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To be or not to be, that is the question: The Marsala meteorite (Italy, 1834) and the role of the doubtful meteorites in the history of meteoritics

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Abstract–This work focuses on the historical and scientific investigation of a presumed meteorite fall that occurred in the Sicilian township of Marsala in 1834. Preliminary studies have classified this phenomenon as a "doubtful meteorite." This term describes, according to the Nomenclature Committee of the Meteoritical Society, an object for which there was significant uncertainty over whether it was a real meteorite or, in some cases, whether it ever existed. Thanks to the analysis of untapped sources, the first objective of this work is to clarify the nature of the event. Subsequently, the results of the minero-chemical analyses that were performed, in 1835, on two fragments recovered after the event are discussed for the first time. This work then shows the collecting history of one of the presumed meteorite specimens. Based on the results presented here, this work highlights the role of doubtful meteorites as a fundamental resource for the history of meteoritics and meteorite collecting as well as for studying the processes that have led to the scientific study of meteorites.

INTRODUCTION

In their major study about meteorite collecting and the development of meteoritics as a science, McCall et al. (2006) highlighted the reports of stones falling from the sky from oral and written chronicles of ancient times to the modern fireball reporting networks (e.g., the Australian Desert Fireball Network, the French FRIPON, and the Italian PRISMA network), which use all-sky cameras to detect and recover meteorite falls (Bland et al. 2012; Colas et al. 2020; Gardiol et al. 2020). As some authors (Fries et al. 2017; Day et al. 2019; Marmo et al. 2019) have rightly pointed out, one of the key aspects of these new networks is the engagement of the general public in reporting meteor sightings as well as in other forms of citizen science participation (e.g., searching for meteorites on public lands for scientific and educational purposes). In this regard, McCubbin et al. (2019) underlined how most of the meteorite falls that have been recovered over the centuries are based on eyewitness accounts. It is therefore not by chance that the literature on meteorites (see Lauretta and McSween 2006; Grady et al. 2014) distinguishes between finds, that is, meteorites that were recovered by people but whose fall was not seen, and falls, that is, meteorites that were collected after their fall was witnessed by observers or camera networks designed for monitoring fireballs. This important distinction is also listed in the guidelines released by the Meteorite Nomenclature Committee of the Meteoritical Society, which is responsible for the approval of new meteorite names and their classifications in the Meteoritical Bulletin Database (MBD; Marvin 1993). Besides data on each sample, including the year and place of recovery, its weight, and if it was a fall or a find, MBD also contains information for meteorites with provisional names, and listings for doubtful specimens and pseudometeorites. In detail, the latter term indicates an object that has been claimed to be a meteorite but is non-meteoritic in origin, whereas the classification "doubtful meteorite" designates a sample for which there is significant uncertainty over whether it is a real meteorite or, in some cases, it ever existed. According to MBD's last update (December 22, 2020), there are 297 entries for "pseudometeorites" and 192 records for "doubtful meteorites." Among these, 18 doubtful meteorites have been found in Italy (Table 1). In spite of their small number—only 42 meteorites, both falls and finds, have been officially approved by the Meteoritical Society—Italian meteorites have often been the core of a lively scientific debate. As an example, the shower of stones that fell on Siena on June 17, 1794 has been defined by Marvin (1998) "one of the most consequential meteorites fall in history." So far, however, little attention has been paid to the Italian doubtful meteorites and their role in the history of meteoritics.

The purpose of this paper is therefore to present a detailed analysis of the presumed meteorite shower that fell on the Sicilian township of Marsala in 1834. By using a wide range of sources, mostly untapped and unpublished, this study examines the animated scientific controversy that arose after the event had occurred and that involved some of the most important scholars and cultural institutions of the time, such as the naturalist and geologist Teodoro Monticelli (1759–1845) and the Gioenian Academy in Catania.

MATERIALS

Case Presentation: Marsala, December 1834

Various Italian and foreign newspapers reported that on the night of December 15–16, 1834, an "extraordinary phenomenon," as it was described by Jerdan et al. (1835), had taken place on the west coast of Sicily, and more precisely at Marsala (Fig. 1). The episode has been reported in detail by the Allgemeine Theaterzeitung und Originalblatt (1835, n. 41, p. 164), and the Atheneum journal (1835, n. 3058, p. 284), which translated the news that appeared in the various Italian gazettes such as the Gazzetta Ufficiale di Zara (1835, n. 16, p. 62), La Voce della Verità. Gazzetta dell'Italia Centrale (1835, n. 545, pp. 1218–1219), the Gazzetta di Firenze (1835, n. 10, p. 4), the Foglio di Verona (1835, n. 14, p. 53), the Nuovo Osservatore Veneziano (1835, n. 14, p. 4), and the Gazzetta di Genova (1835, n. 8, pp. 1–2). There, the event was described as a "dreadful and extraordinary hurricane that, on the night of December 16, brought terror and desolation upon the parish of Marsala and its surrounding countryside." During the day and night that preceded the disaster, the weather was calm, and no one could predict what would happen in a few hours. About eight ante meridians, during the lunar eclipse that occurred that night, a black spot appeared to the north, and spreading in a short time, it broke out into a tremendous storm. The fierceness of the bad weather; the roar of wind, rain, and hail; along with the never-ending lightning and thunder, woke up Marsala's citizens and threw into a panic any who were out of the house. Rain fell like bullets, destroying windows, buildings, trees, and crops, and injuring the livestock. Many birds were found dead. The storm lasted for more than hour, during which it seemed to stop but resumed three times. When day broke, the citizens of Marsala witnessed an unexpected scene that made them realize all the danger they had passed through. It was a horrific spectacle to see all the streets, fields, and roofs covered not by the usual hailstones, which should have been already dissolved in the morning, but by "aerolites." These were the size of a walnut, spherical, or spheroidal in shape, yellowish in color, and of an incredible hardness. Under this flood of stones, Marsala could have been destroyed and its inhabitants exterminated. In the city, almost all the windows were found broken, especially those facing northwest. Furthermore, the climate had changed unexpectedly, and an unusual cold struck the population. The damage was therefore repaired with extreme rapidity. Since then, this event has been documented as a meteorite shower in various chronicles and printed treatises on meteorites such as Parisi (1835, 1838), Paddock Harris (1859), the Report of the Thirtieth Meeting of the British Association for the Advancement of Science (1861), and Chapel (1883). The episode that occurred in Marsala is recorded as a meteoritic phenomenon also in various 20th-century scientific treatises (see Royal Astronomical Society of Canada 1904; Arizona State

Table 1. Italian doubtful meteorites, as reported in the Meteoritical Bulletin Database.

