 g and was found accidentally, near the eastern tip of the strewn field. An important reason for the low efficiency is the similar appearance of the crusted Tissint stones and the dark colored

sandstone fragments found extensively in the strewnfield. The nomads, however, quickly learnt to distinguish meteorite pieces from native rock fragments.

Fig. 1. The Tissint meteorite strewn field.

4. DISCUSSION AND CONCLUSION

Since the year 2000 the discovering of meteorites in the hot desert of South Morocco increased steadily [1-8]. Some of the samples have a very high scientific value. One counts actually 20 Moroccan Martian meteorites of 61 Martian meteorites found worldwide until today [9]. Tissint represents the fifth witnessed fall of a Martian meteorite (the last one being Zagami 19 years earlier) and the first such olivine-phyric shergottite example [3].

In this field, we collected the coordinates of the most significant masses and met eyewitnesses. The coordinates are reported on the 1/100,000th map, with the inferred trajectory NW to SE. These information are in accordance with the reported testimonies. The strewnfield of this meteorite fall extends at least 17 km from the west-north-west to east-south-east, which is also the flight direction of the meteorite after the observations of the nomads. More than 50 fragments of Tissint meteorite weighing about 15 kg have been recovered from the strewn field of 70 km² area. Information about their position in the strewnfield is available in the case of practically all the fragments. Each fragment has been coded and information on the crusting of the surfaces has been documented.

In view of the relatively high efficiency of collection for the Tissint fragments probably higher than for any of the meteorite showers reported earlier, we have made a detailed analysis of the number and mass distribution of meteorite fragments as well as their location in the strewnfield. These data are a true heritage and has to archived.

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