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RESEARCH PAPER

Look at me! The museographic project beneath the Italian Museum of Planetary Sciences in Prato (Italy)

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Abstract

Designing museum exhibitions is a hot topic for architects, designers, museologists, and scholars since museography represents a powerful tool for valorizing collections, promoting education, communicating cultural values, and ensuring suitable conservation conditions for the exhibited specimens. This is especially true for museums displaying authentic objects which are conveyors of scientific, cultural, social, and ethical values. In particular, natural history and science museums often compete with the leisure industry, and thus their museographic solutions have to meet more and more demanding requirements to increase visitor engagement. This paper describes the museographic concepts beneath the Italian Museum of Planetary Sciences in Prato (Italy, hereinafter MISP). MISP is the only museum in Italy entirely devoted to illustrating planetary sciences and displays important collections of extraterrestrial materials (meteorites, tektites, and impactites). The exhibition layout, characterized by a continuous wall belt design, recalls the outer space while providing non-invasive visual means to improve visitors' emotional engagement with the displayed specimens. MISP museographic strategies also outline the importance of spatial designs and transpositions focusing on the illustration of the exhibited collections, thus going against some current museographic practices emphasizing, for example, the use of augmented reality and digital stimuli.

Graphical abstract

Keywords Planetary sciences · Museum · Museography · Meteorite

1 Introduction

In their handbook on the critical concepts in museology edited for the International Council of Museums (ICOM) Committee for Museology (ICOFOM), Desvallées and

Extended author information available on the last page of the article

Mairesse (2010) defined the term «museography» as the practical aspects of museology, i.e., all the practical activities regarding the planning and fitting out of the museum premises, conservation, restoration, security, and exhibition. As recalled by Almeida (2022), the term was first used in *Museographia*, a treatise edited by Kaspar Friedrich Jencquel (better known as Caspar Friedrich Nickel) in 1727 (Jencquel 1727). In this regard, Giovannini (2007) pointed out that Neickel's work represented a guide to organizing museums, collections, and libraries on aesthetic and educational criteria. Even if a comprehensive reconstruction of the history of museography is out of scope here, it is interesting to note, quoting Jamin (2017), that the modern use of the term was introduced during the meeting of the Office International des Musées (OIM) held in Madrid in 1934 and in 1977 was inserted into ICOM and ICOFOM (Soares 2021). However, Desvallés and Mairesse (2010) noted that the term museography covers diverse meanings in today's museum studies. For instance, it is seldom used in the English-speaking world since the expression «museum practices» is usually preferred to indicate all the practical activities commonly carried out in museums. «Applied museology» is utilized in Central and Eastern Europe to describe the practical applications resulting from procedures developed in museological studies. Finally, «museography» is regularly employed in French-speaking countries to define the techniques of exhibitions. Therefore, the term refers to not only the contents of an exhibition and the links between the exhibit areas and the rest of the museum spaces but also to the management of the collections, i.e., the preservation and valorization of the displayed objects through the creation of a scenario, and the usage of visualization methods and communication strategies to deliver various messages to visitors in the most effective way.

Contemporary museographical discourse highlights diverse trends, such as the rising of a social museography concerning, as pointed out by Sospedra-Roca et al. (2022), the use of tangible and intangible resources for sustainable development and the valorization of historical heritage (e.g., archeological heritage) through the participation of social agents, lay public and scholarly communities. In this framework, it is interesting to note the interdisciplinary and didactic approaches that link natural sciences and historical disciplines, even in non-scientific museum environments (e.g., Georgopoulou et al. 2021, 2022).

Regarding natural history museums, it is noteworthy that dioramas are utilized as tridimensional museographic transpositions. Based on the seminal work of Clement (2000), Moormann and Bélanger (2019) considered dioramas as model-based learning tools useful to illustrate animal behaviors (e.g., the animal adaptation to darkness, Mortensen 2012), ecosystems, biodiversity, and the relationships between the human being and the natural world (e.g., Reiss 2015; Marandino et al. 2015, 2019; Colombo et al. 2023). On this subject, Montanari (2022) argued that dioramas, together with other twentieth-century display systems still visible in natural history museums such as evolutionary trees (e.g., Torrens and Barahona 2012), should be considered a museographic heritage representing the development of the modern exhibition design culture. According to Montanari (2022), these transpositions are worth preserving and valorizing in contemporary museum settings as educational tools.

