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# Meteorites as a Scientific Heritage

# Os Meteoritos como Património Cientifico

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## Abstract

This paper investigates the importance of meteorites as a scientific heritage. While the significance of meteorites as natural heritage is relatively easy to establish, the implication of their meaning as scientific heritage may be more difficult to define. With this aim in mind, in this paper, we present the catalogue standards for meteorite specimens, preserved either in natural history museums or in private collections, proposed by the Italian Istituto Centrale per il Catalogo e la Documentazione–ICCD (Central Institute for Catalogue and Documentation). This work outlines the structure of the catalogue card that describes the meteorite specimen along with other information related to the sample (e.g., archival documentation on collectors and traders, museum catalogues and inventories, general bibliography). This essay concludes discussing the cataloguing, according to ICCD standards, of two Renazzo meteorite specimens, which fell in the eponymous Italian village in 1824 and are now preserved at the Natural History Museum of the University of Firenze.

**Keywords**

Natural heritage; Scientific heritage; Cultural heritage; Meteorites; Preservation policies; Catalogue

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## Resumo

O presente artigo investiga a importância dos meteoritos como património científico. Enquanto a relevância dos meteoritos como património natural é relativamente fácil de estabelecer, a implicação do seu significado como património científico poderá ser mais difícil de definir. Com esse objectivo em mente, no presente artigo apresentam-se as normas de catálogo para espécimes de meteoritos preservados, quer em museus de história natural, quer em coleções privadas, propostos pelo Istituto Centrale per il Catalogo e la Documentazione–ICCD (Instituto Central para o Catálogo e Documentação). A estrutura do cartão de catálogo que descreve o espécime de meteorito, juntamente com outras informações relacionadas com a amostra (e.g. documentação de arquivo sobre colectores e comerciantes, catálogos de museus e inventários, bibliografia geral), é aqui delineada. Conclui-se com a discussão da catalogação de acordo com os padrões do ICCD, de dois espécimes de meteorito Renazzo, que caíram na aldeia italiana homónima em 1824 e que estão agora preservados no Museu de História Natural da Universidade de Florença.

**Palavras-chave**

Património natural; Património científico; Património cultural; Meteoritos; Políticas de preservação; Catálogo

## Introduction

More than 50 tons of extraterrestrial material hit the Earth every year [1-2]. Meteorites are natural objects that have survived passage through the atmosphere and have reached the ground. An important difference exists between meteorite falls and meteorite finds: the former are meteorites collected after their fall was witnessed by observers or camera networks designed for monitoring fireballs; the latter are meteorites that were recovered by people but whose fall was not seen [3]. Each meteorite found is given a name by the Nomenclature Committee of the Meteoritical Society, usually that of the closest geographical landmark where it fell or was recovered. All known meteorites recognized by the Meteoritical Society are then included in the Meteoritical Bulletin Database (https://www.lpi.usra.edu/meteor/metbull.php), a digital repository for basic information such as meteorite classification, place and year of discovery, whether it was observed to fall and references to catalogues (i.e., Catalogue of Meteorites from the Natural History Museum in London, MetBase, Antarctic Meteorite Newsletter) in which the meteorite is described.

Meteorites have been falling from the sky for aeons and have been investigated by scientists from a number of various disciplines. In 1858, Karl Ludwig Reichenbach (1788-1869) defined meteorites as cosmological, astronomical, physical, geological, chemical, mineralogical, and meteorological objects, highlighting the fact that they can be studied from different perspectives [4]. Even the term 'meteor' did not have the meaning it has got at the present. In his *Lexicon Technicum*, John Harris (1666-1719) described meteors as "various impressions made upon the Elements, exhibiting them in different forms […] for the most part, they appear up in the Air, and they are either Fiery, Airy, or Watery" [5]. This description stemmed directly from Aristotle's *Meteorologica* (about 340 B.C.). The meteorological tradition, as stated by Jankovic (2006), remained entrenched in the Aristotelian view until the early nineteenth century when naturalists such as Ernst Chladni (1756-1827), Edward Howard (1774-1816) and Jean-Baptiste Biot (1774-1862) established the extraterrestrial origin of meteorites [6-8]. It is beyond the scope of this article to attempt a comprehensive reconstruction of the history of the meteoritics [9-10], nonetheless, even before scholars were convinced of the reality of meteorite falls from the outer space, meteorites were preserved in naturalistic museums and private collections throughout the world. In this regard, Burke [10] noted that the development of mineralogical collecting in the eighteenth century aided the recovery of meteorite specimens to the point that, after the mid-nineteenth century, meteorites collection became a symbol of a nation's scientific prestige and political power [11-13]. Burke [10] further pointed out how, between the late nineteenth and early twentieth century, the major European and American meteorite collections were established and opened to the public. From then on, the specimens in these collections have become an important source of extraterrestrial material for research purposes [14-18]. Hartmann's and Golia's [19-20] studies emphasize how meteorites have a social and cultural history, being surrounded by a significant corpus of myths, legends and folklore. In this regard, there have been numerous studies to investigate

recorded accounts of meteoritic events in the oral traditions of Native Americans and Indigenous Australians [21-22]. For instance, the following studies were conducted using first-hand ethnographic records, literature, and field trip data to locate possible new impact structures or meteorites in Australia [23-26]. A number of authors have also recognized the use of meteorites in ancient human artefacts [27-32]. In short, as rightly remarked by Dorfman [33], the literature pertaining to meteorites in history strongly suggests that meteorites hold many levels of intangible heritage [34]. On this subject, a recent study by Wilson [35] concluded that the way in which planetary science is represented in natural history museums contributes to demonstrating the role of natural heritage as a means of moral and social witnessing. The author argued that in temporary or permanent exhibitions focusing on the formation of galaxies, stars and planets (e.g., the temporary exhibition 'The Evolving Universe' in The Arthur Ross Hall of Meteorites at the American Natural History Museum in New York, and the permanent exhibition 'Kosmos & Sonnensystem' in the Museum für Naturkunde in Berlin), visitors observe, through the display of meteorites, not only the cosmic processes that have shaped the Solar System, but also how humans have interacted with this aspect of the environment thanks to the recovery and the analysis of meteorite fragments. Wilson [35] further points out that meteorite exhibitions demonstrated "how humanity is not the measure but a component in a wider system that is dependent upon the relationships that are built within it".

