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The catalog of the meteorite collection of the Italian Museum of Planetary Sciences in Prato (Italy)

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Abstract–For the first time, this paper presents to the planetary scientists' community the catalog of the meteorite collection preserved at the Italian Museum of Planetary Sciences (Museo Italiano di Scienze Planetarie, henceforth MISP) in Prato (Italy). Founded in 2005, MISP is a type specimen official repository approved by the Nomenclature Committee of the Meteoritical Society. It represents one of the few museums worldwide entirely devoted to planetary sciences. The catalog of its meteorite collection encompasses 430 meteorites for a total of 1536 specimens, including 291 thin sections, 184 thick sections, and 278 specimens that MISP has classified. Furthermore, MISP is currently classifying 57 other meteorites. Some samples were found during meteorite recovery expeditions in hot deserts, promoted by MISP in collaboration with diverse Italian universities and national research institutions. MISP also keeps an impact rocks collection comprising 257 samples. In a country like Italy, where most of the collected meteorites are housed in museums whose catalogs are not available online, the publication of the MISP meteorite collection catalog, together with the catalog of the impact rocks collection, represents not only a significant scientific primary source but also a remarkable tool for disseminating meteoritics to nonresearch audiences in educational activities and citizen science projects.

INTRODUCTION

Celestial objects that fall to the Earth from space have captivated the human imagination for millennia. It is therefore not surprising that meteorites have not only undoubtful scientific importance, being the only physical materials, together with samples returning by missions, available on Earth to understand the formation and the evolution of the solar system (e.g., Grady et al., 2014; Russell et al., 2018), but also bear remarkable social and cultural meanings (e.g., Chen et al., 2018; Franza & Pratesi, 2020a; Golia, 2015; Hamacher & Goldsmith, 2013; Hartmann, 2015). So, it is not by chance that, in his classical critique, Burke (1986) argued that meteorites were one of the oldest puzzles humans attempted to solve. Drawing on an extensive range of sources, the author provided an in-depth analysis of meteorites in history that still represents one of the major studies on this subject, together with the research carried out by Marvin (1992, 2006, 2007). Both Burke (1986) and Marvin (2006, 2007) agreed that even before the extraterrestrial origin of meteorites was recognized at the end of the 19th century, meteorites were collected and preserved in nature museums and private collections worldwide (e.g., Aubele, 2018; Dominik & Deferne, 1992; McCall et al., 2006; Muñoz-Espadas et al., 2002; Zucolotto et al., 2000). From then on, meteorites kept in museum collections have been recognized as objects of intellectual interest whose analysis can still provide valuable scientific data that would otherwise remain unknowable. For example, Llorca et al. (2020) have evidenced how the recent investigations of meteorite specimens preserved in natural history museums may lead to the potential discovery of meteorites previously unknown to the scholarly community.

Furthermore, the analysis carried out by Gattacceca et al. (2007) has outlined the importance of reviewing the characterization of specimens analyzed in the past according to up-to-date classification criteria to gather new scientific data. Investigating meteorites in museum contexts may also help authenticate the place of recovery, thus supporting museum curators in possible legal and ethical issues relative to the acquisition of the specimens (Folco et al., 2007; Gounelle & Gounelle, 2019; Schmitt, 2002).

Given all that has been mentioned so far, meteorite collections encompass tangible and intangible significances, as Dorfman (2012) stated. This view is supported by Wilson (2018), who argued that specimens displayed in temporary and permanent exhibitions were both didactic and scientific tools through which visitors learned not only about the formation of the solar system but also how humans have interacted with the cosmos by analyzing the collecting practices of meteorites through the centuries (Allen, 2010; Blumenfeld et al., 2019; Cerceau & Michard, 2006; Corrigan et al., 2018; Hutson et al., 2006; Madiedo, 2013; White et al., 2010). McCubbin et al. (2019) have then defined advanced curation (AC), the cross-disciplinary field that studies the curation of astromaterial collections, including meteorites preserved in science museums. In this regard, the authors outlined how AC aims to improve the technologies to recover meteorite specimens on the Earth, the techniques for their analysis and characterization, and the practices to preserve at the highest possible level of care and stewardship the specimen for research, education, and public outreach.