Van Geert (2019) pointed out that the museographic approaches used to display natural history collections over the centuries can be regarded as tools to display the meanings they covered. For instance, transpositions underlining the role of local history and culture can justify the financial efforts made by the residents for the conservation and valorization of the displayed specimens. In this case, the museographic solutions convey the meaning of natural objects as links with the territory and its population, emphasizing, for example, the figure of local scholars and amateurs who collected, preserved, and bequeathed them to the community. Therefore, museography is pivotal in improving public engagement in natural history museums, especially for those institutions preserving geo-mineralogical collections. In this regard, in their literature review on geoscience communication, Rodrigues et al. (2023) argued that the establishment of an informed commitment between science and society is mandatory to promote geoheritage and geodiversity awareness.

As suggested by Bueno and Marandino (2017), museographic solutions represent effective scientific and educational tools to outline the theoretical and practical implications of the exhibited objects from a praxeological perspective. Bruno and Marandino's study (2017) supported the hypothesis that museography plays a pivotal role in displaying geo-mineralogical specimens, since museographic transpositions help in illustrating to the general public the purposes of their collecting (e.g., scientific value, aesthetic relevance) and usage (e.g., symbols of social status, scholarly tools, and educational instruments) (De Wever and Guiraud 2018; Hearth and Robbins 2022). Therefore, as pointed out by Macdonald (1998), museography is more than just putting science on display because it produces formal and informal knowledge through traditional transpositions (e.g., display cases, educational panels, graphic design, placement and ordering of the exhibited specimens) and the use of digital technologies as virtual reality and immersive experiences (e.g., Sinitò et al. 2020; Hincapie et al. 2023) to develop an experimental approach design that, as outlined by Parades (2021), uses both forms of art and science (i.e., experimental and object data) to improve museum exhibitions and communicative outreach.

Considering all this evidence, it seems that museographic practices are crucial when exhibiting meteorite collections. In this regard, Golia (2015) rightly remarked that people usually see meteorites for the first time in museums, typically displayed as an extension of mineralogical exhibitions. The author (Golia 2015) recalled her first encounter with meteorites at the National Museum of Prague, where iron meteorite specimens, shining like mirrors and mounted on red velvet, were hanging from the walls. Golia (2015) underlined the strange excitement she felt was induced by the museographic strategies chosen to exhibit each specimen. Golia's study (2015) thus showed the importance of museography in improving visitors' engagement with the meteorite specimens on display.

Meteorites, i.e., fragments of asteroids and planetary bodies originating in outer space and falling to Earth (e.g., Grady et al. 2014), have always captivated human imagination and have been investigated and collected since ancient times (e.g., Burke 1991; Marvin 2006; Gounelle 2006; Trevisani 2011; Gounelle and Zolensky 2014; Franza and Pratesi 2020; Franza et al. 2021a). Most of the natural history museums worldwide have a section dedicated to displaying meteorite collections (e.g., Folco and Rastelli 2002; Folco et al. 2002; Herd 2002; Muñoz-Espadas et al. 2002; Perchiazzi et al. 2004; Bevan 2006; Caillet Komorowski 2006; Clarke et al. 2006; Ebel 2006; Greshake 2006; Ivanova and Nazarov 2006; Russell and Grady 2006; Pratesi 2012, Koeberl et al. 2018) since meteorites represent a unique scientific heritage (Franza and Pratesi 2021) needed to be correctly preserved and valorized (McCubbin et al. 2019). Furthermore, as suggested by Dorfman (2015), meteorite collections are tangible heritage conveying intangible meanings. In this regard, Wilson (2018) pointed out that the transposition of planetary sciences in museum exhibits shows natural heritage as a means of moral and social witnessing. As an illustration of this, Wilson (2018) focused on temporary and permanent exhibitions displaying meteorites (e.g., 'The Evolving Universe' in The Arthur Ross Hall of Meteorites at the American Natural History Museum in New York and 'Kosmos & Sonnensystem' in the Museum für Naturkunde in Berlin), which helped visitors to understand not only the processes forming the Solar System but also how the human being has interacted with it through the recovery, study, and interpretation of extraterrestrial materials. The museographic strategies employed in these exhibitions –including the virtual ones, as recalled by Madiedo (2012, 2013), play a pivotal role in illustrating the historical, scientific, and social meanings carried by meteorites to a wide range of age groups through the designs of both the display areas and the educational panels (Hutson et al. 2006; Carpino 2015; Corrigan et al. 2018). On this subject, Cerceau and Michard (2006) outlined that investigating the museographic approaches used in meteorite exhibitions highlights both the advances in meteorite knowledge and the communication strategies adopted by scientists and museologists to foster public education in meteoritics.

