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African Meteorite Finds: Weathering Processes and Influencing Factors

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Abstract

The African continent includes the second largest meteorite population finds worldwide after the Antarctica collection. This work aimed to study the variation of the alteration rates of the African collection and define some factors influencing the weathering mechanisms. The distribution of weathering grades (W) of the African collection shows a weathering less pronounced than that of the Australian collection, but a deeper alteration than that of Antarctic finds with the peak at the weathering grade W2, which is placed between the peak of Antarctic population (at W1) and that of Australian collection (at W3). The factors that influence the alteration of African finds include climate, which is the main factor, mass, terrestrial residence age and the initial porosity of samples.

1. Introduction

Every meteorite is subject to weathering processes in the terrestrial environment from the moment it enters the earth's atmosphere [1]. Meteorites are exposed to a range of weathering agents such as water, air oxygen, salts, wind, and temperature variations. The classification of African meteorites, which includes all types of meteorites discovered until now, shows that stony meteorites are the most abundant (97.41%), with chondrites accounting 80.29% and achondrites about 17.12%, whereas stony-iron and iron meteorites represent only 1.17% and 1.42%, respectively [2]. The data collected from the «Meteoritical Bulletin database» indicate that 7610 of 9660 samples have weathering grades ranging from W0 to W6. In this work, the distribution of alteration grades and the factors influencing the weathering processes of African meteorites were studied in comparison to Australia and Antarctica meteorite populations

2. Methods

The data on the weathering grades of African meteorites were based on the information provided by the Meteoritical Bulletin database [3], and included only meteorites classified officially by the Meteorite Nomenclature Committee of the Meteoritical Society. During 300 years (1716-2017), 9660 meteorites have been recovered in Africa, of which 7610 samples show weathering grades ranging from W0 to W6.

3. Results and discussion

African meteorites show a weathering grade ranging from W0 to W6 with 66% of samples having a value below W3. The frequency histogram of alteration percentage for African, Australian, and Antarctic populations is shown in Figure 1. The African population shows a less pronounced weathering than that of the Australian collection, but an alteration more extended than that of the Antarctic population, featuring a peak at the weathering grade W2 that is placed between the peak of the Antarctic population (at W1), and the Australian collection (at W3). These results indicate that the alteration of the African population has not started to destroy the meteorites, which begins to occur at about the weathering grade W3 (66% of samples have a weathering grade under W3). The factors that influence the mechanisms and rates of weathering of African meteorites include:
(a) *The climate*. The spatial distribution of African meteorites shows that climate is the major responsible for their alteration. In particular, the semi-arid to arid climate with very limited precipitations in North and Southwest Africa (Namib and Kalahari deserts) does not sustain almost any vegetation that contributes to the weathering of meteorites by its acidity, thus permitting the preservation and the accumulation of meteorites.
(b) *The sample mass.* Most samples (80%) recovered in Africa have masses between 10g and 1kg. As the percentage of meteorites featuring a weathering grade higher than W2 decreases with increasing mass (Fig. 2), the weathering grade appears correlated to the mass of the specimen, i.e. small samples are preferentially more weathered than the large ones. Thus, the medium to large mass of African meteorites favors their preservation with respect to Antarctic and Australian populations.
(c) *The terrestrial residence age*. The distribution of terrestrial ages of African finds (91 samples checked) shows that most of them (80%) feature values below 20 kyrs (Fig. 3). In particular, meteorites with a weathering grade W2 show a terrestrial age of 2.5-16.3 kyrs, whereas samples with a value of W3 show ages ranging from 3.5 to 29.1kyrs, and those with a value of W4 have ages ranging from 15.1 kyrs to 35 kyrs. These results point to an apparent correlation between the weathering grade and the terrestrial age. Thus, based on the low proportion (32%) of samples that have a weathering grade higher than W2, the African population can be

considered to be constituted by young and less altered meteorites.

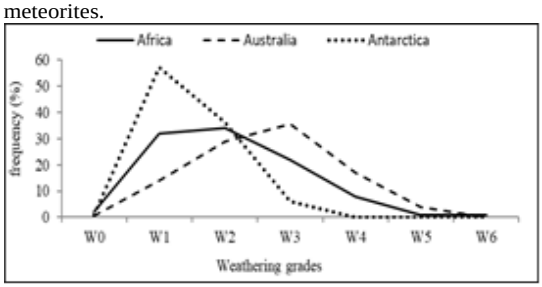

Fig. 1: Weathering grades of African, Australian, and Antarctic meteorites population.

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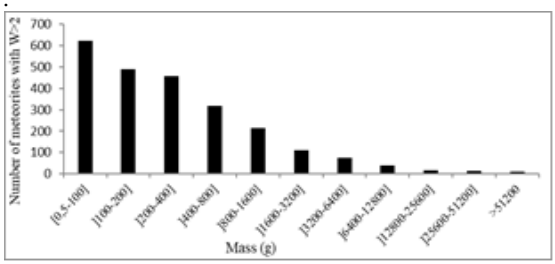

Fig. 2: Number of African meteorites with a degree of weathering greater than W2 as a function of sample masses

Fig. 3: Terrestrial age frequency histogram of 91 African meteorites. Data Source: [4, 5, 6]

(d) *The shock degrees.* The African collection includes 49% of samples featuring shock degrees between S0 and S2 and 51% between S3 and S6. The frequency histogram of weathering grades, as a function of shock degrees for the African collection (Fig. 4) shows that meteorites with low shock degree (S0-S2) are generally more weathered than meteorites with high shock degree (S3-S6). According to Hutzler et al. [7], a relationship exists between the shock degree and the initial porosity of samples, i.e. S0-S2 values correspond to a porosity of about 10% and S3-S6 of about 5%. Therefore, high shock degrees cause a decrease of the initial porosity limiting the weathering of meteorites.

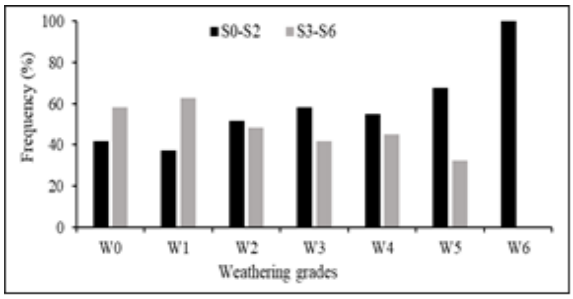

Fig. 4: Frequency distribution of weathering grades as a function of shock degrees (S0-S2 and S3-S6) for African meteorites.

4. Conclusion

The weathering of meteorites collected in Africa is less pronounced (dominance of grade W2) than those of the Australian collection. This result can be ascribed to their relatively low mass, low residence time on Earth (80% of them have a terrestrial age below 20 kyrs) and low porosity. On the contrary, African meteorites are more weathered than Antarctica ones due to the predominant factor of arid climate in Africa.

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