Name	Year	Place
Lucania	−56	Basilicata
Italy (956)	956	Italy
Italy (963)	963	Italy
Aglar	1112	Friuli-Venezia Giulia
Viterbo	1474	Lazio
Crema	1511	Lombardia
Milan	1525	Lombardia
Piedmont	1583	Piemonte
Crevalcore	1596	Emilia-Romagna
Calce	1635	Veneto
Pentolina	1697	Tuscany
Terranova di Sibari	1755	Calabria
Novellara	1766	Emilia-Romagna
Fabriano	1776	Marche
Turin	1782	Piedmont
Massa-Lubrense	1819	Campania
Marsala	1834	Sicily
Civitavecchia	1855	Lazio

Fig. 1. A panoramic view of the Sicilian township of Marsala at the beginning of the XIX century. Courtesy of the Historical Archive at Marsala.

University, Center for Meteorite Studies 1962; American Geological Institute 1977) as well as in the Catalogue of Meteorites' most recent edition (Grady 2000). In this latter source, the event we are investigating was described, quoting von Boguslawski (1854), as a "stone of 15 lb (6.8 kg), yellowish, spheroidal, very hard and solid." However, Grady (2000) concluded that "the evidence is not conclusive" and the stone was identified as a doubtful meteorite. In the same vein, the MBD classified Marsala as "an object for which there is significant uncertainty over whether it is a real meteorite or, in some cases, whether it ever existed," that is, a doubtful meteorite.

Two important themes emerge from the studies discussed so far: The first is that much uncertainty exists about the meteoritic origin of the event, and the second is that no real meteorite fragments were recovered. Nonetheless, there remain several aspects about which relatively little is known. In particular, there was no detailed investigation about what happened after the event took place, and how the scientific community of the time interpreted and explained this "extraordinary phenomenon." In this regard, La Cerere, which was Palermo's official gazette and one of the most important news agencies in the Kingdom of the Two Sicilies (Palazzotto 2007), published not only the report on the rain of stones that had fallen on Marsala but also claimed to have various "aerolites," which would be subjected to chemical analysis. The results would be made available to the public to know the substances of which they were composed (La Cerere, Giornale officiale di Palermo, 1834, n. 286, pp. 1–2). On February 18, 1835, La Cerere published further information on the "aerolites" that fell on Marsala to "satisfy the public curiosity and the impatience of the natural sciences scholars." The article began by apologizing for the delay in reporting the results of the chemical analysis, an inconvenience due to Antonino Furitano's illness (1778–1836; Vaccaro 1837), who was the chemist to whom one of the stones received by the newspaper's editorial office had been delivered for testing and examination. The analyses were then performed by Gioacchino Romeo (d. 1844). Both Furitano and Romeo were professors of chemistry at the University of Palermo (Cancila 2006). Before illustrating the findings of the investigations, the article focused on the events that occurred in Marsala on December 15–16. First of all, the "aerolites" were recovered inside the hailstones as if they were the "kernel," if not of all, then at least most of the hail that fell on the ground. These stones were sent to La Cerere with an anonymous letter, which described what happened during that tremendous night. While the chemical analyses on the recovered stones were being performed, some rumors questioned the reality of this extraordinary phenomenon. This was why La Cerere reported part of the declaration made by Antonio Galbo (dates uncertain), Baron of Montenero and Superintendent of the Trapani Valley (Galluppi 1877). Galbo stated that even if the violence of the storm might have been overestimated, the fall of the aerolites from the sky could not be questioned. In this regard, he reported how the nuns of the Convent of St. Peter in Marsala recovered six or seven stones after the storm had passed. The samples were spherical and whitish in color and the superintendent undertook to get one from the nuns to take it to Giuseppe Alvaro Paternò (1784–1838), Prince of Sperlinga Manganelli, and President of the Gioenian Academy in Catania, who had requested it (Logerot 1842; Frusca 2014).

La Cerere thus summarized the findings in support of the "aerolites" fall on Marsala as (1) the widespread opinion among the citizens of Marsala that stones had rained down from the sky during the storm in mid-December; (2) the anonymous letter in which the sender asserted that they had observed the phenomenon and sent some recovered stones to the editorial office of the newspaper as an evidence of what s/he said; (3) the accounts of the nuns of the St. Peter's convent who observed the same event from their cloistered retreat; (4) the similar physical characteristics between the stone sent to La Cerere and the sample given to the Superintendent of the Trapani Valley; (5) and last, but not least, the results of the chemical analyses performed on one of the stones sent to the newspaper. The only argument against the truth of the event were the doubts in the minds of the people who had not witnessed the phenomenon. However, the article claimed that this was not sufficient to believe that the event had never existed. It was reasonable that not everyone had the idea of searching through the mud of the melting hail and the shattered glass, to see if there were extraneous objects whose presence was hardly foreseeable. So, it was not by chance that only a few people had noticed the aerolites like the nuns of St Peter's convent had; for them, the stones were unusual and certainly must have arrived from overhead in order to be found within the cloister. Furthermore, it was not unlikely that, after some time had passed, other fragments had not been found, or had been merged with the debris covering the streets.