As reported in the Meteoritical Bulletin Database (MBD), 42 is the number of meteorites recovered in Italy. Despite their small number, data from several studies suggest that Italian meteorites have represented the core of a vibrant scientific debate over the centuries (Agostini & Fioretti, 2013; Baldanza et al., 1970; Baldanza & Triscari, 1985; Barbieri et al., 1997; Bhandari et al., 1989; Bonatti et al., 1970; Cevolani, 2005; D'Orazio et al., 2004; Fioretti & Zipfel, 2004; Grier et al., 2004; Levi Donati, 1967; Levi Donati et al., 1980; Levi Donati & Jarosewich, 1971, 1972; Levi Donati & Sighinolfi, 1977; Maras et al., 1979; Marrocchi et al., 2020; Marvin & Cosmo, 2002; Moggi et al., 2017; Nozette, 1979; Tinazzi, 1994; Triscari et al., 1993; Zucchini et al., 2018). For example, the meteorite that fell on Siena in 1794 has been defined by Marvin (1995, 1998) as one of history's most consequential falls because the analysis of the recovered samples contributed to the acceptance of meteorites' cosmic origin in the early 1800s. Furthermore, Italian meteorites were pivotal in establishing new meteorite groups over the centuries. For instance, the meteorite that fell on January 15, 1824 near the parish of Renazzo was identified as the type specimen of the CR (Renazzo-type) chondrites in the second half of the 20th century (Cevolani, 2001; Ebel et al., 2008; Franza & Pratesi, 2020b; Zagnoni, 1985), while the meteorite that fell near the township of Vigarano on January 22, 1910 was recognized as the type specimens of the CV (Vigarano-type) chondrites (Trevisani, 2011). There is then a large number of published studies that describe how most of the Italian meteorites are preserved in geo-mineralogical museum collections (Baldanza, 1965; Cipriani et al., 1999; Cipriani & Corazza, 1998; Costa et al., 2018; Costa & Gallo, 2009a, 2009b; Fioretti & Finotti, 2012; Folco et al., 2002; Folco & Rastelli, 2000, 2002; Folco & Zeoli, 2005; Franza et al., 2021; Gallitelli, 1974; Perchiazzi et al., 2004; Perchiazzi & Mellini, 1995; Pratesi, 2012; Zuanetti, 1999). In this regard, it has to be noted that most of the catalogs of these collections are not available online, on local repositories, or national databases, thus leaving the specimens they account for in the shadows. This is the case of the Piancaldoli meteorite, fallen in the surroundings of Firenze on August 20, 1968, which has been recently re-examined by Marrocchi et al. (2020) after the first author of the study (Y.M.) was fortuitously informed about its fall while vacationing in Sicily. The episode indicates a need to understand the consistency, in both quantity and quality terms, of the Italian meteorite collections kept in natural history museums and research institutions. In this regard, Sigfúsdóttir (2020) outlined how collection research must be considered a pivotal museum practice equivalent to conservation, preservation, management, and display. A fundamental step in museum research is cataloging since properly documenting the collections leads to the proper intellectual use of each specimen. Furthermore, making the catalogs available online ensures that the specimens are known to anyone interested in studying them. This paper, therefore, set out to present to the planetary scientists' community the catalog of the meteorite collection preserved at the Italian Museum of Planetary Sciences (MISP) in Prato. The reason to focus on the catalog of the meteorite collection housed in this specific institution is that MISP is the only Italian nature museum (and one of the few in the world) to be entirely devoted to the exhibition of extraterrestrial material. MISP is also a type specimen repository officially recognized by the Nomenclature Committee of the Meteoritical Society. Among the diverse type specimens that are preserved at MISP, it is noteworthy to highlight the presence of the Cavezzo meteorite (inv. no. 8527/1), that is, the first Italian meteorite fall recovered on January 4, 2020 by the PRISMA fireball network, which is part of the Fireball Recovery and InterPlanetary Observation Network (FRIPON; Colas et al., 2020; Gardiol et al., 2021; Pratesi et al., 2021; Figure 1).