While diverse studies (as detailed above) have been published on meteorite museum collections, there is little available literature (e.g., Pinto et al. 2020) on the role of museography in museums entirely devoted to the illustration of planetary sciences and the exhibition of meteorites. The purpose of this work is, therefore, to explore the relationships between museography and museums exhibiting mainly meteorites by discussing the design of the Museo Italiano di Scienze Planetarie (hereinafter, MISP) in Prato, which represents the only Italian museum institution entirely devoted to the exhibition of meteorites. In this regard, it is important to note that the rest of the meteorite collections in Italy are preserved in natural history museums (e.g., Folco and Rastelli 2000; Folco et al. 2002; Perchiazzi et al. 2004; Pratesi 2012) and therefore are parts of more complex collection systems. In these contexts, museography is generally used to illustrate the various aspects of natural sciences and their history. The museographic strategies and transpositions employed at MISP are specially designed to make planetary sciences and the exhibited meteorite collection intelligible to diverse audiences. In the following pages, the history of MISP is reviewed, and its museographic setting is presented to the scholarly community for the first time.

2 Case study

The MISP project started in the 2000s when the Province of Prato and the Pro Verbo Foundation committed to increasing citizens' scientific literacy and culture. The first goal achieved was the establishment of the Prato Ricerche Foundation—Institute for Environmental Research and Hazard Mitigation- to promote and coordinate scientific activities in the province. Later, the Prato Ricerche Foundation and the Province of Prato entered a contract to found and manage a museum devoted to illustrating planetary sciences and exhibiting meteorite collections. MISP was opened to the public on 19 March 2005.

MISP is situated on the ground floor of the former firehouse in Prato, which was established at the end of the 1950s and located on Galcianese Street, within the parking zone of the fire trucks. The area covered ca. 440 sqm and was originally divided into six garages by walls and pillars made of reinforced concrete (Fig. 1).

The MISP museographic project was realized by the architect Piero Roberto Papi between 2001 and 2002. From an architectural perspective, the project highlighted two contingency factors: (i) the physical constraints given by the load-bearing structure consisting of very rigid structural elements, regularly spaced to form the six garages for the fire

Fig. 1 Side view of the former firehouse in Prato during the renovation works

department vehicles; (ii) the need for the architectural design to reproduce the curved perception of space. To resolve these challenges, MISP was designed as a belt characterized by convex and concave geometries defining a curved and ergonomic exhibition path (Fig. 2). In this regard, it is worth mentioning that the path shape is wholly curvilinear, including the display cases. The only exception is a corner space bordering the museum entrance, where the ticket office and bookshop are located.

The display cases run along the whole belt perimeter. The walls are made with ALUCOBOND® cladding sheets, which is a composite panel consisting of two aluminum sheets, one of which is finished and pre-painted by heat, with interposed high-density thermoplastic material bonded by a continuous manufacturing process that allows the sheets to be cut and bent while maintaining flatness. All the cladding is connected to the primary(vertical) and secondary (horizontal) structures without any rivets or nuts being visible from the visitor's side. On the top of the primary vertical structure are fireproof wooden slats, calendered according to the curvature of the display walls to avoid differences in flatness (Fig. 3). All the wooden processing is realized in medium-density fiberboard.

The flooring is realized using first-rate absolute black stoneware floor tiles (60 × 60 cm), which is a hard, compact, and polishable material that simulates decorative rocks with a phanerocrystalline texture. Showcases are plugged with curved laminated extra-clear glass sheets (thickness 16 mm), mounted flush polished, without structural posts, and with transparent silicone sealing (Fig. 4). Five different dimmable systems consisting of luminaires connected in series to terminal controllers are placed within the display cases.

All the didactic panels in the display cases are realized with FOREX® to adapt their designs to curvilinear structures. In all panels, a fictional character, designed by Cristina Andreani, illustrates the key concepts of meteoritics and planetary sciences to children.