The article then reported the full text of Romeo's report on the results of the chemical analyses, without expressing any opinion on the nature of the supposed "aerolites." Romeo began his report describing the specimen's physical characteristics, "no matter where it came from." The volume of the specimen was that of a "hazelnut"; its weight was 52 grapes (about 3.4 g; see Martini 2018); the color was yellowish white; the configuration was globular; the surface was rough; its specific weight was 2.08; the fractures were the same size as each other. The specimen's inside was granular, and the grains were spheroidal. Overall, the stone was fragile, with no smell or taste whatsoever. Romeo therefore illustrated the main steps that were performed during the chemical analyses. First, he removed 10 grapes (about 0.6 g) of material from the specimen and then powdered them in a crystal mortar. Subsequently, he inserted the resulting powder into an analytical tube, pouring hydrochloric acid and distilled water into it. A chemical reaction characterized by a strong effervescence with the development of carbonic acid gas then occurred. The sample dissolved completely, forming a clear liquid. Romeo mixed this solution with oxalic acid and distilled water. The result was a copious white distillate, insoluble in nitric acid that the chemist recognized as lime oxalate. Afterward, he poured the liquid onto a felt to separate the lime oxalate. After having washed it with distilled water and let it dry, Romeo weighed the compound that resulted to be formed by 7.25 grapes (about 0.5 g; see Martini 2018) of lime carbonate. He poured on the felt some neutral ammonia oxalate (*ossalato neutro di ammoniaca*) that did not generate any precipitate, so the chemist was sure that all the lime had been removed. Romeo then mixed the solution with some neutral phosphate of ammoniacal soda (*fosfato neutro di soda ammoniacale*), obtaining a second white precipitate that he recognized as phosphate of ammoniacal magnesia (*fosfato di magnesia ammoniacale*). The latter, collected on a felt, washed with distilled water and dried, appeared composed of 2.50 grapes (0.16 g; see Martini 2018) of magnesium carbonate basic (*sotto-carbonato di magnesia*; see Mamone Capria 1841). The liquid which passed through the felt formed a blue precipitate with the prussiate of potash (*prussiato di potassa*, i.e., potassium ferrocyanide; see Orosi 1851). Romeo did further analysis on the sample, which did not show significant results and therefore were not included in his report. After finishing all the tests, Romeo concluded that the specimen was composed by carbonic acid, magnesium, and iron (Table 2). The stone could therefore be identified as a magnesian spar sample (*spato magnesiaco*). The article ended without expressing any conclusive statement about the origin of the analyzed sample (La Cerere, Giornale officiale di Palermo, 1835, n. 38, pp. 1–2).

As mentioned previously, one of the stones that were recovered in Marsala was given to the President of the Gioenian Academy in Catania. In a scientific memoir published on the Giornale del Gabinetto Letterario dell'Accademia Gioenia in 1834 (Journal of the Literary Cabinet of the Gioenian Academy), Carmelo Maravigna (1782–1851), who was a professor of chemistry at the University of Catania and also a founding member of the Gioenian Academy in 1824

Table 2. Romeo's analysis of the collected specimen.

Carbonate of lime	37.70 grapes (2.44 g)
Magnesium carbonate basic	23.00 grapes (1.49 g)
Iron	1.30 grapes (0.08 g)

(Alberghina 2005; Cristofolini 2016), described the fall of the presumed "aerolites" and reported the analysis that was carried out on the specimen delivered by the Superintendent of the Trapani Valley to Giuseppe Alvaro Paternò (Maravigna 1835). When La Cerere published the news of the unusual stones that fell on Marsala in mid-December, the members of the Gioenian Academy, who were involved in the natural sciences, showed a great interest in obtaining some samples to determine their origin and chemical composition. So Paternò received from Galbo one of the six/seven stones that the nuns of the St. Peter's convent in Marsala had found in their cloister. Paternò then sent the sample to the Academy's members inside a little box along with a billet in which he said that "the stone has been shipped with the aim of contributing to the Academy's scientific progress, although to me it appears to be a limestone fragment, rounded off by art, and therefore very different from those formations defined as aerolite." When the box was opened, the specimen was recognized as a tertiary limestone carbonate (*carbonato calcare terziario*) without the need to have it chemically analyzed, since the specimen's nature was distinguishable by its physical characteristics. These findings were also reported during the Gioenian Academy's ordinary assembly on February 19, 1835 (see Giornale di Scienze, letteratura ed arti per la Sicilia, n. 57, pp. 196–197). Maravigna (1835) therefore stated that the sample could not be an aerolite because "aerolites differ from any stone you can find on the Earth due to their chemical and metal composition." He then gave a brief account of the aerolite specimens he had been studying such as the Aigle, which fell on April 26, 1803 in Lower Normandy, France (Gounelle 2006), and the Calvados. Of both these aerolites, Maravigna (1835) had samples in his private mineralogical collection. He also mentioned the specimens that were preserved at the University of Catania as the samples of the aerolites that fell on the surroundings of Bordeaux, precisely at Barbotan, on July 24, 1790 (Baudin 1796), at Chantonnay on August 5, 1812 (Caillet Komorowski 2006), at Juvinas on June 15, 1821, and the fragments of the aerolite that were discovered in the Russian province of Krasnoyarsk in 1749, but described by the German-born naturalist Peter Simon Pallas (1741–1811) in the early 1770s (Ivanova and Nazarov 2006). Maravigna (1835) highlighted that all of the aerolites he mentioned were distinguished by the amount of native iron they contained. Neither the specimen he investigated nor the sample of globular limestone carbonate held by the La Cerere, which Maravigna examined privately, could be therefore identified as aerolites. So the Palermitan journalist, according to Maravigna (1835), contributed voluntarily to the spread of misinformation.