MISP's earliest roots date back to the 1990s when the Province of Prato decided to actively promote the dissemination of scientific culture into local communities through a model leading to a global perspective. MISP opened to the public on March 19, 2005. Since its early

FIGURE 1. The Cavezzo meteorite. MISP Inventory number 8527/1. Specimen weight 52.19 g.

years of activities, the museum staff operated not only in preserving and enhancing the meteorite collection through the development of cultural and educational activities but also in its enrichment through the organization of research expeditions in hot deserts—that is, Adrar and Erg Chech (Algeria), Hammadah al Hamra (Libya), Hadramawt (Yemen), Libyan desert in Egypt, al-Kufra (Libya), Acfer (Algeria), Atacama (Chile)—to recover new specimens (Cigolini et al., 2012; Orti et al., 2010; Pratesi et al., 2005). Regarding the path choice in the exhibition area, MISP organized the meteorite collection on display, combining educational functions and aesthetic concerns with a perspective centered on the needs and interests of the visiting public (Figure 2). The first part of the curvilinear museum pattern guides the visitors from the genesis of the Universe to the formation of the solar system through the representation of the Milky Way, the exhibition of scale models of diverse planets, and educational videos. The exhibition route continues into six sections devoted to illustrating meteorites, tektites, and impact rocks. On these subjects, the visitors can learn, for example, information about meteorite formation, classification, and recognition through wall panels and labels with educational explanations and stories distributed throughout the museum. The MISP exhibition path has thus been designed as a "micro-cultural universe" (Boda, 2016) in which the visitors can network while creating new intellectual scenarios around the specimens by processing their sensory feeling. In this regard, visitors can experience an emotional, intimate, and tactile object–subject engagement while enhancing their interest in learning meteoritics, touching the Nantan meteorite (1516), the largest meteorite specimen preserved in Italy (inv. no. 1363/1, 272 kg). These kinds of hands-on activities performed with meteorite specimens of different types and sizes are also the core of educational programs designed to improve the museum experience and the subject well-being of visually impaired visitors, individuals with autism spectrum disorders, older adults with dementia and their families (Carpino et al., 2017, 2019, 2020; Carpino & Morelli, 2016).

The catalog of MISP meteorite collection (Table S1) comprises 430 meteorites for a total of 1536 specimens, including 291 thin sections, 184 thick sections, and 278 specimens that MISP has classified. Furthermore, MISP is currently classifying 57 additional meteorites. The MISP meteorite collection specimens have been purchased at national and international market fairs, found during research expeditions, or acquired through

FIGURE 2. Italian Museum of Planetary Sciences main hall, where most of the meteorite collection is displayed. In the center of the picture is the Nantan meteorite (MISP inventory number 1363/1) weighing 272 kg.

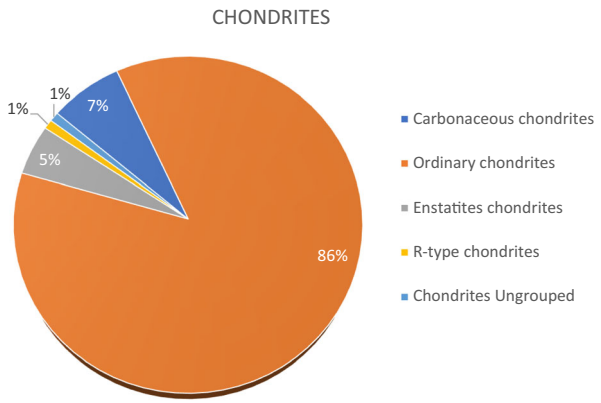

FIGURE 3. Pie chart showing the percentage of the chondrite meteorites in the MISP meteorite collection.

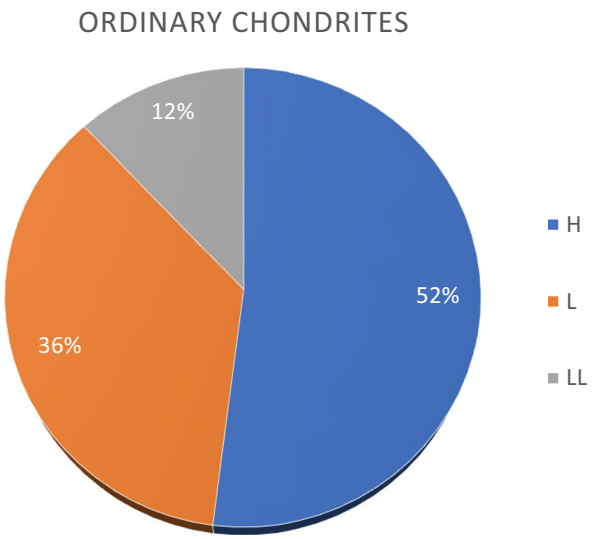

FIGURE 4. Detail of the ordinary chondrites in the MISP meteorite collection.

classification services. In the latter case, the catalog shows that 102 specimens entered the museum through MISP's services for analyzing and classifying meteorites. The type/group statistics of the meteorites in the collection are summarized in Figures 3–8. The catalog of the meteorite collection is available on the MISP official website (https://www.fondazioneparsec.it/it/il-museo-di-scienze-planetarie/catalogo_meteoriti/).

