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New Mars meteorite fall in Morocco: collecting observations and determining the spatial distribution in the strewnfield

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The existence of Martian meteorites in the region of Tissint (Tata, Morocco) dropped by a very bright fireball on July 18, 2011, had been notified to a group of scientists of the Ibn Zohr University of Agadir, Morocco, at the beginning of January 2012, by a nomad of Tata who had found a small fragment in the region. A soon as a scientific expedition arrived at the place of the meteorite fall, the members of the laboratory of Geo-heritage and Geo-materials Science started gathering information and collecting the debris of this Martian meteorite. The Tissint fireball has been observed and reported by numerous witnesses across the southeastern Morocco. The event was extremely valuable to the scientific community: it was the brightest and most comprehensively observed fireball in Morocco's known astronomical history. We are now in a position to draw the distribution ellipse of the fall, which starts at Jbel Al Gallab and continues in east-southeastern direction, above big rocky plateaus.

1 Introduction

A meteoritic body entered the Earth's atmosphere in the south-east skies of Tata, Morocco, On Sunday morning July 18, 2011, around 1^h UT. Its interaction with the atmosphere led to brilliant light flashes accompanied with sonic detonations. The fireball was brighter than magnitude -20 . A large number of fragments survived the fireball phenomena. The Saharan 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 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, the price of which appears to have reached 700 USD per 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, professor at the Ibn Zohr University and collector of meteorites, in order to inform him about the findings of freshly fallen meteorites in the region of Tata. Immediately, a scientific expedition formed by two teaching researchers and two students of the Geo-heritage and Geo-materials Science Laboratory went to the fall area equipped with modern navigation and detection instruments. The member of this team succeeded in gathering information on the fall and collecting debris of this Martian meteorite.

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

2 Collecting observations

The Tissint fireball is the first fall of a Martian meteorite observed in Morocco and the fifth worldwide (Nishiizumi et al., 2012). It is classified as a depleted permafic olivine-phyric shergottite (Irving et al., 2012). Historically, observed falls of Martian meteorites took place only once in 50 years or more (1815 in France, 1865 in India, 1911 in Egypt, and 1962 in Nigeria), which is only once in the career of a human being.

When the nomads of the region of Tissint (a region in the east of Morocco, situated 60 km to the southeast of the town of Tata, nearby the Moroccan-Algerian border) heard that the pieces of rocks collected in the vicinity of their camp in early 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 are small, which is explained by the explosive nature of the bolide. Most fragments were found to have a well developed crust. More precisely, 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 (Figure 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.

The bolide broke into parts when it entered the Earth's atmosphere, throwing numerous fragments into similar tracks ending in an extended zone called the distribution ellipse of the strewnfield. The nomads and the military reported that the fireball was at first yellow in color, and then turned green before it appeared to split into two parts. One portion seemed 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



Figure 1 – Samples of the Tissint meteorite.

southeast of Tata. The fireball detonated at a height of approximately 10 km above the point with coordinates $29^{\circ}31' N$, $7^{\circ}36' W$, close to the Oued Drâa in the Tissint Region.

An accurate speed could not be determined.

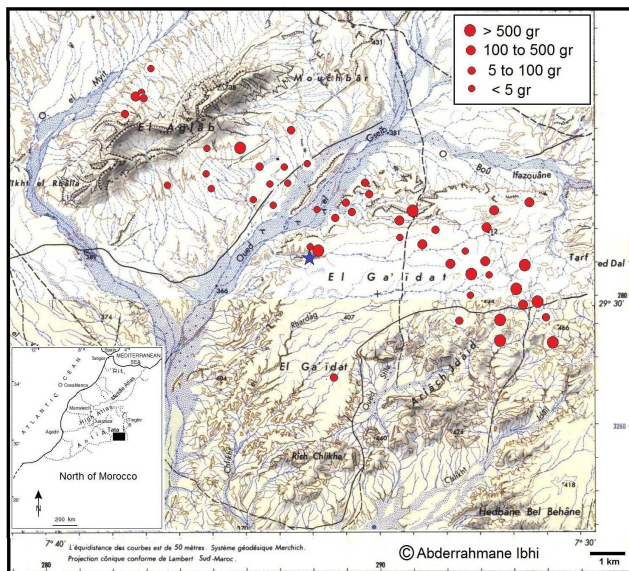


Figure 2 – Dispersion of Tissint fragments in Oued Drâa on the topographic map 1:100 000 of Tata, Morocco.