Concerning the propagation of misinformation about the aerolites, the Catanian gazette Lo Stesicoro published in April 1835 an article signed with the initials "Y.K." about the presumed "aerolites" that were supposed to have fallen on Marsala the year before (Y.K. 1835). This signature was the pseudonym of Salvatore Barbagallo Pittà (1804–1837), who was a scholar and one of the forerunners of the Sicilian Revolution in 1837 (Cirone 1964; Russo 1987; Signorelli 2015). The article opened with a brief description of the storm that occurred on the night of December 15–16 in Marsala that arrived along with a rain of hail and tiny stones. This last detail raised the interest of the general public to the point that several citizens wrote to those who might have witnessed the event. Many of the people who had been contacted replied that the story was a hoax created by journalists. If the story had been true, the number of fallen aerolites would have been so high that no one in Marsala would have been able to deny the truthfulness of the event. In the meantime, the news had reached the majority of the European naturalists, who immediately contacted their colleagues in Sicily searching for a sample of the fallen stones. "In this regard, the Gioenian Academy's President received one of the presumed aerolites from the Superintendent of the Trapani Valley, but the specimen was recognized as a very common rock, rounded perhaps by children to be useful in some of their games." Y.K. (1835) continued by saying that he was extremely surprised when he read a second article in La Cerere, reporting the results of the chemical analysis performed by Gioacchino Romeo on one of recovered fragments. To show to the general public that this sample could not be an aerolite, Y.K. (1835) illustrated the main events that usually occurred when an aerolite reached the ground, along with the examination of aerolites' main chemical and physical properties. He explained that all the stones that fall from the sky exhibit the same meteorological and atmospheric phenomena. Furthermore, the aerolites that were classified as "earthy" ("*terrose*"), such as the presumed samples that were recovered in Marsala, show similar chemical compositions and comparable physical properties. Y.K. (1835) therefore noted, supporting his observations with bibliographical references, that "meteorites flare up in the air and look like fast-moving luminous globes. This is the reason why they are hot when they fall to the ground, and smell like sulfur and gunpowder (D'Aubuisson de Voisins 1819). In this regard, it is well known that the meteorite that fell on Angers (1822) burned the fingers of those who wanted to touch it immediately after falling (AA.VV. 1824)." When a meteorite crashing to the ground extinguishes its light, it is possible to hear detonations similar to the discharge of cannons, to the noise of wagons traveling down a street, or to the sound of drums. “Now the reporter did not mention any of these phenomena, but he wants us to believe that those little stones have fallen from the sky covered with ice.” Subsequently, Y.K. (1835) quoted Rose (1826), who classified the aerolites into two main groups. The first class included those specimens—for example, Ensisheim (1492; see Marvin 1992), Mauerkirchen (1768), Lissa (1808), Barbotan (1790), L’Aigle (1803), Doroninsk (1805)—that presented a compact mass in which you could not distinguish, with the naked eye, any physical substance other than a few “pieces” of native iron. The second class to which belonged aerolites such as Stannern (1808) and Juvinas (1821) contained specimens that were composed by various elements not melted together. Both the aforementioned groups listed aerolites presenting an external surface full of edges and covered with a layer made by a black substance that sometimes could be thick. This crust became shimmering when it was cut with a sharp knife. The internal part was ash gray in color, and if exposed to the air, it became covered with rust stains. “Read the description of the presumed aerolite recovered in Marsala,” stated Y.K. (1835) “and see if it shows any of these properties.” Regarding aerolites’ chemical composition, Y.K. (1835) quoted the analysis carried out by Edward Charles Howard (1774–1816; Howard 1802; Wisniak 2012), Louis-Nicolas Vauquelin (1763–1829; Vauquelin 1802; Sears and Sears 1977), Martin Heinrich Klaproth (1743–1817; Klaproth 1803, 1810; Czegka 1997), André Laugier (1770–1832; Laugier 1821, 1827; Kaspar and Jaussaud 2005), and Friedrich Stromeyer (1776–1835; Stromeyer 1825; Ebach 2016). According to Y.K. (1835), these studies highlighted how aerolites’ chemical composition usually contained silica, iron, magnesium, sulfur, nickel, and chrome. There might also be traces of manganese, cobalt, alumina, lime, and soda. “No aerolite has ever been found that has the chemical composition noted by Mr. Romeo,” concluded Y.K. (1835). Furthermore, he challenged the sample’s mineralogical characterization proposed by Romeo (i.e., magnesian spar), and suggested that the presumed aerolite was a Haüy’s carbonate of lime with magnesia (*calce carbonate magnesifera di Haüy*). The latter had the same chemical composition of the fragment analyzed in Palermo and the similar physical properties. Y.K.’s article (1835) ended by warning the La Cerere’s editor not to give credit to any news, and by advising Romeo to get informed about the published scientific data relative to the sample he wanted to analyze, to not throw caution to the wind.

In response to the Y.K.’s (1835) article, a letter appeared in the Maurolico gazette of Messina (Narbone 1855) by Agatino Longo (1791–1889; Longo 1835), who was a professor of chemistry at the University of Catania and one of the Gioenian Academy’s founders (Alberghina 2005). After criticizing the writer for choosing to stay anonymous, Longo (1835) began Romeo’s defense, pointing out that the chemist was never convinced he was analyzing an aerolite, nor did he think the magnesian spar to be a meteorite. Romeo had to analyze the stone recovered in Marsala by “orders from above,” and had to write his report “because he was so ordered to.” Furthermore, the sample’s chemical analysis was not useless, as argued by Y.K. (1835), since a chemist’s duty was to investigate and clarify the real nature of the object he was supposed to analyze. Thanks to Romeo’s report published in La Cerere, Longo (1835) concluded that “all European naturalists find the Marsala meteorites to be counted as fables.”