As stated before, meteorite collections are the subjects of studies looking into the evolution of both the universe and our planets [36-40]. Within these research projects, the analysis of historical documents, museum catalogues and inventories can lead both scientists and historians to the potential discovery of meteorite specimens previously unknown [41-43]. Meteorite collections in natural history museums are therefore representative of scientific as well as historical and cultural meanings that add extra value to a specimen. The issue that then naturally arises is how best to define museum meteorite collections in the heritage context. Revisiting the questions posed by De Chadervian [44], we can ask why meteorite collections in natural history museums are an issue we are invited to think about? Has the way in which meteorite specimens are valued and collected changed? Is the access to the samples an issue? Are science historians, museum curators and planetary scientists raising the issue?

These questions are especially true for the meteorites that have been recovered in Italy over the centuries. Due to physiographic factors, Italian meteorites are extremely rare and to date only 42 meteorites–both falls and finds–have been officially approved by the Meteoritical Society. In spite of their small number and their belonging to a rather common typology (among these, 25 are ordinary chondrites) the study of Italian meteorites has long been the subject of intense historiographic and theoretical debates [45-51] such as the lively controversy that arose after the shower of stones that fell on Siena on 17 June 1794 [52-53]. Furthermore, Italian meteorites, such as those of other Western countries, are particularly sought out in the collector market due to their rarity. This can sometimes lead to false 'discoveries' designed to meet this market demand,

e.g. the compelling case of the Castenaso meteorite in 2003 [54]. Some authors have also suggested that increased commerce in meteorites raises legal and ethical questions for museum curators, considering that international law about meteorite acquisition is non-uniform [55-56]. Natural history museums preserve the majority of the Italian meteorites known, as well as archival sources regarding the history of their discovery. These collections are repositories of specimens, documents and artefacts that allow reconstructing the processes by which they were assembled, beginning from the late seventeenth century, as the result of diverse cultural practices that involved different persons, places and things [57-62].

Starting from the methodological approach presented by Alberti [63], this work revisits the metaphor of "unpacking museum collections", proposed by Byrne et al. [64], in the light of the establishment of cataloguing standards for meteorite specimens. The creation of a standardized cataloguing card, elaborated by the Italian Central Institute for Catalogue and Documentation (Istituto Centrale per il Catalogo e la Documentazione–ICCD henceforth) together with museologists and academics, describes meteorite collections as a scientific heritage, problematising the specimens as both naturalistic and cultural objects through the compendium of data about their minerochemical classification, the roles they had over the times and in contemporary planetary science, the social relations they formed and the interactions they continue to have with varied persons and groups (i.e., collectors, scholars, museum curators and visitors) within a complex network of agency. As Godsden et al. [65] and Bennett [66] have noticed, this agency does not end with the specimen acquisition, but it continues in the procedures of display as well as in the social and cultural practices or researching and learning which arise from the study of the single meteorite sample [67] (Figure 1).

**Figure 1.** Ordinary chondrite meteorite with fusion crust (weight 2236 g). Museum of Planetary Sciences–Prato, Italy, Inv. No. 1413/1.

The management of the catalogue cards through the SIGECweb digital database then shows how meteorite collections have not only a documentary value, but they represent a scientific heritage, the study of which helps to increase and improve our understanding of the cosmos, through the sharing of data otherwise unknown to the scientific community [68].

## The standardized cataloguing of meteorite collections

Much has been said about the concept of heritage in museum studies [69-70]. Quoting the expression proposed by Boundia and Soubiran [71], the "heritage fever"–and thus the notion of heritage–has been the subject of countless studies since the 1980s. De Chadarevian [44] underlined how the term 'heritage' usually indicates "something preserved from the past"–from artefacts to buildings, from cities to landscapes–but also living cultures and intangible heritage (i.e., gestures, feasts, ceremonials) according to the definition proposed by the UNESCO [72]. Policies for safeguarding and management both material and intangible heritage have been developed by the International Council of Museums (ICOM), which established a new international committee dedicated to the cultural heritage of museum universities (UMAC) in 2002 [73-74]. In 2005, the Committee of Ministers of the Council of Europe adopted the Convention on the Value of Cultural Heritage for Society (also known as the Faro Convention), which emphasizes the concept of heritage and its relationships to communities and society [75-76].

Lourenço and Wilson [77] advocate the view that, while natural or industrial heritage are concepts of immediate understanding, the notion of scientific heritage is "diverse, complex, multi-layered, and more difficult to define." The authors then underline how the concept of scientific heritage lies "at the intersection of two distinct and complex worlds–the world of science and the world of (cultural) heritage." In this context, the term 'heritage' refers not only to buildings and landscapes of historical value (e.g., astronomical observatories and botanical gardens) but also–and among many others–to anatomical preparations, scientific instruments, herbaria, fossils, archives and documents, ethical issues in conducting research and teaching practices, meteorite specimens. This material is often dispersed in scientific museums or institutions and university collections [78-84].

Scientific heritage, due to the variety of the material and immaterial media that it encompasses, raises broad-spectrum issues related to its preservation, conservation and dissemination. The problems related to the preservation of meteorite collections concern, for instance, the transfer of the specimens into research and teaching laboratories making the samples more exposed to the risk of damage or loss. This is especially true when samples are involved in inter-institutional loans under international research agreements. In this section, we, therefore, discuss how the standardized cataloguing of meteorites preserved in natural history museums–whether

historical or newly acquired specimens–can prove to be a useful tool to safeguard their roles and identities as well as to promote their scientific heritage preservation and use (Figure 2). The case study research has been conducted on the legislation and regulations promoted in Italy regarding the standardized cataloguing of the planetological heritage (*beni planetologici*).

**Figure 2.** Acfer 371 oriented meteorite showing well visible regmaglypts (weight 9608 g). Museum of Planetary Sciences−Prato, Italy, Inv. No. 2282/1.

The decree 22 January 2004, n. 42 (*Codice per i Beni Culturali e del Paesaggio,* Code for Cultural Heritage and Landscape) acknowledged as cultural heritage all the collections preserved in public museums and institutions in Italy regardless the typology of the objects that are part of it (art. 10, part 2, letter a). In Attachment A (n. 13), the Code directly mentions as cultural heritage "collections and/or specimens belonging to zoological, botanical, mineralogical and anatomical collections." In 2007, the Ministry of Cultural Heritage and Activities (*Ministero per i Beni e le Culturali e per il Turismo*–MiBACT) in collaboration with the Conference of the Rectors of the Italian Universities (*Conferenza dei Rettori delle Università Italiane*–CRUI), ENEA (*Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile*), ICCD, the National Association of Scientific Museums (*Associazione Nazionale Musei Scientifici*–ANMS) scholars and museum practitioners, established a standardized procedure to catalogue objects identified as natural heritage. The ICCD realised six different catalogue cards for: botanical specimens (*Beni Naturalistici, Botanica*–BNB), paleontological specimens (*Beni Naturalistici, Paleontologia*–BNP),

zoological specimens (*Beni Naturalistici, Zoologia*–BNZ), mineralogical specimens (*Beni Naturalistici, Mineralogia*–BNM), petrological specimens (*Beni Naturalistici, Petrologia*–BNPE), planetological specimens (*Beni Naturalistici, Planetologia*–BNPL). The last type of catalogue card has been defined for the study of meteorite samples.