Besides the meteorite specimens mentioned above, it is noteworthy to highlight the presence of aesthetically relevant specimens such as an Estherville (Shepard, 1879) slice measuring 32 × 30 × 1 cm (inv. no. 2267/1; Figure 9); an Imilac (Buchwald, 1973) slice 40 × 35 × 1 cm in size (inv. no. 2308/1; Figure 10); a slice of the Seymchan meteorite (Van Niekerk et al., 2007) measuring 40 × 30 × 2 cm (inv. no. 5075/1); and one Martian Dar al Gani 670 (Folco & Franchi, 2000) shergottite meteorite specimen weighing 688 g (inv. no. 2325/1; Figure 11). It is

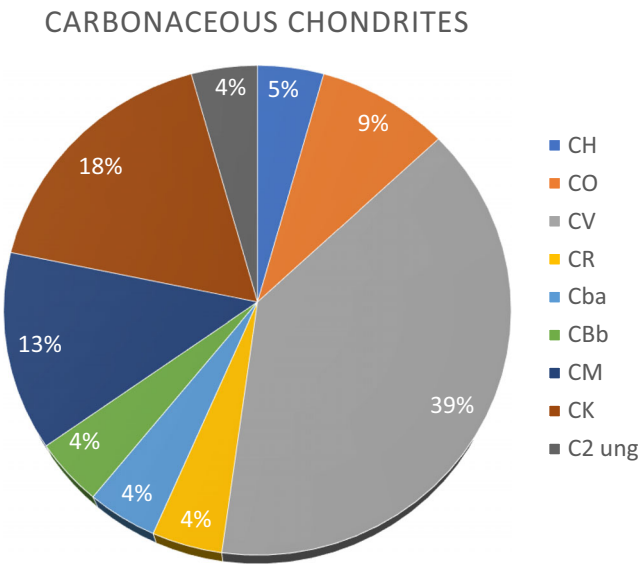

FIGURE 5. Insight into the carbonaceous chondrites in the MISP meteorite collection.

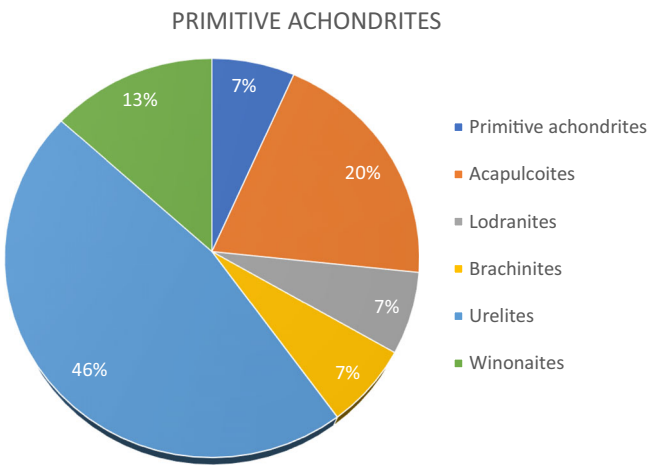

FIGURE 6. Graph displaying the primitive achondrites in the MISP meteorite collection.

then worth observing that a significant part of meteorites preserved at MSP has been cataloged using the Italian national standard for cataloging planetological heritage (BN-PL), and the resulting catalographic datasheets have been published in full Open Access on the General Catalog of Cultural Heritage, which is the official database of the Italian Minister of Culture (https://catalogo.beniculturali.it/search/typeOfResources/NaturalHeritage?typology=Beni+naturalistici-Planetologia&cis=Museo+di+Scienze+Planetarie). This database also presents the meteorite collections kept in the Natural History Museum of the University of Firenze and the Felice Ippolito National Antarctic Museum in Siena (Franza et al., 2022).