RESULTS

Marsala as a Doubtful Meteorite

According to the MBD, Marsala is not an official meteorite name as noted in the previous section. In this regard, Grady (2000) also considered Marsala a doubtful meteorite because scientific memoirs reporting the event, such as von Boguslawski (1854), are not conclusive. The principal reason the meteorological event that occurred in Marsala on the night of December 15–16, 1834 cannot be considered a meteorite shower is that neither visual observation was recorded nor meteorite fragment was found.

But as we have shown here, two putative aerolites were in fact recovered after the event. The chemical analysis performed on these specimens in early 1835 indicated that both of them had a terrestrial origin and that the naturalists of the time interested in the study of meteorites were aware of these data. In fact, both the mineralogical characterizations proposed by Maravigna (1835) and Y.K. (1835) identified a mixture of calcite and dolomite (De Fourestier 1998; Bayliss 2011). The next section therefore moves on to discuss the scientific meanings of the lively cultural debate that followed the event and to characterize the event itself.

DISCUSSION

Role of Doubtful Meteorites in Meteorite History Research

The content of the results could easily represent the conclusion of this research, which aimed at ascertaining the nature of the objects that fell from the sky on Marsala that December night 1834. Probably, if this had been the exclusive purpose of the work, it would not even have been necessary to write the paper, since a few months after the event it was already understood that the objects that fell from the sky were not meteorites. But this is not the case.

There are in fact many elements, emerged from this work, that help us to realize how the study of doubtful meteorites can actually give a great contribution to knowledge and not only to science.

Provocatively, we could start from the nomenclature currently adopted in the MBD which is, it is important to bear in mind, the official database that has been constructed and maintained by the Nomenclature Committee of the Meteoritical Society to provide basic information about all known meteorites. In fact, although Marsala was quickly recognized as not being a meteorite, it has been inserted in MBD as a doubtful meteorite, that is, a sample for which there is significant uncertainty over whether it is a real meteorite or, in some cases, if it ever existed.

However, the specific objective of this study does not end up being just a terminological disquisition, although a proper usage of the nomenclature is extremely important in meteorite research. The historical and scientific reconstruction of the presumed Marsala fall has revealed various aspects related to the condition of knowledge on meteorite composition in the early 19th century; to the way in which the scientific community, embedded in socio-cultural contexts, differed in the event's readiness; and to the communicative aspects on the dissemination of science news about meteorite falls that deserve and must be investigated so that meteoritics can express all the values that are proper in science. Commenting on values in science, Griffiths et al. (1989) argued that "scientists bring more than just a toolbox of techniques to their work." As an example, scientists must make complex decisions on the interpretation of data, on which problems to pursue, and how to judge between competing hypotheses. In an area such as meteorite research between the 18th and 19th century, there were different assumptions that might account for the explanation of meteorites' origin and nature (Burke 1986). This paper shows that even as early as 1834—only 30 years after Biot's work on L'Aigle (Gounelle 2006)—scientists in Sicily were well aware of the literature in meteoritics. They knew what to look for in judging whether or not a given sample was terrestrial or not. In this regard, the citation of the L'Aigle meteorite is not accidental. L'Aigle was one of the meteorites. Maravigna (1835) had studied and collected in his private cabinet. Therefore, it is not by chance that Maravigna's report (1835) focused on the comparative analysis between the recovered specimens in Marsala and various samples whose meteoritic origins were experimentally confirmed, preserved in mineralogical collections. Among the mentioned meteorites, the presence of a sample known as Calvados is noted. What is surprising is that all the meteorites listed by Maravigna are confirmed falls, but no name like this is found in Grady (2000) or MBD. Calvados is one of the 83 French departments established during the Revolution in 1790. It is located in the Normandy region, in northwestern France. MBD showed three records for meteorites from this geographical area: Nicorps (1750), L'Aigle (1803), and Le Teilleul (1845). Excluding the latter entry since it happened after the events investigated in this work and Nicorps because Grady (2000) stated, quoting Chladni (1819), that all trace had been lost before 1818, a possible explanation for Calvados could be that it was a specimen recovered in the eponymous department after the L'Aigle fall. Grady (2000) described L'Aigle as a shower of stones estimated at 2000–3000 in number and Calvados could thus be included in L'Aigle's strewn-field area. This temporary shift of subject showed how the analysis of doubtful meteorites may lead to the potential discovery of new data that might be of interest to the meteorite science community. To better picture the role of doubtful falls in meteorite history research in general, and to point out what meteoricists can learn from the analysis of the presumed Marsala fall, this section has been divided into several parts. The discussion of the most interesting findings is shown in the first few sections, while a hypothesis substantiated by research on the nature of the event is best defined in the last section.