Tucci [85] noted that all the catalogue cards, generally speaking, contain: (a) both descriptive and more detailed data, which highlights the cultural value of the catalogued specimen; (b) geographical information (i.e., the place of recovery, the place where the specimen is actually preserved and/or previous institutions where it was stored); (c) information about other data possibly related to the specimens (i.e., archival documents, museum catalogues and inventories); (d) administrative data such as economic evaluations. The structure of the data is then organized in a series of sections, which are dedicated to a specific topic (e.g., identification of the specimen, location, scientific and historical background, technical data, archival or general documentation). Each catalogue card presents a set of guidelines for the standardized filling of the sections (i.e., which sections must be completed, which can be repeated for additional information, which need the use of a predefined vocabulary) as well as for management of the catalogue card on the digital database (SIGECweb). About filling some sections according to a predefined terminology, the ICCD guidelines provide for the use of an 'open' vocabulary or a 'closed' vocabulary. Open vocabularies consist of lists of terms that can be increased during the editing of a catalogue card, with the insertion of new headwords by the cataloguer. The proposals for updating the vocabularies are subsequently submitted to a scientific verification committee and, in case of acceptance, they are officially published on the ICCD website. Closed vocabularies consist of a series of predefined terms that cannot be updated by the cataloguer. Open and closed vocabularies may be formed by a list of terms, definitions, references to primary sources or general bibliography, thesauri. The cataloguing activity can be conducted at a (1) inventory level (i.e. the level of minimum information required for the correct preservation of the specimen as well as for the planning of conservation and valorisation activities); (2) pre-catalogue level that provides additional information deduced from the direct observation of the specimen; (3) catalogue level, which corresponds to a more in-depth study of the specimen (e.g., bibliographical and archival research). It is noteworthy to mention that the cataloguing system here described can be arranged from (1) to (3) depending on the type of sample to be catalogued. However, the main objective of any cataloguing level remains the precise identification of the specimen and its historical, cultural and geographical background, in order to emphasize the network of relations between the natural heritage and the territory [86-89].

## How to catalogue a meteorite? The cataloguing card BN-PL

The catalogue card BN-PL consists of more than 400 sections. It is therefore not possible to describe all the individual sections, so this study discusses the most

significant paragraphs of the card for the correct preservation, conservation and valorisation of a meteorite specimen [90-91].

After having established which institution is carrying out the cataloguing activities, the Object Section (OS) contains the essential information for the identification of the catalogued specimen. The name of the collection to which the specimen belongs must then be indicated in full. The Meteorite Systematics Section (MSS) provides for information about the classification of the specimen based on its mineralogical and petrographic characteristics as well as on its whole-rock chemical and O-isotopic compositions [3] (Figure 3). As Weisberg et al. [92] rightly pointed out meteorite classification is the basic framework from which planetary scientists and cosmochemists work and communicate. The process of classification evolves with both the collection of new data and the discovery of unknown meteorite types. Therefore, it is also very important to reanalyse the historical meteorites in order to confirm their extra-terrestrial origin and to revise their classification. This is the reason why the catalogue card must provide accurate information about the meteorite analytical data.

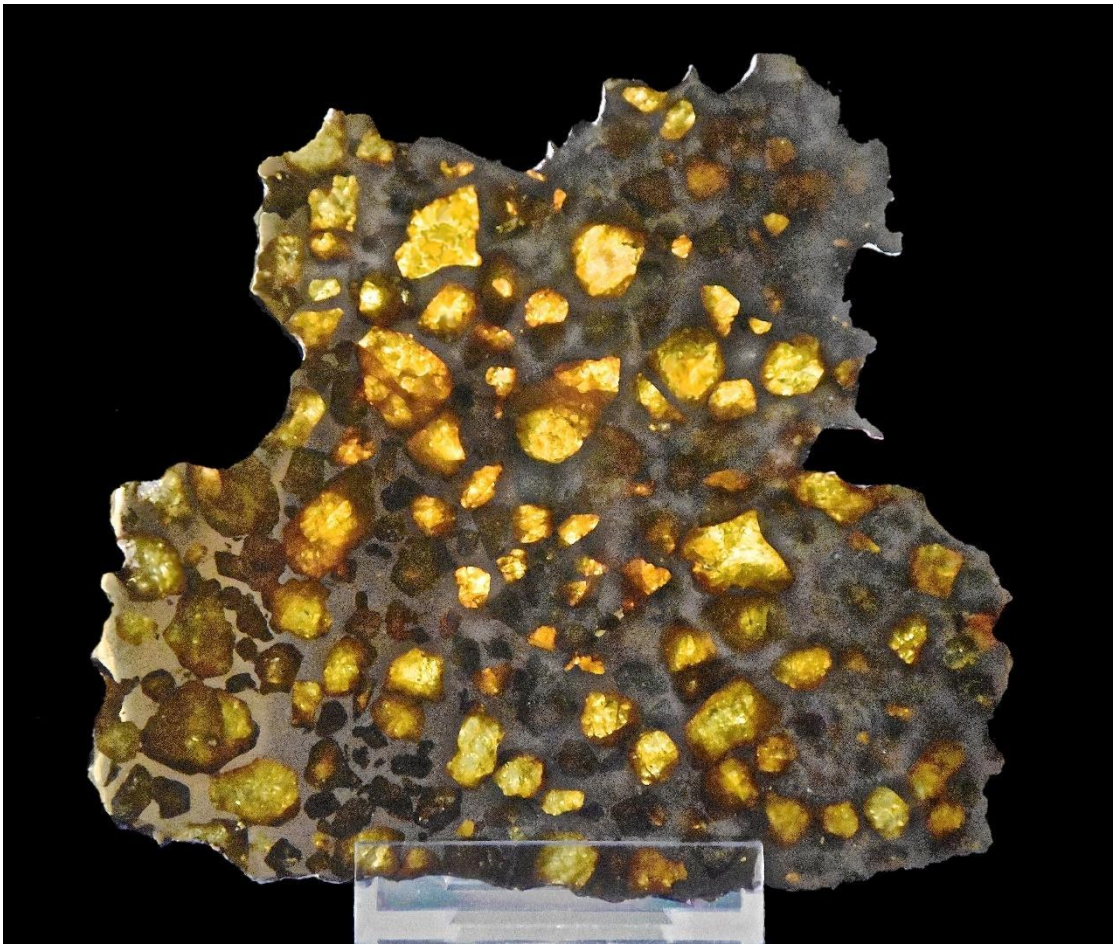

**Figure 3.** Slice of Imilac pallasite with olivine crystals embedded in metal (weight 199 g). Museum of Planetary Sciences - Prato, Italy, Inv. No. 1394/1.

