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Meteorite falls in Africa

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ABSTRACT

The study of meteorites provides insight into the earliest history of our solar system. From 1800, about the year meteorites were first recognized as objects falling from the sky, until December 2014, 158 observed meteorite falls were recorded in Africa. Their collected mass ranges from 1.4 g to 175 kg with the 1–10 kg cases predominant. The average rate of African falls is low with only one fall recovery per 1.35-year time interval (or 0.023 per year per million km^2).

This African collection is dominated by ordinary chondrites (78%) just like in the worldwide falls. The seventeen achondrites include three Martian meteorite falls (Nakhla of Egypt, Tissint of Morocco and Zagami of Nigeria). Observed Iron meteorite falls are relatively rare and represent only 5%.

The falls' rate in Africa is variable in time and in space. The number of falls continues to grow since 1860, 80% of which were recovered during the period between 1910 and 2014. Most of these documented meteorite falls have been recovered from North-Western Africa, Eastern Africa and Southern Africa. They are concentrated in countries which have a large surface area and a large population with a uniform distribution. Other factors are also favorable for observing and collecting meteorite falls across the African territory, such as: a genuine meteorite education, a semi-arid to arid climate (clear sky throughout the year most of the time), croplands or sparse grasslands and possible access to the fall location with a low percentage of forest cover and dense road network.

1. Introduction

A meteorite is a natural, solid object larger than 10 μm in size, derived from a celestial body, that was transported by natural means from the body on which it formed to a region outside the dominant gravitational influence of that body and that later collided with a natural or artificial body larger than itself (Rubin and Grossman, 2010). It has an extremely old formation age (4.55Ga) and many have remained essentially unaltered since their formation (Wasson and Wetherill, 1979). So, when reaching the Earth, it constitutes a great source of information about the history of the solar system and about the interior of a planet, which are otherwise not available. Some of these rocks, rich in complex organic molecules, helped to renew questions about the origin of life (Gounelle, 2009). Because of this, their collection is important for scientific research, especially the observed meteorites falls, which offer fresh material to be investigated. Based on photographic data of fireballs from the Canada network cameras for eleven years, Halliday (2001) calculated that 4500 events per year drop at least 1 kg of meteorites on the Earth's land surface. However, many of these extraterrestrial rocks vanish into shooting stars (Kress, 2001), get lost by plunging into the oceans, or remain unobserved on the land. On average, only five to six meteorites have been observed and recovered annually throughout the world and recovered over the two last centuries (Graham et al., 1985).

In this article, we attempt from statistics how observed meteorite falls or meteorites seen to fall and subsequently collected, can be best observed and collected. We focus on the African continent as the region for this study because of its important scientific contribution to meteorites, some of the African meteorites have great scientific and cultural value, as the Martian observed falls "Nakhla" and "Tissint" (Ibhi, 2013a; Ibhi et al., 2013; Treiman, 2003). Furthermore its geographic location between the northern and southern hemispheres, for the diversity of its landscapes

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(desert, forests, mountains) as well as the different climates and its large surface area (20% of the emerged lands' surface with more than 30 million km^2, FAO, 2002) justify the choice for this study. This large area is supposed to host an important part of the number of meteorite falls on Earth.

Our purpose is to characterize the number and the classification of the African "observed meteorite falls" in time and space and to examine some of the demographic and geographic factors that contribute to the recovery of meteorite falls.

2. Temporal and spatial distribution

The data were collected from 52 African countries during the period between 1801 and 2014. It is based on the information provided in the "Meteoritical Bulletin Database" (www.lpi.usra.edu/meteor/metbull.php). The list used includes only those meteorite falls which have been approved subsequently by the Meteorite Nomenclature Committee of the Meteoritical Society. The geographic and demographic data are from several FAO reports.

2.1. Evolution of observed meteorite falls' number and meteorite classes' number

2.1.1. African meteorite falls' numbers

1800 is the year in which meteorites were recognized as objects falling from the sky. Since this date, 158 observed meteorites falls were recorded in Africa, totaling a mass of2145.4 kg. The oldest meteorite fall (L6) was in 1801 in Mauritius. The most recent, dated back to September 9th, 2014. It was a fragment of a more than 1.8 kg ordinary chondrite (H) that has exploded in the Tinjdad region in southeastern Morocco (Meteoritical bulletin database, 2014).

Recoveries from the Africa region constitute more than 12.3% of all meteorite falls known worldwide on December 31st, 2014. The number of falls is exactly the same as in the USA (158) and it is higher than in some other countries with a similar period of time for the oldest meteorite fall (Russia counted 52 falls observed since 1805). This shows that the contribution of the African continent to the collection of observed meteorites has improved. Moreover, the ratio of falls to finds in Africa (1:68) is much lower than in most other continents or large countries of similar size (e.g., Australia (1:43); South America 1:12; USA 1:13; Canada 1:5; Russia 1:2 and India 1:0.1).