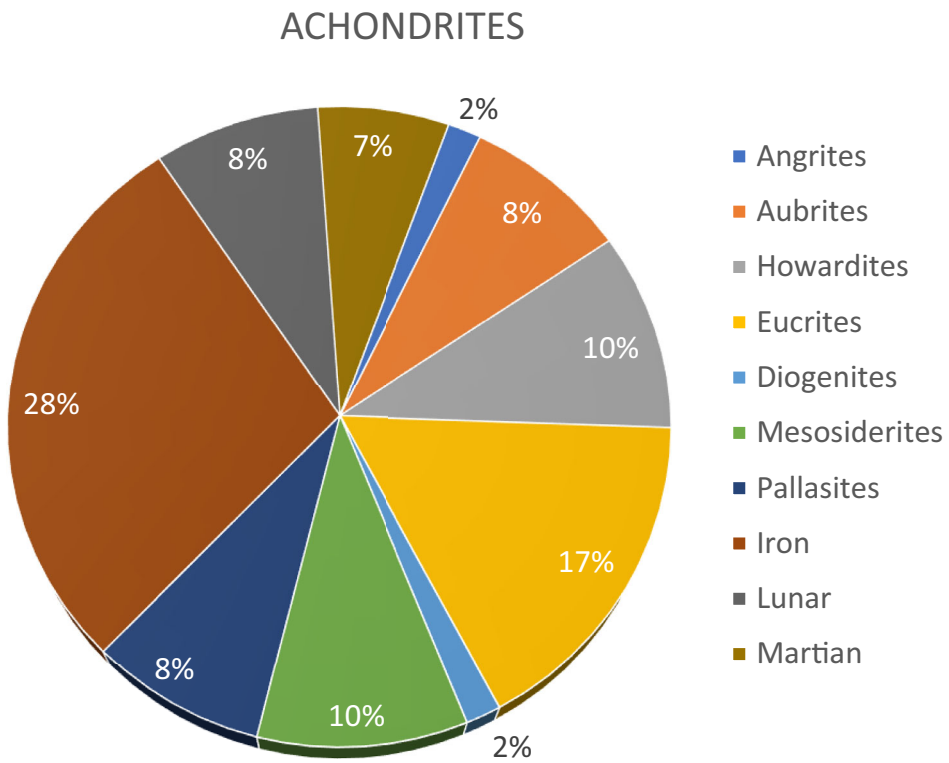

FIGURE 7. Pie chart outlining the percentage of the achondrites in the MISP meteorite collection.

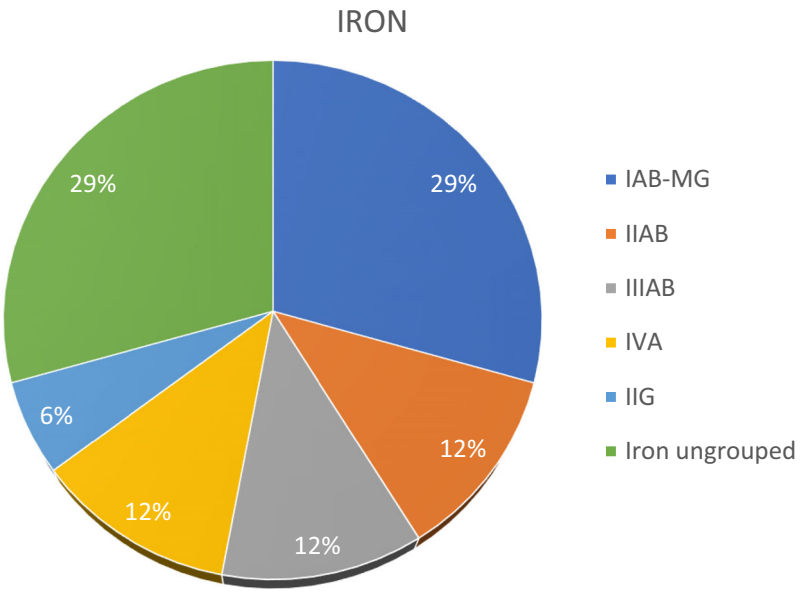

FIGURE 8. Detail of the iron meteorites in the MISP collection.