3 The strewnfield

The strewnfield of Tissint is situated about 60 km southeast of Tata in the area of the rural commune of Tissint. It is completely covered by the topographic map of Tata, scale 1:100 000 (Figure 2). The Lambert coordinates are $x = 280\,800$ and $y = 280\,100$, and the GPS coordinates are $29^{\circ}31'2881 N$ and $7^{\circ}36'4472 W$.



Figure 3 – Nomads collecting debris of the Tissint meteorite.

Actually, 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 the whole year on their wanderings through the desert (Figure 3). In several weeks of thorough search, the nomads collected about 12 kg of fragments of the meteorite, some of them not passing 1 g.

It took us months to explore the entire distribution ellipse of the strewnfield due to the rough surface, difficulties of access, and the overall uneasy conditions. Nevertheless, reliable coordinates of most of the fall locations had to be obtained in order to define the strewnfield of the Tissint meteorite. Obviously, we had to use 4WD cars for this purpose; sometimes, we even had to resort to motorbikes to explore narrow foot paths. 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 determined conveniently on the 1×1 km grid map (Figure 4 with respect to local landmarks). To date, a total of 50 nominal fragments collectively weighing about 12 kg have been found. The largest fragment weighs 1100 g and was found accidentally, near the eastern tip of the strewnfield. An important reason for the low efficiency is the similar appearance of the crusted Tissint stones and the dark-colored sandstone fragments found abundantly in the strewnfield. The nomads, however, quickly learnt to distinguish meteorite pieces from local rock fragments.

4 Discussion and conclusion

Since the year 2000, the discovery of meteorites in the hot desert of South Morocco increased steadily (Russell et al, 2003; Connolly et al., 2006; 2007; Ibhi et al., 2009; Ibhi, 2012). 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 (Stephen et al., 2012). Tissint represents the fifth witnessed fall of a Martian meteorite (the previous one being Zagami in 1962, 49 years before the present fall) and the first witnessed fall of an olivine-phyric shergottite (Irving et al., 2012). In the field, we collected the coordinates of the most significant masses and met eyewitnesses. The coordinates

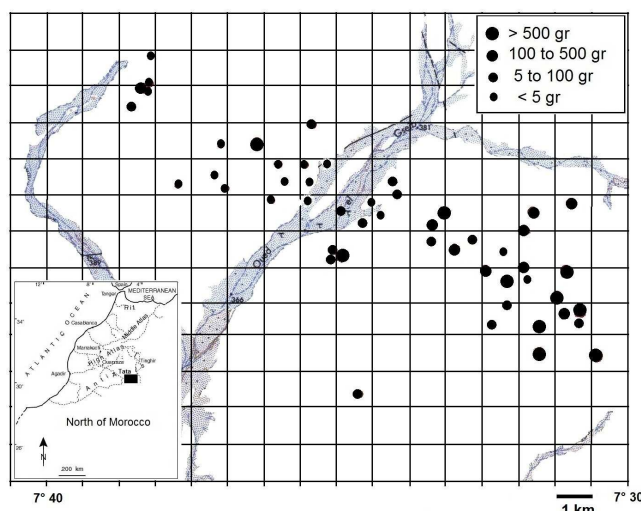


Figure 4 – Grid map used to determine the fall locations. The relative size of the fragments found is also indicated.

are reported on a scale 1:100 000 map, with the inferred trajectory, from northwest to southeast. These findings are in accordance with the eyewitness reports.

The strewnfield of this meteorite fall extends at least 15 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 strewnfield of 60 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, which was probably higher than for any of the meteorite showers reported earlier, we have been able to make a very 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 have to be archived.

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