Along the exhibition path are present 17 touchscreens with short footage (150 videos), images (more than 250), informative text (ca. 190 pages in total), and interviews with

Fig. 3 A top-view 3D model of the curvilinear MISP's exhibition path. The image shows the ALUCOBOND® cladding sheets of the display walls and the fireproof wooden slats on the top of the primary vertical structure

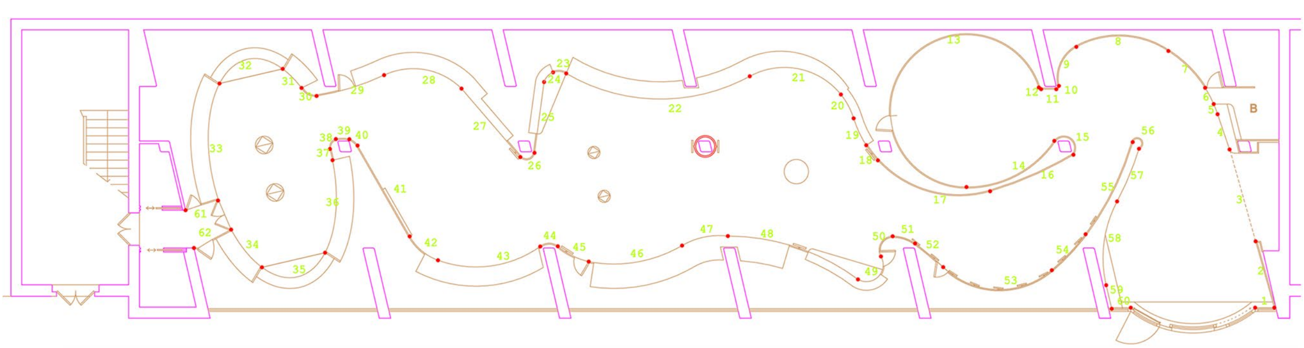

Fig. 2 Table drawn by architect Piero Roberto Papi illustrating the curvilinear and ergonomic structure of MISP's exhibition path. Besides recalling the curvilinear perception of space, the belt design incorporates the pillars that originally delimited the fire truck garages

Fig. 4 3D model of a showcase in MISP main all

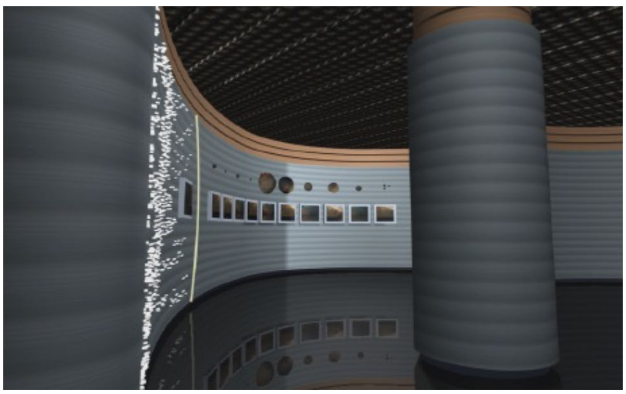

Fig. 5 The multimedia stations about the Universe and the Solar System at the beginning of the exhibition rooms. Above the workstations are scale models of the planets

planetary scientists (ca. 70 videos) about the Universe, the Solar System (i.e., the Sun, planets and their satellites, asteroids, comets), meteorites (i.e., chondrite and differentiated meteorites, history of Italian meteorites for a total of more than 240 text pages, 70 interviews, and 60 videos) impacts and impactites, impact craters found on Earth (ca. 200 text pages, 200 images, 100 short videos for both the topics), and minerals (ca. 40 text pages, eight interviews, and 18 videos). The multimedia stations are placed in different areas of the exhibition path. For instance, ten workstations are located at the beginning of the exhibition rooms and are entirely devoted to the illustration of the Universe and the Solar System (Fig. 5), while those relative to meteoritics in general and the history of Italian meteorites, in particular, are placed in the main hall, where the meteorite collection is on display, next to the exhibited specimens (e.g., chondrite meteorites on the right, differentiated meteorites on the left, and impactites at the end of the main hall on the left side) (Fig. 6). The contents of the short videos about the Universe, the Solar System, and meteoritics have been requested from NASA, ESA, and STSCI (Space Telescope Science Institute,