The MSS section then contains information if the specimen was a fall or a find. This is an important distinction because finds are more prone to contamination with the terrestrial environment, depending on the time they spent on the ground [3, 92]. Most of the meteorites actually preserved in Italian natural history museums are falls. Nonetheless, in the last two decades, diverse institutions have increased their meteorite collections with finds recovered in hot and cold deserts [60, 93]. It is important to note that the date of the meteorite fall could not be the same as of the meteorite recovery. For instance, fragments of the Sikhote-Alin meteorite (Figure 4), which fell on the eponymous Russian mountains on 12 February 1947, are still being found today. The MSS then contains information about where the holotype is preserved and who holds the biggest meteorite specimen (i.e., naturalistic museum or private collector). Within this section, the cataloguer can also enter data about the presence of meteorite fragments, thin sections and powder available for loan as well as general bibliography and any information taken from museum catalogues, inventories or original exhibition labels.

The subsequent section is dedicated to Meteorite Collection Data (MCD). In these paragraphs shall be included data about the year and the place where the meteorite specimen was found and any information concerning the scientific expedition that led to its discovery. As stated before, meteorites are given names based on the location in which they were recovered. Fragments from cold or hot desert areas are given names and numbers. For instance, Istifane 005 is a meteorite find that was collected in the Moroccan ridge of Istifane in 2017, and it is now preserved at the Florentine Natural History Museum. The cataloguer can specify all this information in MCD as well as other data about the mineralogical and petrographic characteristics of the collected meteorite. A specific sub-section is then devoted to the description (about 2000 characters) of the paper labels attributed to the specimen during the meteorite-hunting expedition.

After providing detailed information on the scientific institution or the natural history museum preserving the specimen, the BN-PL catalogue card provides an economic evaluation of the meteorite fragment along with information about the collector and the collection in which the specimen is included. The economic evaluation of the single meteorite sample is a very important data that the cataloguing process returns to the community and stakeholders. In recent years there has been a growing interest in the processes for determining the economic value of naturalistic collections. This is an indicator useful for establishing the costs of protection, conservation, valorisation and insurance cover against theft, fire, and damage to be used even in the case of loans for temporary exhibitions or study purposes [91, 94-101]. As pointed out by Burke [10], museum curators complained from the 1840s about the prices of meteorites in what seemed to be a chaotic market. An element that seemed to influence this chaotic market was, as Burke [10] further asserted, the total weight of the recovered specimen. In this regard, Buchner [102] made the first attempt to standardize meteorite pricing, listing 263 specimens held in various private and public collections and their total weight. A

few decades later, Wülfing [103] brought Buchner's survey up to date, considering eight factors as determining meteorite exchange values: (1) the amount of preserved material, (2) the total weight of the petrographic group in which the meteorite was classified, (3) the number of owners, (4) the addition of a new fall or find to a group of limited weight, (5) the cost of acquisition, (6) the state of preservation, (7) the historical interest, and (8) whether the meteorite was a fall or a find. The factors 1-3 were then used in a mathematical formula to determine the correct exchange value of a meteorite specimen.

**Figure 4.** Sikhote Alin meteorite (weight 290 g). On the upper side of the specimen, it can be noted a fragment of wood that remained attached on the hot meteorite surface following the impact with a tree. Museum of Planetary Sciences - Prato, Italy, Inv. No. 2241/1.

**Figure 5.** Slice of Nantan iron meteorite showing Widmanstätten figures (weight 3100 g). Museum of Planetary Sciences−Prato, Italy, Inv. No. 1364/2.

All the criteria listed in Wülfing's essay are still valid today and considered within the BN-PL catalogue card. Furthermore, as rightly pointed out by Moggi Cecchi et al. [104] the classification of newfound meteorites according to their mineralogical and petrographic characteristics (Figure 5), carried out by natural history museums on behalf of third parties, is a useful instrument in terms of both economic enhancement of naturalistic heritage and improvement of museum's image in the scientific community. The next paragraph of the BN-PL catalogue card reports the coordinates X, Y where the meteorite fragment was recovered. These parameters are very important because failure to report precise locality information makes it difficult for scientists to pair up recent finds with previous ones [105]. The last paragraphs describe technical and analytical data relative to the meteorite specimens including size, colour, shape, surface, interior features (Figure 6), weight, and magnetic properties. Information about meteorite care, preservation, previous restoration works, and laboratory analysis is also given within these sections.

The BN-PL catalogue card ends with bibliographical data on essays and scientific articles about the specimen as well as references to archival material. In this section, the cataloguer can also upload a high-resolution image relative to the sample along with the photo credits.