The cumulative number of African meteorite falls since 1800 is shown in Fig. 1.

A steady increase occurred from 1800. During the past 214 years the African meteorite fall recovery rate is 0.74 falls per year on average (or approximately one fall recovery per 1.35-year time interval, or equivalently, 0.023 falls per year per 10^{6}km^2).

Fig. 2 illustrates the number of meteorite falls for every 10 years since 1800. It reveals a varied temporal distribution. The falls distribution rate has increased from 0.017 meteorites/10^{6}km^2 every 10 years (3 falls only on the continent) during the period 1800–1860, to 0.17 falls/10^6 km^2 every 10 years (41 falls) between 1860 and 1940 with a small but uniform growth in the recovery number for the period between 1900 and 1940 (2 new falls per decade).

This rate has been tripled (0.50 falls/10^{6}km^2/10 years) during the period 1940–2014 which recorded 113 falls. This represents 71% of the collection in the study period. Moreover, the distribution over a period of 10 years shows some periodicity since 1940: a decade with an average of 10 falls, i.e., one fall annually, followed by a decade with twice as many records (on average 19 falls, i.e., two falls per year). It is only a statistical coincidence due to the "statistics of small numbers." The evolution of the numbers meteorite falls during the same period for the entire Earth does not show the same pattern.

2.1.2. African meteorite falls' masses

The masses of collected African meteorite falls go from 1.4 g for the "Natal" South African fall up to 175 kg recorded for the Moroccan fall "Zag". Fig. 3 shows the distribution of these meteorites as a function of retrieved mass, on a logarithmic scale. It shows the African meteorite falls with a maximum between 1 and 10 kg (43.2%). Meteorites observed with masses higher than 100 kg are rare (only 3.4%). 24.3% of all falls have masses between 10 and 100 kg and one third (32.4%) has a mass under 1 kg. It must be noted that the mass of the meteorite falls that is effectively retrieved is a lower limit of the mass that actually hits the ground. That shows the difficulty to observe and to recover the meteorites on the ground and a lot of small meteorite falls are being missed. Besides, the chance percentage to survive a fall on the Earth's surface for a mass of the parent body depends strongly on the entry velocity (Heide, 1957). The loss of the surface layer thickness of a body due to the atmospheric ablation is about 7–10 cm during its atmospheric transit at a velocity of 14.2 km/s (Hughes, 1992). Moreover, grit with the size of a tennis ball strikes our atmosphere daily, but almost all evaporate completely (Gounelle, 2009). So, the collected mass depends on the size of the meteorite fallen on the ground and the size of the fragments resulting from its explosion; the smaller ones will be difficult to find. It is also possible that people in remote areas did not report genuine meteorite falls to the authorities or the scientists because they wanted to keep the precious stones they collected. Burke (1991) mentioned that in Nigeria natives did not reveal their discovery of Uwet iron fragments (54 Kg), found in 1903, for years. This phenomenon could

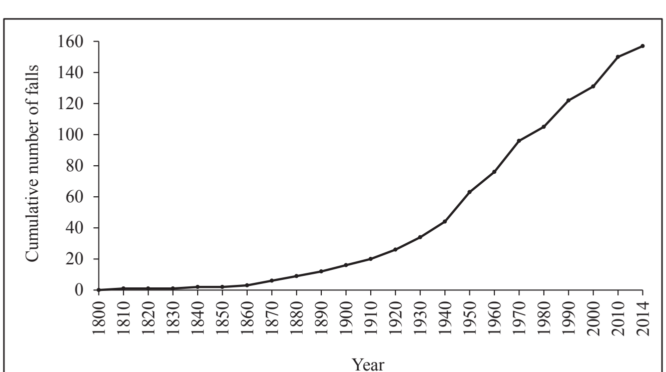

Fig. 1. Cumulative number of observed meteorite falls recorded in Africa.

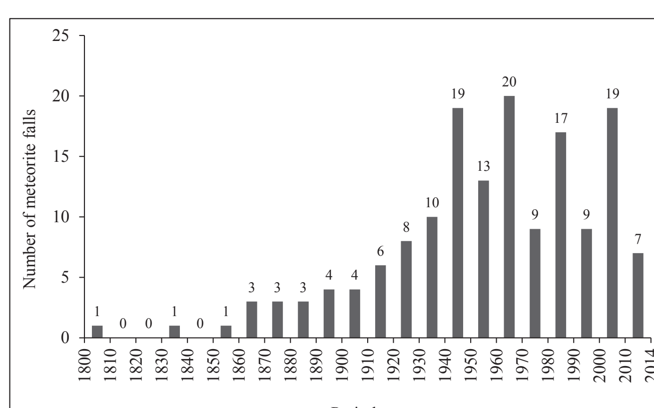

Fig. 2. Evolution of observed meteorite falls' number in Africa between 1801 and 2014.