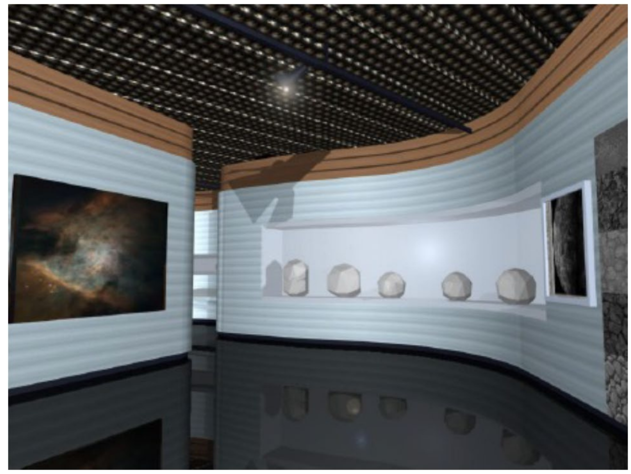

Fig. 6 Impactite rocks room

Fig. 7 The last MISP exhibition room is devoted to illustrating minerals, mineralogy, and the main mineralogical species in Tuscany

Baltimore), which authorized their unrestricted use. The multimedia station about terrestrial minerals and mineralogy is in the last exhibition room (Fig. 7).

Besides the multimedia stations described above, interactive museographic devices create immersive experiences. At the entrance of the museum halls on the right side, there is the Quadrisphere room, a multimedia installation (ca. $6 \times 2.50 \times 2.50$ m). Here, visitors can watch a short video (lasting ca. 4 min) on a compelling play of mirrors that tells the origin of a meteorite, its impact on the Earth, and the birth of life on our planet.

The MISP exhibition path is divided into five thematic areas, illustrated on a panel at the museum entrance. The panel also shows the curvilinear architectural design characterizing the entire exhibition (Fig. 8).

The first thematic area concerns the Universe and the Solar System. It is located at the entrance of the museum

Fig. 8 MISP entrance. In the background is the panel illustrating the curvilinear design of the exhibition path and its thematic sections

halls and consists of the ten multimedia stations described above. Subsequently, there is the main hall, where meteorite specimens are displayed to illustrate chondrite meteorites, differentiated meteorites, and impact processes. The last oval-shaped room displays terrestrial minerals, including samples from Tuscany.

The exhibition path is circular since its perimeter forms a continuous wall (the belt mentioned above) running from one side of the entrance and returning to it from the other after crossing the entire exhibition area. It is about 316 cm high with 140 cm high glass openings, representing the showcase's frontal side. The meteorites are displayed in interior containers ranging from 30 to 85 cm. The specimens can be viewed through curved glass panels (up to 6 m long) laid in place without structural mullions. This design emphasizes the shape of the exhibition path while ensuring that the display cases cannot be opened from the visitor's side. The tabletop is about 66 cm from the ground, thus providing a view of the displayed samples even by children and people with disabilities. The removal and maintenance of the meteorite specimens is allowed only from the back of the display cases. This design results in a "service belt" that runs parallel to the display area and is reserved for MISP staff.

Six circular showcases are placed along the exhibition path. The so-called "islands" are individually illuminated and include one pedestal without a glass cover. All of them display particularly relevant samples from a scientific and aesthetic perspective.

Concerning the museum lighting, the MISP entrance is partially illuminated with natural light from the glass front door. The remaining areas are fully illuminated with artificial light placed within the false ceiling and the showcases. Spotlights next to the display cases draw the visitors' attention to specific meteorite specimens. A brighter light source is then present in the showcases to avoid reflections on the curved glass. The latter is placed backward from the showcase ceiling to cast as little light as possible on the visitors and thus eliminate possible mirroring effects.

3 Discussion

As mentioned in the literature review, museography is pivotal in conveying tangible and intangible meanings relative to the objects displayed in science and natural history museums, especially when geo-mineralogical specimens are exhibited. Regarding meteorite collections, Dorfman (2015) and Wilson (2018) highlighted how museographic transpositions and strategies are fundamental in conveying the diverse scientific, historical, cultural, and social meanings of these museum collections to scholars and the general public.

Even if meteorite collections can be found in several Italian natural history museums, MISP is the only scientific institution in Italy founded to illustrate planetary sciences and display extraterrestrial materials; therefore, its museography and design were studied to communicate concepts relative to meteoritics while promoting citizen science ideas (e.g., national meteorite recovery campaigns) and scientific literacy. On this subject, following Önal and Önal (2021), it is worth mentioning that astronomy and sciences related to this field of knowledge, such as planetary sciences and meteoritics, create a positive attitude toward learning science and promote its learning by gathering students' attention.