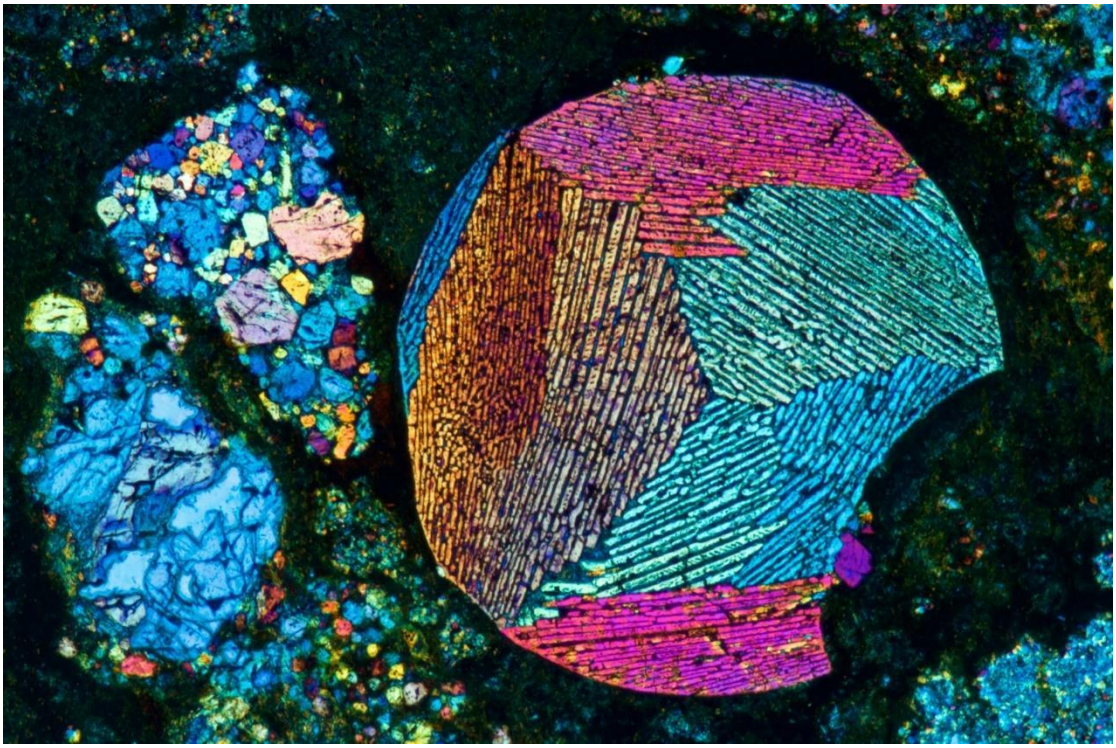

**Figure 6.** Cross polarized nicols image of a chondrite meteorite. It is to be noted the barred olivine chondrule on the right-middle of the image. Museum of Planetary Sciences - Prato, Italy. Photo credit Prof. Bernardo Cesare (University of Padova).

## The Renazzo meteorite (1824): cataloguing a meteorite specimen through the BN-PL card

According to the chronicle written by Francesco Lenzi (dates uncertain) and now preserved at the Historical Archive of Cento [106], on 15 January 1824, a stone fell on the small village of Renazzo, in the current province of Ferrara (Italy). Three fragments of the meteorite were found, one of which was 5 kg, for a total mass of 10 kg. Two weeks later, Camillo Ranzani (1775-1841), the director of the Natural History Museum of Bologna from 1803 to 1841 [107], went to Renazzo to recover as many samples as possible. In 1827, he sent one of these specimens to the French chemist André Laugier (1770-1832) for analysis. The mineralogical and petrographic description of the fragments was then provided by Pierre Louise Antoine Cordier (1777-1861), who was a naturalist and a founder of the French Geological Society [108]. Cordier noted that the sample was not similar to other known meteorites, except for the black and glassy crust which partly covered its surface. On this basis, he classified the specimen as a *meteorite vitreuse* (vitreous meteorite) [109]. Contemporary petrological, geochemical and oxygen isotopic studies have identified the Renazzo meteorite as the holotype of the CR (Renazzo-type) carbonaceous chondrite group because of a set of properties that distinguishes it from other chondrite groups [110]. For this reason, the meteorite

Renazzo is still today one of the most studied meteorites by the scientific community as well as one of the most sought-after on the collectors' market.

The Natural History Museum of the University of Firenze preserves two specimens of the Renazzo meteorite that have been catalogued through the BN-PL card. The first is a specimen of 70 g acquired by the Museum in 1824 (Figure 7, Table 1).


**Figure 7.** The largest sample (70 g) of the Renazzo meteorite preserved at the Natural History Museum of the University of Firenze, Collection of Mineralogy and Lithology (ICCD Cat. No. 1142167).

Table 1 illustrates data regarding the cataloguing of the Renazzo meteorite specimen using the BN-PL catalogue standard. The information shows the date of the fall, where the meteorite was recovered, and its minerochemical classification. Furthermore, the table indicates the state of conservation of the specimen, its economic valuation, and how it was acquired by the Florentine Natural History Museum. In this regard, it is interesting to note the information that stands out from the Sources and Documents (SD) field. This field is repeatable within the BN-PL card and contains all the references relative to the catalogued specimen. In this case, the SD reports the historical documentation about the Renazzo meteorite preserved both at the Historical Archive of the Natural History Museum (HA-NHM) of the University of Firenze and at the Historical Archive of the Galileo Museum (HA-GM). The archival documents kept in HA-NHM reconstructs the trajectories of the Renazzo meteorite specimen within the Natural History Museum through catalogues and museum inventories. Thanks to the study of this material, it is possible to trace the “career” of the specimen from its acquisition in 1824 to 1947, and to analyse the different scientific contexts and the

changes of value incurred by these shifts [111-113]. In this regard, the specimen was described in the *Catalogue of the Mineralogical Collection* (1843-1845) as a "meteoritic iron fallen on 15 January 1824 [112]". It will be necessary to wait until 1947, when the meteorite collection was first inventoried, to see the sample described as a meteorite whose economic value was 130 lire [113].

**Table 1.** Extract of the BN-PL catalogue card for the Renazzo meteorite specimen (ICCD Cat. No. 01142167) preserved at the Natural History Museum (Collection of Mineralogy and Lithology) of the University of Firenze.

| | |
|---|---|
| **ICCD catalogue number** | 01142167 |
| **Name** | Renazzo |
| **Genre** | Chondrite |
| **Class** | Carbonaceous Chondrite |
| **Group** | CR |
| **Fall/Find** | Fall |
| **Date** | 1824 |
| **Definition** | Renazzo Carbonaceous Chondrite |
| **Locality** | Renazzo, Province of Ferrara, Italy |
| **Type of localization** | Recovery location−historical data |
| **Valuation** | 2.500 € |
| **Weight** | 70 g |
| **State of conservation** | Good |
| **Laboratory analysis** | Minerochemical analysis |
| **Date of analysis** | 1998 |
| **Type of acquisition** | Donation |
| **Name of the donor** | Camillo Ranzani |
| **Date of the donation** | 1824 |
| **Sources and documents** | Archivio Storico, Collezione di Mineralogia e Litologia, *Appendice di Aumenti al Catalogo della Mineralogia del 1824,* n. 00525.<br>Archivio Storico, Collezione di Mineralogia e Litologia, *Catalogo della Mineralogia e Orittologia 1843-1845,* n. 7148.<br>Archivio Storico, Collezione di Mineralogia e Litologia, *Catalogo della Collezione di Meteoriti,* 1947, n. 13770.<br>Archivio Storico, Museo Galileo, ARMU Affari 038, Carteggio della Direzione, gennaio-dicembre 1824, c. 37. |