Time and Culture

In the event history analysis of what occurred at Marsala in 1834, one of the key aspects is the difficulty of assigning to the events a proper temporal collocation in the past. The sources (e.g., the Gazzetta di Genova) reported that the phenomenon took place at 8 o'clock, but La Cerere referred that the event occurred at eight ante meridians. It is worthy of mention that La Cerere was printed in Palermo, which is about 100 km relevant from Marsala. This is a not-redundant information because different chronometrical scales were adopted in Italy from Roman times to 1866 when the Rome Mean Time was introduced as the country's standard to regulate the administrative services (i.e., railways, telegraphs, and postal services) of the Italian continental provinces (Royal Decree 22 September 1866). Therefore, timekeeping was a local matter in early 18th-century Sicily. It is no wonder that La Cerere dated the events that occurred in Marsala at eight ante meridians, when it was night, and everyone was sleeping. What could be, at first glance, an unsolvable dichotomy is easily explained by the use of the Italian time (*Ore Italiane*). Dominici and Marcelli (1979) described this time convention as closely linked to the Catholic culture and tradition. In Italian time, the day started at sunset—around 6 in the afternoon during the winter—in conjunction with the Vespers (also called Evening Prayer). According to this time convention, the middle of the day (meridian) was around 6 in the morning, so the 8 o'clock before the middle of the day (ante meridian) was at the current 2 am UT. This hypothesis is demonstrated by the lunar eclipse that La Cerere reported on the night of the event. According the NASA GSFC eclipse website tables (https://eclipse.gsfc.nasa.gov/LEcat5/LE1801-1900.html), the lunar eclipse visible in December 1834 reached its maximum around 4 am UT. This information is important not because the eclipse had any effect on the fall, but as a way of indicating the time of the fall itself relative to the time of the eclipse. A proper interpretation of historic time measures is important in astronomical events, and especially in the analysis of meteorite falls occurring in the past. Many of the samples that meteoricists analyze and interpret today are historic falls, and it is important that even the non-historians have a good sense of what our predecessors knew and understood so that their contemporaneous results can be interpreted appropriately.

The Importance of Analytical Chemistry in Characterizing Meteorites

One of the most interesting findings is that the scholars who analyzed the presumed meteorite specimens recovered in Marsala demonstrated their terrestrial origins on the basis of their chemical compositions. Burke (1986) highlighted that about 550 meteorites fell or were found during the 19th century and more than 250 scientists published articles on the chemistry, mineralogy, or petrography of meteorites during that century. These data showed on the one hand scientists' interest in meteorite research and on the other hand how the identification of a reported fall as meteoritic was a hot topic in the 19th century. As Sears (1975) rightly pointed out, one of the most important factors in establishing the scientific study of meteorites was the discovery that most meteorites were physically and chemically alike. One of the main goals of 19th-century foundations of meteorite analysis was to recognize the chemical elements, compounds, and minerals in order to identify in what ways they differed from terrestrial rocks. Between 1800 and 1840, the number of chemical elements known as constituents of meteorites rose from 6 to 19 (Sears and Sears 1977). In his major study on early meteoritics, Sears (1978) pointed out the significant advancements that analytical chemistry made between the work of Antoine-Laurent de Lavoisier (1743–1794), who laid down the basics of quantitative chemistry and could analyze for four elements in meteorites, and the work of Jöns Jacob Berzelius (1779–1848). A complete survey of Berzelius's works is beyond the scope of this paper; however, it is worth noticing, as suggested by Sears and Sears (1977), that in his 1834 essay, Berzelius summarized the mineralogy of stony meteorites as metal, sulfide, olivine, pyroxene, feldspar, and chrome-iron. The analysis of Maravigna's report (1835) demonstrated that he was aware not only of meteorites' chemical characteristics but also of their texture and appearance. He had been studying aerolites in relation to volcanic phenomena (Maravigna 1832),and observing their physical features thanks to various meteoritic samples (e.g., Aigle, Chatonnay, Juvinas, Krasnoyarsk) that were preserved both in his private mineralogical cabinet and at the University of Catania. These data showed how Maravigna and the other Sicilian scientists that characterized the presumed Marsala fall were able to investigate the nature of recovered specimens and to distinguish between terrestrial rocks and meteorites using analytical techniques as those illustrated in Berzelius's works. This finding proves the importance of Berzelius in the advancements of analytical chemistry and how his works were well known to the international scholarly community interested in meteorite research (Beckman 2016).

The Role of the Press and the Objectivity

Another interesting finding concerns the role of the press in the dissemination of scientific news. The local newspapers and gazettes did a credible job of describing the facts and reporting the debates among the scientists by applying a great measure of rigor, precision, and correctness to the writing process. In the articles that followed the event, the only opinions that found space were those of experts and scholars. No margin of freedom was granted to the voices of the opinion makers as can happen today in discussing scientific events. However, journalists and reporters expressed personal comments in narrating both the facts and the stories told by witnesses. This finding confirms that that aperspectival objectivity, that is, the elimination of individual (or occasionally group) idiosyncrasies, spread to the natural sciences only in the mid-19th century, as a result of a reorganization of scientific life that multiplied professional contacts at every level (Daston 1992). What stands out in this analysis is that not only the press was interested in reporting news about meteorite events but presumably also the readers were interested, and followed, these discussions as well. Even today the dissemination of science news about meteorites is a sensitive topic (Kiernan 2000). For example, the media may report falls—that although not true—are then picked up by various press agencies around the world. One example is the since-disputed report of a bus driver who was hit and killed by a meteorite in southeast India in 2016 (Hauser 2016). Furthermore, the data presented in this paragraph are a reminder to the scholars that characterize historic falls today. Several studies have found that European journalism, which was born in the early 16th century, became an efficient network between the 17th and 19th century, thus showing the local newspapers and periodical gazettes as a source of primary importance for the study of the European culture in the modern age (e.g., Arblaster 2005; Espejo 2011). Taking into account that journalistic sources have not been properly surveyed in meteorite research, the contribution that local gazettes can bring to the study of historic falls appears to be considerable. Even if critical analysis has always been carried out when historical sources of any kind are investigated, the case of the Marsala presumed fall brought to the attention of meteoricists that journalistic sources are rich in contents (e.g., in the case-study presented here, all the experimental analyses were accurately described), and more reliable than others. In this regard, Gozzini (2000) and Farinelli (2004) pointed out how Italian gazettes rated among the most accurate journalistic sources at that time because they usually had an educated readership and most of them were printed in the main city centers of the Italian regional states (e.g., Milan, Venice, Rome, Naples, and Palermo), thus helping the reporters in the fact-checking process. It was the geographical proximity that allowed the Sicilian journalists to rectifying information about the events that occurred in Marsala. The amount of data about possible meteorite events contained in journalistic sources, which in the age of the internet are largely accessible online, can significantly improve the knowledge of historic meteorite fall by leading both to the potential discovery of new meteorite specimens, and to the retrieval of data that can be used to define hypotheses on doubtful or confirmed falls already known to the scientific community.