MISP museographic project thus represents a design strategy that, starting from the illustration of the Universe, comes to the display of meteorites whose recovery and study made possible the knowledge of the Solar System (Grady et al. 2014) and via impact rocks and tektites leads the visitors back to the Earth in the last exhibition room where minerals, representing the extraordinary geodiversity of our planet, are on display. The elements that are on the MISP exhibition path (the so-called "islands") thus present the specimens on display as linking elements (Morrissey 2002) to attract visitors' attention for effective communication. For instance, in the main hall, on a pedestal without barriers, there is a specimen of the Nantan meteorite (Figs. 9 and 10).

According to the chronicles, the fall might have been observed in China in 1516, but the fragments were recovered only in 1958. Nantan has been classified as an iron meteorite belonging to the main group (MG) of the IAB complex (Caporali et al. 2018). The Nantan meteorite specimen kept at MISP represents the largest meteorite preserved in Italy and can be touched freely by visitors. In this regard, MacDonald (2007) highlighted how museums (except for science centers and children's museums) commonly represent "no touch" environments since the opportunity for the visitor to touch the exhibited objects is very restricted and usually limited to interactive spaces. This

Fig. 9 MISP main hall, where the meteorite collection is on display. The curvilinear path of the museum exhibition and the continuous walls are visible. The Nantan specimen is on the pedestal in the center of the image

Fig. 10 The Nantan meteorite (weight 272 kg, MISP inventory number 1363/1)

object-based interaction has an essential role in enriching the learning experience for both disabled and non-disabled visitors while simultaneously opening imaginative, speculative, and emotional ways of knowing meteorites (e.g., Classen 2008; Chatterjee 2008; Candlin 2008; Pye 2016; Nicolaisen and Achiam 2020). In this regard, Carpino and Morelli (2024) highlighted, quoting Tokar (2004) and Ciaccheri (2022), how the possibility of touching meteorites was conceived following the Universal Design Learning (UDL) model, i.e., a transitional framework between learning sciences and education design to create exhibit spaces and museum programs usable by and effective for as many learners as possible (Rappolt-Schlichtmann and Daley 2013).

As shown in Figs. 9 and 11, the MISP exhibit areas are designed as a continuous curvilinear path, recalling the perception the human being has of outer space. On this subject, Vartanian et al. (2019) stated that curvilinear contours in interior architectural spaces are usually preferred since visitors are more likely to enter curvilinear than rectilinear spaces. This assumption is supported by the last research in cognitive neurosciences and neuro-architecture, where curvilinear spaces, as pointed out by Wang et al. (2022) in their literature review, are perceived to be more aesthetically beautiful than rectilinear ones since the vision of curvilinear contours activates the lingual and the calcarine gyrus in the visual cortex more than images of rectilinear interiors. Based on the above, all the perimeter walls and showcases (including the so-called "islands") are curvilinear, a design choice that helps to induce positive emotional states in visitors, as shown by Bower et al. (2019) in their systematic review.

The materials used in the exhibition path reflect the purpose for which MISP was established: to illustrate planetary sciences and meteoritics. The light gray-green ALUCOBOND® horizontal bands traversing the entire perimeter walls recall the sidereal space and the interior of a spaceship, while the floor and the ceiling remind us of the absolute black of the outer space and the petrographic texture of the chondrite meteorites. The wooden slats on the top of the vertical elements represent the organic matter on the Earth, and their combination with the ALUCOBOND® bands resemble the alberese and green serpentinite (Verde di Prato) rock cladding employed in alternative rows in Prato's medieval architecture (e.g., Fratini et al. 2022; Carmignano and Brandao 2023).

The connections between the materials used in the museographic design, the Earth planet, and the local territory continue in the last museum room, where the mineralogical collection is displayed (Fig. 12).