As stated by Alberti [63], collectors, curators, and scientists encountered museum objects in very different ways. For instance, things collected in the field, as meteorite specimens, can be connected to institutions and scientific practices, providing insights into the role of museums in scientific and civic culture. Of this, the HA-GM preserves the *Archivio del Reale Museo di Fisica e Storia Naturale di Firenze* (Archive of the

Royal Museum of Physics and Natural History of Florence), a fund of more than 5700 documents covering a period of almost a century (1780-1872), and representing one of the most important sources to reconstruct the history of the Florentine Natural History Museum and its relationships with the main European scientific institutions. Within these funds, we can trace a letter from the Grand Duke of Tuscany Leopold II (1797-1870) to Girolamo Bardi (1777-1829), Director of Natural History Museum of Firenze from 1806 to 1829 [114-115]. On 23 March 1824, Leopold II sent to Bardi an "aerolite that fell in the village of Renazzo on the night of 15 January", which he had received from Camillo Ranzani. The Grand Duke stated that the meteorite was sent to Bardi as Director of the Natural History Museum of Firenze so that he could display it in the mineralogical collections, specifying the name of the donor on the specimen label [114] (Figure 8).

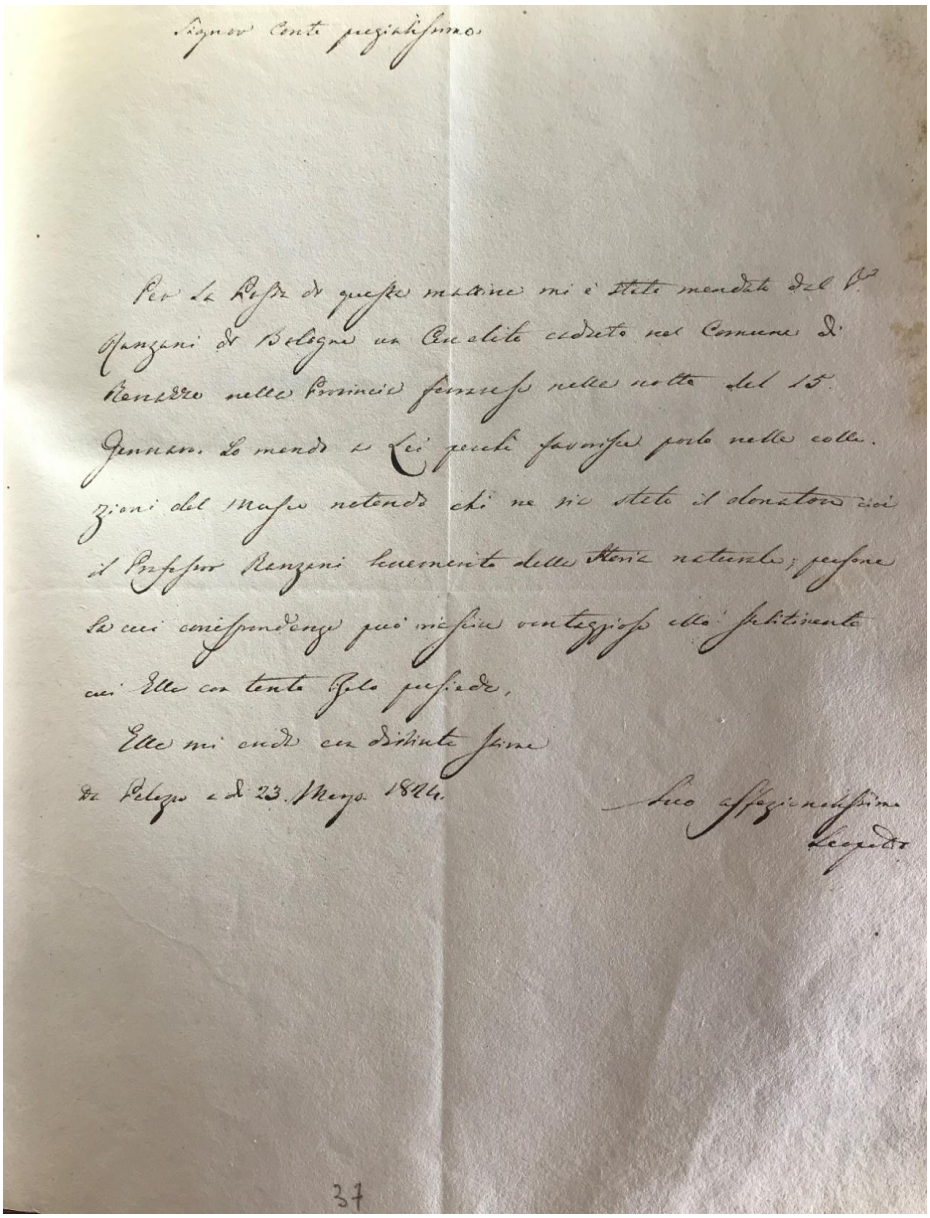

**Figure 8.** Letter of donation to the Florentine Imperial and Royal Museum of Physics and Natural History, by the Grand Duke Leopold II, of an aerolite fallen in the village of Renazzo and sent to him by Camillo Ranzani, 23 March 1824. Historical Archive, Galileo Museum, Firenze.

This important document (Figure 8), which represents the deed of donation of the Renazzo meteorite to the Museum, was found thanks to the cataloguing of the specimen through the BN-PL card. It reveals not only the scientific importance attributed to the meteorite Renazzo since its discovery, but also the primary role played by the meteorite exchange within naturalistic collections [10-11]. Furthermore, it is interesting to note how Ranzani did not send the meteorite specimen directly to Bardi, but to Leopold II, thus confirming the importance of the House of the Habsburg in the mineralogical collecting in the nineteenth century [116-119].

The Natural History Museum of the University of Firenze preserved a second fragment of the Renazzo meteorite, i.e. a small specimen of about 7 g that was acquired by the Museum in 1840 (Table 2, Figure 9).

