ANTARCTIC METEORITES: A STATISTICAL LOOK AT A UNIQUELY VALUABLE RESOURCE

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Introduction: As of the end of the 2018-19 field season, the U.S. Antarctic meteorite program has surpassed 23,000 meteorites collected. The U.S. collection is valuable in that it is classified in its entirety. The systematic methods employed to collect the meteorites have provided meteorites of more than 40 types, many of which are the first of their type ever recognized. One of the early drivers for consistent and methodical characterization of the entire U.S. Antarctic collection was to allow statistical comparisons. Early statistical assessments of the U.S. Antarctic collection examined mass distributions and the relative frequency of meteorite types as well as comparisons to a defined set of modern falls [1-3]. Using these statistics [4-6] argued that the flux of H chondrites changed over time. [7] used model size distributions to deconstruct the contribution of wind movement, meteorite supply and search losses to the Antarctic collection. Mass-based statistics [8] and size distribution comparisons were examined by [8,9]. [10,11] investigated various aspects of the statistics, including comparison with modern falls/Saharan finds. [12, 13] also discuss geospatial statistics. [14] provides a comprehensive overview of the statistics of the Antarctic collections for the first 35 seasons of U.S. collection by ANSMET. Here we build upon that assessment and that from [15].

Statistics of the U.S. Collection: One of the most important questions surrounding the collection of meteorites in Antarctica is whether the collection procedure is recovering a representative sample of what is actually present at each site. In 40 seasons of searching, we have collected samples from 50 named field sites. Sixteen sites have produced over 100 meteorites, and nine sites have produced over 1000 [14]. Field areas with smaller populations (under 1000) appear to have an overabundance of unusual meteorite types. However, field sites from which over 1000 meteorites have been collected have type populations that converge at approximately 90% ordinary chondrites (OC). Antarctic meteorite populations also show a number of interesting trends when comparing certain classes and sizes among falls and hot desert populations. One of these trends shows large numbers of small samples in the H, L, and LL chondrite populations. This points to the possibility of preserved ancient and modern showers at these sites that may not have been taken into account in the overall numbers of parent meteorites (as opposed to individual stones from a shower), such as in [16]. These OC populations, combined with the unresolved issue of pairing amongst meteorites, have a significant impact on a comprehensive statistical evaluation of the Antarctic meteorite population. Another visible trend between Antarctic meteorites, worldwide falls and hot desert meteorites is that there is a startling under-abundance of iron meteorites with low masses in the Antarctic collection [17]. Based on a theory that there should be a layer of iron meteorites stranded below the ice, the a team from Open University [17] spent the 2019-2020 Antarctic field season in the Outer Recovery ice fields searching for clues to where these meteorites may (or may not) be hiding.

Mass Distribution: An alternative approach to these statistics is to examine the cumulative mass distribution of a population relative to the number of actual meteorites represented. [1,14,15,18] point out that the mass of meteorites found in Antarctic field sites peaks at ~10 g, while those of modern witnessed falls peak at ~5 kg.

When specifically viewing mass distribution between meteorites found in the Antarctic and those from the Sahara, it can be seen that Saharan meteorites in particular, have masses that peak at ~300 g (Figure 1). As discussed previously [18,19], systematic collection of meteorites in Antarctica and elsewhere recovers more small meteorites than do random searches. This conclusion remains logical in light of the fact that small (<2 cm) meteorites are much easier to spot on Antarctic ice than they are in non-Antarctic locations.

[18,19] show that the number of meteorites collected in various locations (including falls) has a wide variation when compared with total mass. However, if these meteorites were all thoroughly examined and put into pairing groups, the number of meteorites after pairing would certainly decrease, and if more small modern falls were actually recovered [18] this discrepancy would be minimized.

When looking at total mass between Saharan and Antarctic meteorites (Table 1), it can be seen that while there are ~3 times fewer Saharan meteorites (~14600 classified) vs. Antarctics (~44000) [20], the mass of Saharan meteorites (31.5 metric tons) vs. Antarctics (6.1 metric tons) is ~5 times higher. The major difference between these two populations of meteorites is that the Antarctic meteorites, in all collections worldwide (United States, Japan, China, South Korea, Europe, etc.), are available to science.

While we may never completely understand all the mechanisms that impact the population of meteorites collected in Antarctica, we can be confident that the Antarctic Meteorite Programs have exceeded expectations for providing a broad sampling of Solar System materials and has had a significant impact on meteorite science.

Mass (g)	Sahara	Antarctica
0-1	8	3793
1-10	270	17837
10-100	4051	16573
100-1000	7457	4992
1000-10000	2193	782
10000-100000	385	70
100000+	3	3
Total Mass (g)	31497193.16	6130434.49
Total Mass (tons)	31.5	6.1

Table 1: Masses of Saharan vs. Antarctic meteorites

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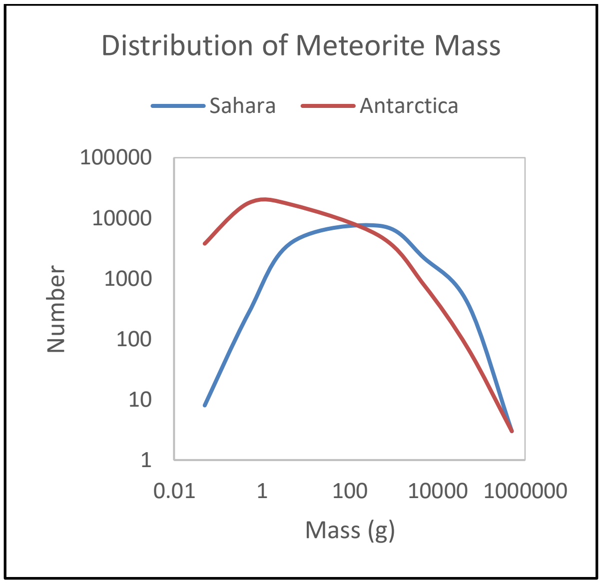

Fig. 1 – *Meteorite mass distribution between Saharan meteorites and Antarctic meteorites from all collections. Mass peaks ~300 g for Saharan meteorites and ~10 g for Antarctic meteorites.*