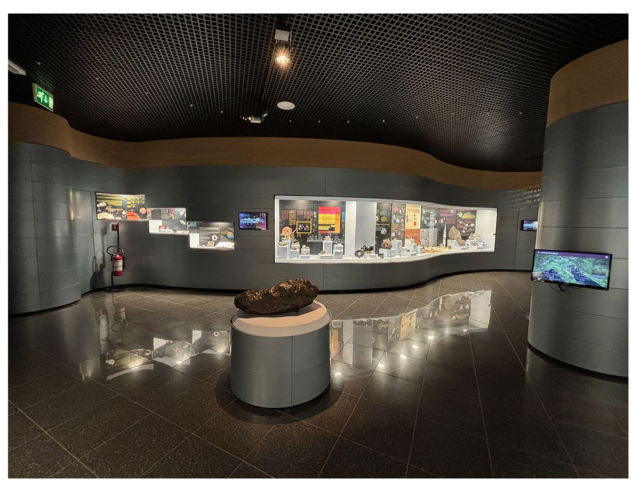

Fig. 11 The curvilinear path of the MISP exhibition

Fig. 12 The last room of the MISP exhibition, where the mineralogical collection is displayed

Here, outstanding worldwide specimens (Fig. 13) are exhibited together with samples from Tuscany mineralogical outcrops or closed mines (Fig. 14). The latter represents evidence of the local mining sites and their history (e.g., Tanelli et al. 2001).

Furthermore, the MISP mineralogical collection comprises a fluorescent mineral display (Fig. 12, top right). The fluorescence phenomenon is observable thanks to the specimens' exposure to ultraviolet (UV) lamps set in the display case that can be turned on and off by a push button.

Fig. 13 An outstanding specimen of Brazilianite

Fig. 14 A pyrite specimen from the inactive mines of Elba Island (Tuscany)

As underlined by Lustrino (2021), displaying fluorescent minerals is an effective educational tool to increase learning engagement in diverse audiences (e.g., curiosity-driven visitors, Rounds 2004) about complex science topics such as electromagnetic radiation, radioactivity and the origin of colors.

Museographic solutions, such as explanatory panels and multimedia installations, are integrated along the museum path to provide a logical reading guide for visitors to assimilate meteoritics and planetary sciences knowledge (Pasquaré Mariotto and Venturini 2017). The touchscreens and the digital installations –e.g., the devices at the beginning of the exhibition illustrating the Solar System (Fig. 15) and the quadrisphere (Fig. 16) – thus encourage free-choice environmental learning, foster curiosity, and improve self-education while enhancing STEM learning (e.g., Falk 2005; Russo and Sisto 2023).

It is then interesting to note the presence of satellite museographic solutions, i.e., tools that can project information in different communication spaces such as audiovisual, smartphones, and apps (Sospedra-Roca et al. 2022), such as QR codes (e.g., Pérez-Sanagustín et al. 2016) to distinguish meteorites from terrestrial rocks. In this case, diverse specimens are placed on pedestals at the same levels so as not to influence the visitor's decision-making ability. After commenting on the nature of a specific specimen, visitors can check their responses by scanning the QR codes placed on each pedestal using their phone's built-in cameras. QR code contents deal with the specimens' origin and main features.

Fig. 15 Touchscreen multimedia stations illustrating the Solar Systems and its planets

Fig. 17 QR code exhibition area

These tools improve interactive edutainment (e.g., Komarac et al. 2020) while enabling rapid user information processes and decision outcomes without diverting the visitors' attention from the displayed specimens [Fig. 17].

However, interactive museography is mixed with traditional transpositions along the MISP exhibition path. In the main hall and the room devoted to the illustration of impact rocks, dioramas display cold and hot deserts where meteorites can be found, as well as the Martian and lunar environments (e.g., Pratesi et al. 2005; Aboulahris et al. 2019; Fan et al. 2022) [Fig. 18].

The academic literature on lighting design in museum contexts, as Balocco and Volante (2018) outlined, showed that the identification of the best lighting solutions was strictly linked to the improvement of visitors' understanding, perception, vision, and emotions concerning the displayed objects, also based on cognitive mechanisms. The MISP lighting design, whether natural or artificial, thus represents a spatial variable for conveying messages and stimulating visitors' emotional responses along the exhibition path (e.g., Jeong and Lee 2006; Zhisheng and Nagai 2020; Gharib and Shohdy 2023; Graser 2023). Besides the MISP entrance, illuminated by the daylight filtering through the front door windows, artificial light is set up within the continuous wall and the false ceiling. The overall effect is a restful, diffused light throughout the rooms inducing an emotional experience of calm in visitors (Duan 2022). The use of artificial light sources as lightning solutions is motivated as follows: (i) the simulation of a "non-light" typical of sidereal space; (ii) the possibility to focus on specimens exhibited both in the display cases and on the pedestals (e.g., the Nantan meteorite); (iii) the creation of an immersive atmosphere that, as Forrest (2013) pointed out in his literature review, acts a route to an affective, cognitive, and behavioral response in visitors.