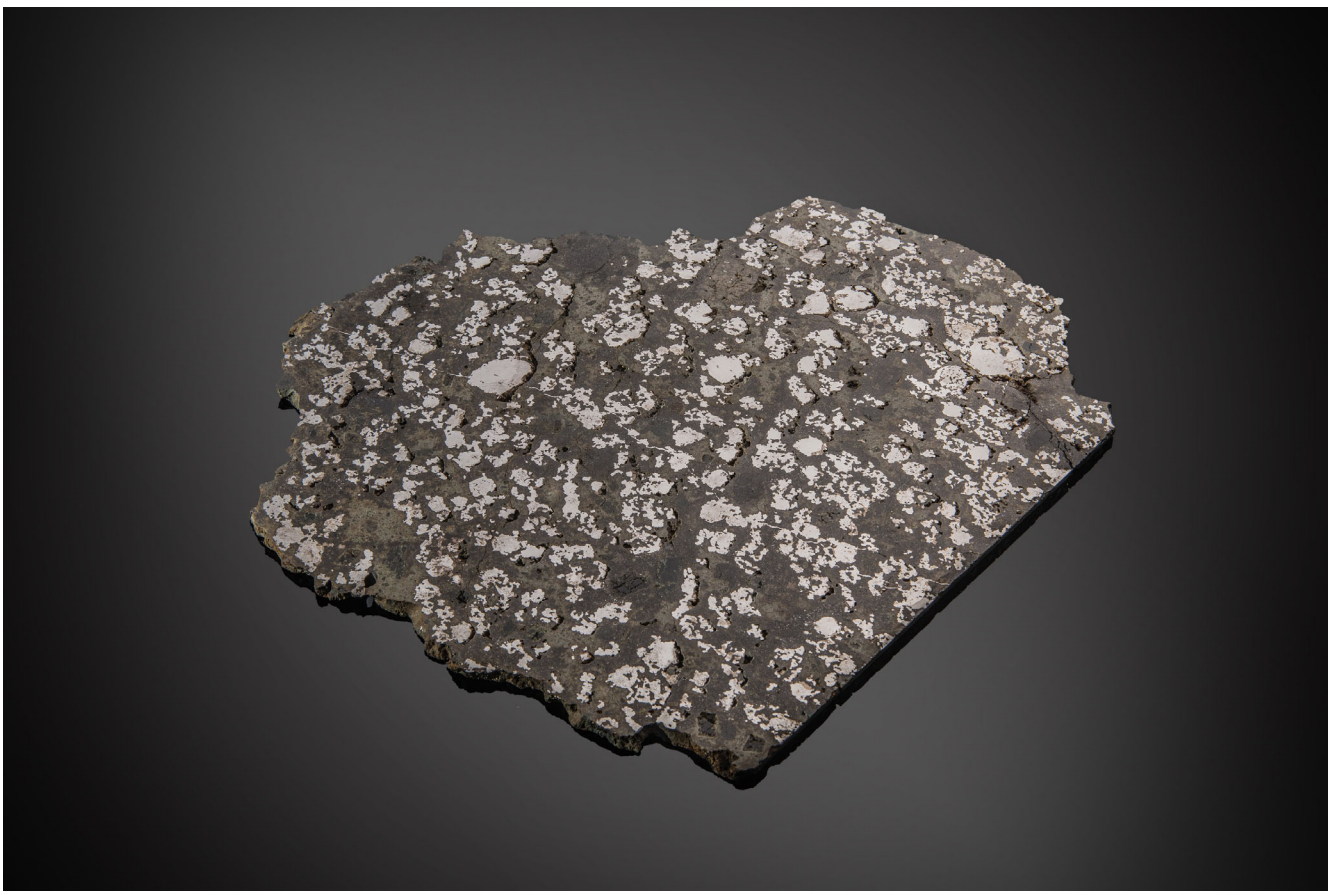

FIGURE 9. Estherville meteorite slice. MISP inventory number 2267/1. Size 32 × 30 × 1 cm.

Following the catalog of the meteorite collection, this paper presents the catalog of the impact rocks kept at MISP. The specimens listed in Table S2 are grouped according to confirmed terrestrial impact structures, unconfirmed terrestrial impact structures, and unidentified impact structures.

FIGURE 10. Imilac meteorite slice. MISP inventory number 2308/1. Size 40 × 35 × 1 cm.

FIGURE 11. Dar al Gani 670 meteorite. MISP inventory number 2325/1. Weight 688 g.

MISP collections are open to the public from Tuesday to Sunday, and guided tours must be pre-booked. Research loans can be requested by filling out the form on the MISP website (https://www.fondazioneparsec.it/media/filer_public/3f/a6/3fa62175-1def-438b-bb29-2c9cda90e5d7/loan_req__museo_scienze_planetarie_mod_feb2023_per_sito_.doc).

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article.

Table S1. Catalog of the MISP meteorite collection. The weight of the specimens is in grams. In gray are the meteorites whose classifications have been submitted to the Nomenclature Committee of the Meteoritical Society to be approved as new meteorite names.

Table S2. Catalog of the MISP impact rocks collection.