The Marsala Event: A Possible Explanation

An initial objective of this work was to clarify the nature of the event that occurred in Marsala in 1834. In accordance with the present results, it cannot be identified as a meteorite shower. So, can it rain rocks even if they are not meteorites? In this regard, there are a number of historical accounts that have also been published in major scientific journals (Gray 1859; McAtee 1917; Gudger 1929; Bajkov 1949), describing rains of animals from the sky. Such stories were present in the literature of the first century AD—for example, the Roman naturalist Pliny the Elder (AD 23/24–79) documented storms of frogs and fish (e.g., Dennis 2013)—and have continued to be reported ever since. Among these chronicles, the tale of Heraclides Lembus (dates uncertain), a Greek philosopher who lived in the second century B.C., described a rain of frogs in Paeonia and Dardania during which "so great has been the number of these frogs that the houses and the roads have been full of them" (Barnett 2015). With the beginning of the Renaissance period, these reports became more frequent and documented by engravings (Fig. 2) (Martin 2011). These "marvelous rains," as they have been defined by various authors (e.g., Rao 1582; Maffei 1601; Della Porta 1669), typically involved fish and frogs, although rare depictions of snakes and mice raining from the sky may also occur (Fig. 3). They were usually related to very strong meteorological phenomena (namely tornadoes and waterspouts), where the ascending currents have sufficiently high speed to raise objects of low density for tens or hundreds of meters.

Nevertheless, when historical sources reported stone showers, these events usually described meteorite falls or volcanic ejecta (e.g., Franza and Pratesi 2020). It should be noted that ancient chronicles can also report the fall of icy stones. In such cases, the word "stone" does not indicate rocky material but hailstones (Tate 1889). In this regard, Kumjian et al. (2020) described a thunderstorm (Argentina, 2018) that produced some of the biggest hailstones on record (ca. 18.8–23.7 cm wide). In the case of the rain of stones reported to have fallen from the sky in Marsala, one may postulate that these stones did actually fall along with hail. It is worth mentioning that in the surroundings of Marsala, within a few kilometers' radius, there are outcrops of Upper Triassic—Lower Liassic limestones, dolomitic limestones, and dolostones, which are very similar to the specimens described in Romeo's and Maravigna's analyses. The presence of these lithologies (namely outcroppings at Favignana Island and at Erice Mt.) was officially recognized when the geological map of Sicily was printed in the second half of the 19th century (Fig. 4). However, the findings suggested that this type of rocks was probably known to the local scientists at the time of the event. This observation may help us to understand why Maravigna (1835) was so astonished that a chemical analysis had been carried out on a sample of limestone, whose terrestrial nature was recognizable to the naked eye. According to these data,

Fig. 2. Olaus Magnus (1490–1557) 1555 engraving of rain of fish—16th century engraving from a description of the northern peoples.

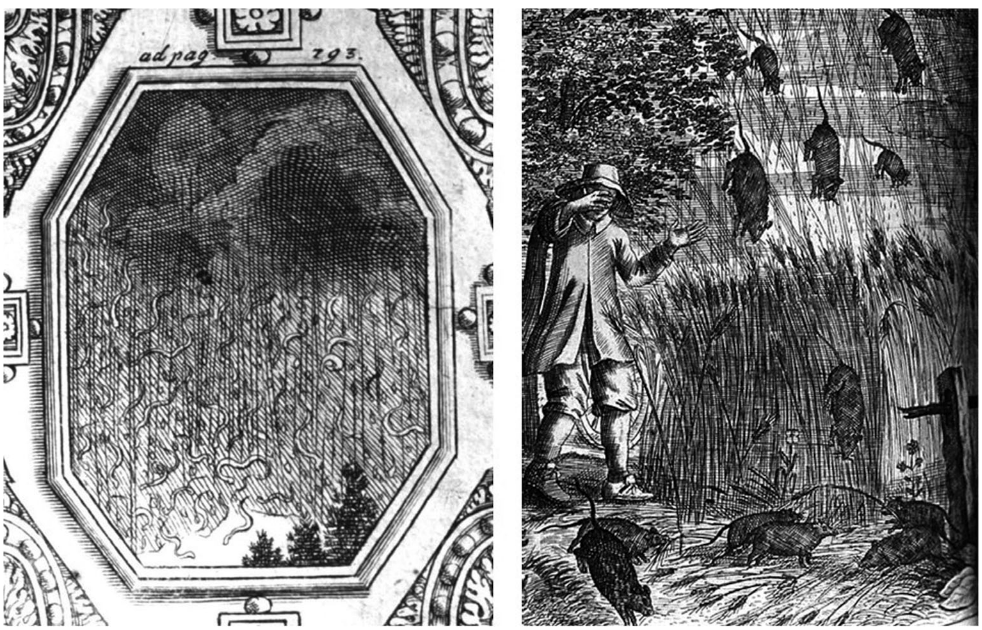

Fig. 3. Left) Raining snakes during a Renaissance storm. In: "Der Wunder-reiche Uberzug unserer Nider-Welt...." by Erasmus Francisci, 1680. Library Call Number QC859.F72 1680. Archival Photography by Steve Nicklas, NOS, NGS. - NOAA Photo Library: wea02218. Right) Raining rats during a particularly violent storm. In "Der Wunder-reiche Uberzug [sic] unserer Nider-Welt…." by Erasmus Francisci, 1680. NOAA's National Weather Service (NWS) Collection, NOAA Photo Library.

the recovery of this type of rock in Marsala would not be surprising.