The results of the present study suggest how museography plays a crucial role in natural history museum exhibitions. The case study presented here shows that the materials, techniques, and museographic solutions adopted at MISP are specifically designed to valorize the displayed collections within a narrative environment where spaces and specimens

Fig. 16 A frame from the quadrisphere footage showing extraterrestrial environments

Fig. 18 Dioramas of the Martian and Lunar environments. From the left: Dar al Gani 670 (Martian meteorite belonging to the shergottite type, weight 688 g, MISP inv. n. 2325/1), Dar al Gani 400 (lunar meteorite that is primarily anorthositic, weight 11.8 g, MISP inv. n. 2237/1), and Northwest Africa 13,942 (lunar meteorite, weight 34 g, MISP inv. n. 8543/1)

are part of a storytelling process, whose experience continues after the museum visit ends (Hanks Hourston et al. 2012, Dal Falco and Vassos 2017). The information learned about meteoritics and the history of the meteorites found in Italy over the centuries motivates visitors to be active in their recovery, joining citizen science projects in which they can participate in field campaigns and report the findings of potential meteorite specimens (e.g., Blake et al. 2018, Zanda et al. 2023). In this regard, MISP is actively involved in the PRISMA (Prima Rete Italiana per la Sorveglianza sistematica di Meteore e Atmosfera) all-sky camera network (Gardiol et al. 2016, 2019), a project managed by the Italian Institute of Astrophysics (INAF) in collaboration with the FRIPON project (Fireball Recovery and InterPlanetary Observation Network) (Colas et al. 2020). As Gardiol et al. (2021a) outlined, since the start of the project, PRISMA has experienced increasing participation of amateur astronomers and non-expert citizens reporting visual fireball observations and possible meteorite finds. The latter led to the recovery of the Cavezzo meteorite (Gardiol et al. 2021b; Pratesi et al. 2021), which is now kept at MISP. In collaboration with MISP, PRISMA organizes meteorite search campaigns and free training courses to teach citizens about meteorite identification. Furthermore, MISP is open to receiving samples of possible meteorites and performing scientific analyses, in collaboration with the Earth Sciences Department of the University of Firenze, to investigate their potential extraterrestrial origin (Franza et al. 2021b).

Finally, the findings of the present study highlighted how museographic solutions designed to valorize the specimens also play a crucial role in correctly preserving them. At MISP, the conservation practices of the displayed and stored meteorites comply with the Advanced Curation policies for extraterrestrial materials illustrated in McCubbin et al. (2019). Furthermore, most of the MISP meteorite collection has been cataloged using the national standard BNPL (Casto et al. 2007; Franza et al. 2022), issued by the Central Institute for Catalog and Documentation (ICCD), part of the Italian Ministry of Culture (MiC). The catalog records are accessible in open access on the Catalogo Generale dei Beni Culturali database (https://catalogo.beniculturali.it), managed by MiC, which represents the official repository for cataloging the entire Italian cultural heritage (Veninata 2020). To date, 66,398 samples relative to the natural heritage have been cataloged (data accessed on 28 April 2024). Among them, 43,646 are geo-mineralogical specimens (i.e., 41,932 minerals, 621 rocks, 1093 meteorites). The meteorite specimens preserved at MISP and present in the database are 376. Since 2002, the entire MISP meteorite collection has been accessible online on the museum's official website. The inventory shows data regarding the weight and typology of the collected specimens (i.e., sample, complete individual, part slice, polished slice, sawn fragment, partially sawn fragment, thin or thick section), together with information about the meteorite classification, type, year, and place of recovery (Morelli et al. 2023).

4 Conclusions

This work has discussed the museographic solutions adopted at MISP, the only museum in Italy established to exhibit extraterrestrial materials and illustrate planetary sciences. The investigation outlined the following significant results: the design of the exhibition path, the use of the space, the presence of distinctive museographic transpositions, the materials, and the lighting design. Together, these findings highlight the central role of museography in valorizing the displayed specimens. Museographic strategies and transpositions should be representative of object-oriented analysis and design to enhance naturalistic museum collections properly. The findings of this research suggest how MISP museographic solutions contribute to sharing valuable information about the exhibited meteorites, which represent a unique scientific and cultural heritage in the Italian scenario.

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Data availability We do not analyse or generate any datasets, because our work proceeds within a theoretical approach.

Declarations

Conflict of interests The authors declare no competing interests.

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