**Table 2**. Extract of the BN-PL catalogue card for the second Renazzo meteorite specimen (ICCD Cat. No. 01142168) preserved at the Natural History Museum (Collection of Mineralogy and Lithology) of the University of Firenze.

| | |
|---|---|
| **ICCD catalogue number** | 01142168 |
| **Name** | Renazzo |
| **Genre** | Chondrite |
| **Class** | Carbonaceous Chondrite |
| **Group** | CR |
| **Fall/Find** | Fall |
| **Date** | 1824 |
| **Definition** | Renazzo Carbonaceous Chondrite |
| **Locality** | Renazzo, Province of Ferrara, Italy |
| **Type of localization** | Recovery location–historical data |
| **Valuation** | 2.000 € |
| **Weight** | 7 g |
| **State of conservation** | Good |
| **Laboratory analysis** | Minerochemical analysis |
| **Date of analysis** | 1998 |
| **Type of acquisition** | Unknown |
| **Date of the acquisition** | 1840 |
| **Sources and documents** | Archivio Storico, Collezione di Mineralogia e Litologia, *Appendice di Aumenti al Catalogo della Mineralogia del 1820-1844,* n. 02378.<br>Archivio Storico, Collezione di Mineralogia e Litologia, *Catalogo della Mineralogia e Orittologia 1843-1845,* n. 7151.<br>Archivio Storico, Collezione di Mineralogia e Litologia, *Catalogo della Collezione di Meteoriti,* 1947, n. 13771. |

As noted earlier, the museum catalogues provide information for the second Renazzo meteorite fragment since its acquisition by the Natural History Museum in 1840 onwards. The *Catalogue of the Mineralogical Collection* (1843-1845) described the specimen as an "aerolite, year 1824", while the inventory of the meteorite collection (1947) gave the sample a 10 lire value [120-122]. Even if the museum catalogues do not provide further data about the sample except for the year of acquisition, this information is crucial to trace the object's career through archival sources kept in other Florentine research institutions.

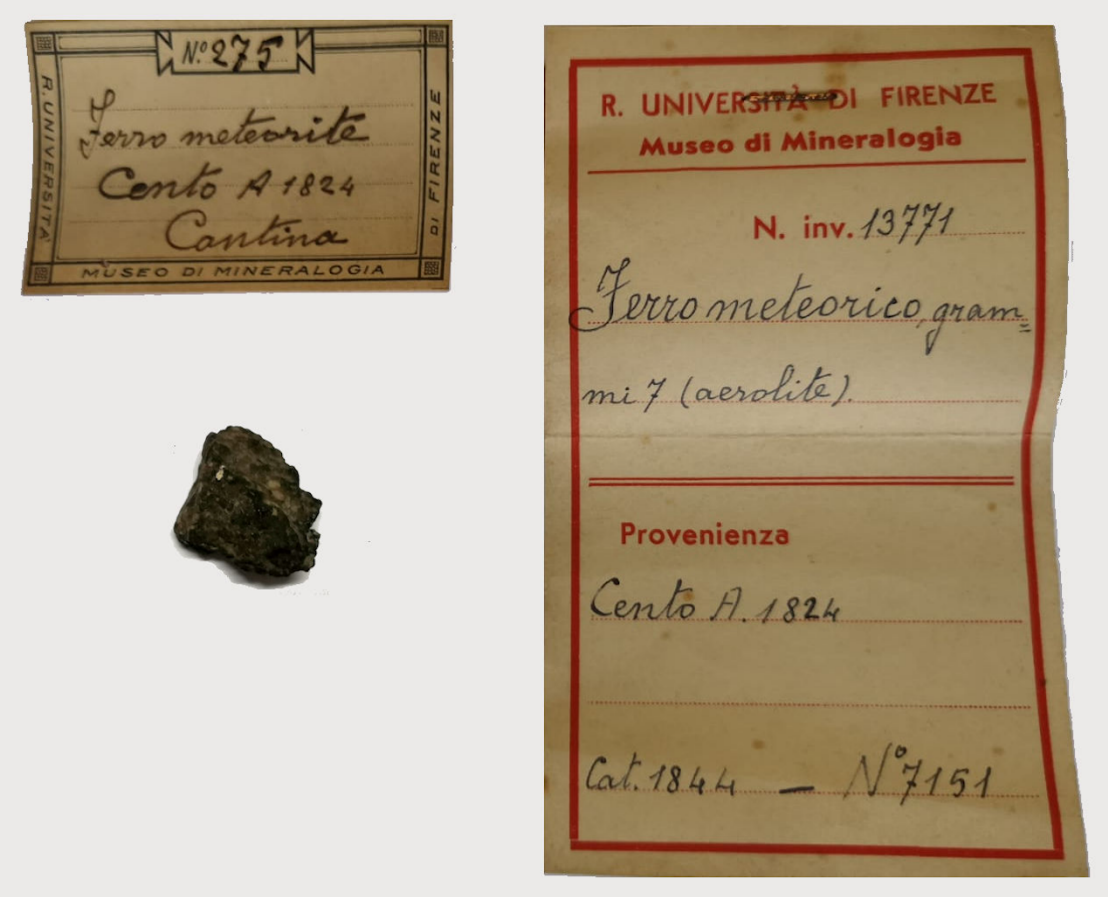


**Figure 9.** The smallest sample (7 g) of the Renazzo meteorite specimen. Natural History Museum of the University of Firenze (ICCD Cat. No. 1142168).

In this regard, the National Library of Firenze preserved the Targioni-Tozzetti Fonds', which includes more than 2500 documents belonging to the Targioni Tozzetti family, and therefore of great interest for the history of physics and natural sciences between the eighteenth and the nineteenth century [123-125]. In this fonds is also preserved the correspondence of Ottaviano Targioni Tozzetti (1755-1826), a naturalist and an expert in mineralogy, who maintained scientific relationships with the Natural History Museum of Firenze. The analysis of Ottaviano Targioni Tozzetti's scientific correspondence showed how his studies on meteorites were well known to the scientific community of the time, to the point that he had a close exchange of letters with Ambrogio Soldani (1733-1808) about the mineralogical analyses carried out on the

Siena meteorite (1794) [52-53, 126-128]. On 13 July 1824, Ottaviano Targioni Tozzetti received from Camillo Ranzani "a very small fragment of the aerolite that fell on Renazzo" in exchange for "fossil bones from Valdarno, in particular hippopotamus and rhinoceros' bones" [129] (Figure 10). On 18 December 1824, Ranzani wrote a second letter to Targioni Tozzetti to thank him for the historical notes he sent about the "aerolites fallen on Italy" that Ranzani will use as a preface to his "book on the aerolites that fell on the Cento area this year." Ranzani was, therefore, preparing to write an essay on the meteorite of Renazzo (Cento is the largest city near the place of fall). The book was never published, as Ranzani had predicted in his letter to Targioni "but when will I be able to write this book? God only knows" [130].

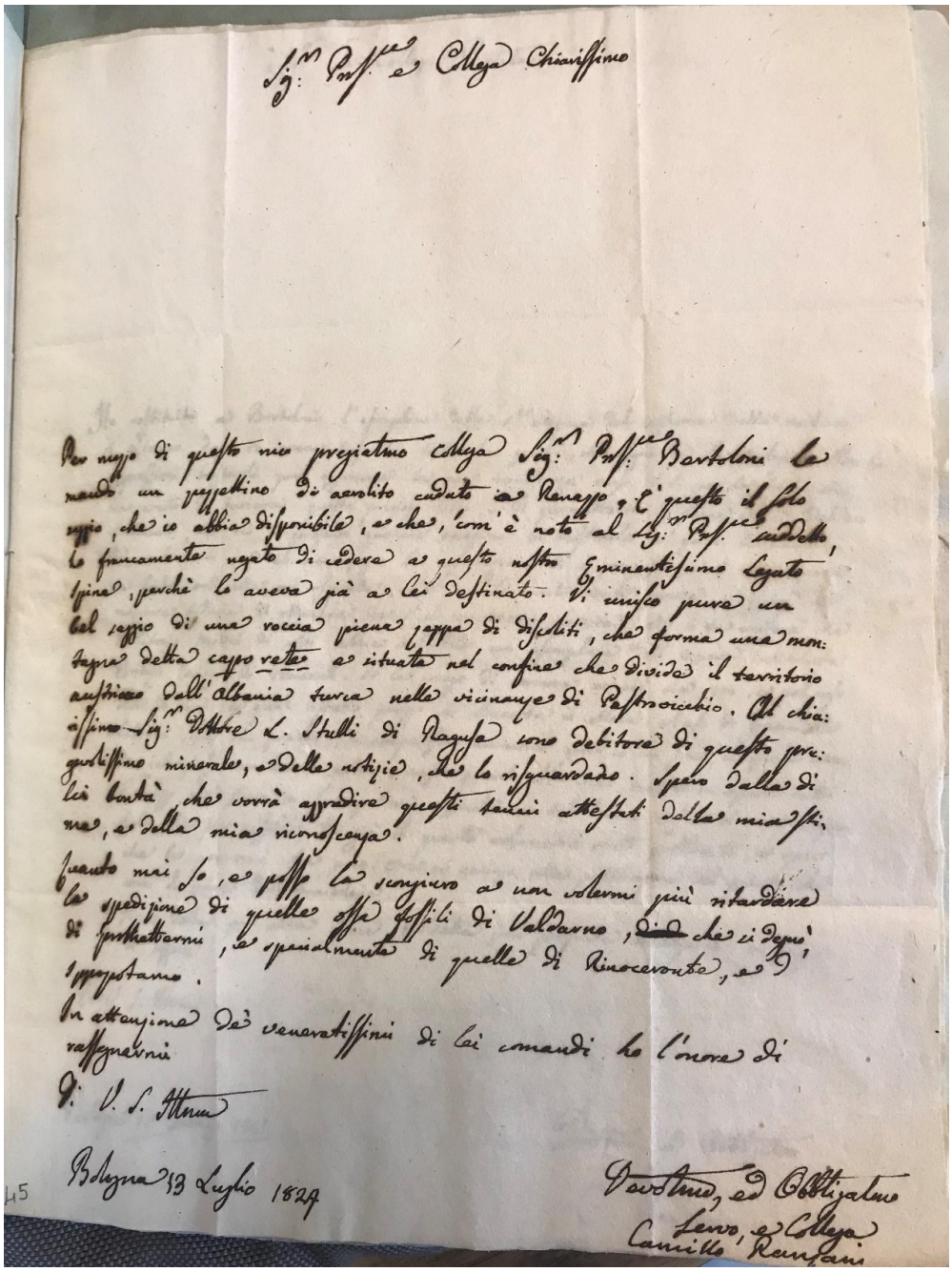

**Figure 10.** Letter sent to Ottaviano Targioni Tozzetti by Camillo Ranzani, which deals with the small fragment of the Renazzo meteorite, 13 July 1824. National Library of Firenze.

No further information about the Renazzo meteorite fragment sent by Ranzani to Targioni was available before the specimen was catalogued thanks to the BN-PL card. As already been said, this meteoritic sample was recorded for the first time in the museum inventory in 1840. One year before, although the negotiations had begun in 1836, the mineralogical collection belonging to the Targioni Tozzetti family was acquired by the Natural History Museum of Firenze for a price of 12.000 lire [131-132]. This mineralogical collection was initiated by the naturalist Pier Antonio Micheli (1679-1737), acquired by his pupil Giovanni Targioni Tozzetti (1712-1783) that enriched it and accompanied it with a catalogue in 12 volumes, and at last inherited from Targioni's son, Ottaviano, who added his own collection of minerals [133]. A first survey of the samples was made by the chemist Andrea Cozzi (dates uncertain) at the end of February 1839. Afterwards, the Court Secretariat of the Grand Duchy of Tuscany approved the project presented by the geologist Filippo Nesti (1780-1849) for the arrangement of the Targioni Tozzetti mineralogical collection [134]. From this standpoint, the second Renazzo meteorite specimen preserved at the Natural History Museum of Firenze can be considered as the small fragment that was sent by Camillo Ranzani to Ottaviano Targioni Tozzetti in 1824. It is important to highlight the fact that this result would not have been achieved without the cataloguing of the sample with the BN-PL card, which identified the year of the specimen’s acquisition and therefore linked the archival material about the Renazzo meteorite stored in other Florentine research institutions, with the fragment preserved at the Natural History Museum of Firenze.

## Conclusions

Since the early 1800s, naturalists began to collect meteorites systematically. As might be expected, Chladni was among the first to join this activity (he possessed about 33 specimens in 1820), along with Martin Klaproth (1743-1817), Johann Blumenbach (1752-1840) and Johann Kaspar Lavater (1741-1801) (10, 135). The first catalogue that collected all the meteorite specimens belonging to a museum was published in 1847 by the Natural History Museum of London. Since then the catalogue has been kept up to date and its last and fifth edition was issued in 2001 [136].

Despite the fact that there is still no international standardized regulation for the cataloguing of meteorites, the BN-PL catalogue card proposed by the ICCD proves to be an efficient and scientifically valid instrument for the cataloguing of meteorite collections preserved in Italian naturalistic museums and could represent a useful guideline for an international standard. The use of the BN-PL catalogue standard within the meteorite collection of the Natural History Museum of Firenze has allowed not only the cataloguing of the Renazzo meteorite specimens, but also to trace correctly their historical and scientific background.

In conclusion, cataloguing is an essential part of managing a natural history museum on which are based important museum activities such as research, conservation, risk management, exhibition development and publications. The standardized cataloguing of meteorite collection discussed in this paper proves how meteorite specimens are part of a scientific heritage, which is important to preserve at the highest possible level of care and stewardship.

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