Nevertheless, it has yet to be explained how limestones and dolomitic limestones could have been lifted off the ground and then transported for several kilometers. A possible explanation for this might be that severe weather events such as tornadoes can occur in Europe (e.g., Antonescu et al. 2017; Taszarek et al. 2019). In this regard, Mediterranean countries are also affected by waterspouts, which can be very violent (e.g., Giaiotti et al. 2007). The coast near Marsala was the scene in 1851—just 17 years after the event we are investigating—of what is counted as one of the strongest and most disastrous waterspouts in the history of meteorology.

According to the Illustrated London News of December 20, 1851, which reported information received by Lloyd's from Malta (dated December 8),

Fig. 4. Geological map of Sicily. The blue color indicates areas where Upper Triassic—Lower Liassic limestones, dolomitic limestones, and dolostones outcrop.

two waterspouts crossed the coast of Sicily near Marsala, which became two giant tornadoes a quarter of a mile apart. They appeared to have moved in a NE direction, and returned to the sea at Castellamare. The chronicle stated that "in their progress houses were unroofed, trees uprooted, men and women, horses, cattle, and sheep were raised up, drawn into their vortex, and borne on to destruction." Half of the town of Castellamare was destroyed, and 200 of its inhabitants were washed into the sea, where they all perished. Upward of 500 persons were killed in total. The tornadoes were accompanied by torrents of rain and huge hailstones. Even though Miglietta and Matsangouras (2018) stated that the nature of the event was uncertain, the same authors confirmed the number of victims reported in the chronicle.

Going back to the meteorological event of 1834 that caused the fall of the presumed "Marsala meteorite," the witnesses' reports (e.g., the fierce bad weather; the roar of wind, rain, and hail; many birds found dead) suggested that it was surely an extraordinary storm accompanied by very strong winds similar to those occurring in tornadoes and waterspouts. As clarified by De Lange et al. (2006), the addition of 2.5–5% of atomized water to a waterspout vortex significantly increases the flow competence, so that intensity T3–T5 (TORRO Tornado Intensity Scale) or F2 (Fujita Tornado Intensity Scale) waterspouts could be capable of moving boulders up to 2 m in size.

Therefore, it should come as no surprise that pebbles of various sizes might have been lifted and tossed by the wind. It is much less likely that these might have been the condensation nucleus of hailstones. The fact that they were covered with ice does not necessarily indicate that they were the nuclei of the hail; they could have been covered, once fallen to the ground, by a shell of ice due to contact with supercooled water droplets.

Another interesting finding was that Sicilian scientists interested in meteorite research were also meteorite collectors. This information, in addition to pointing out how meteorites were collected as objects of scientific interest (McCall et al. 2006; McCubbin et al. 2019; Franza and Pratesi 2021), suggested the possibility that the recovered specimens have become part of a museum collection. To demonstrate the reliability of this hypothesis, a survey within the collections of the Museum of Mineralogy, Petrography and Volcanology of the University of Catania has been carried out. However, no specimens corresponding to any of the samples recovered in Marsala were found (Mazzoleni, personal communication). Nonetheless, a search performed at other Italian natural history museums discovered that the naturalist and geologist Teodoro Monticelli (1759–1845) acquired a sample of the presumed aerolites that fell on Marsala in 1834 and classified it as meteoritic iron in his Catalogue of Exotic Minerals (Monticelli 1839). Monticelli was a prominent scholar of his time. He was the author of several works on the volcanic activity of Mount Vesuvius and its products as well as the owner of a mineralogical cabinet, which encompassed more than 16,000 samples (Di Gregorio 2000; Mendetti and Petti 2001; De Ceglia 2012). In the aforementioned book, Monticelli (1839) classified about 2986 mineralogical specimens belonging to his private collection according to the classification system proposed by Réné Just Haüy (1743–1822) and François Sulpice Beudant (1787–1850; Schütt 1984; Saeijs 2004). Among these samples, there were 26 specimens recorded as meteoritic iron (*ferro meteorico*). This compound was usually found, according to the scientific literature of the time, in those meteorites in which the most abundant chemical element was indeed iron, mixed to other substances of metallic origin (Burke 1986). The last inventoried specimen of meteoritic iron was a fragment that Monticelli briefly described as recovered in Marsala in 1834. Monticelli's meteorite collection, along with the remaining minerals belonging to his cabinet, is currently preserved at the Royal Mineralogical Museum of the University of Napoli "Federico II" (Franza et al. 2021). However, no meteorite specimen recovered in Marsala is actually part of Monticelli's collection nor has any ever been recorded in the ancient Royal Mineralogical Museum's catalogues and inventories.

On the basis of all these findings, Marsala cannot be considered as a doubtful meteorite and should be definitively considered as a terrestrial stone.

CONCLUSIONS

This study set out with the aim of assessing the role of doubtful meteorites in the history of meteoritics. With respect to the research question, the work investigated the presumed witnessed fall that was recorded in Marsala (Sicily, Italy) on the night between December 15 and 16, 1834. Very little was found in the literature on this "extraordinary phenomenon," and previous studies as Grady (2000), who quoted von Boguslawski (1854), observed inconsistent results on whether the event was meteoritic in origin, because no meteorite fragments had ever been recovered. This explains why the MBD classified Marsala (1834) as a doubtful meteorite, and not as an official meteorite name.

The current study found that this unusual event provoked a lively debate in the press and among the scholars of the time. Various Italian and foreign newspapers reported the news, while the pages of several Sicilian gazettes followed the scientific discussion, which involved chemists and naturalists belonging to the Gioenian Academy and to the Universities of Catania and Palermo, about the real nature of the event.

The purpose of the current study was therefore to contribute to the knowledge of the role of the doubtful meteorites in the history of meteoritics and to characterize the event that occurred in 1834 in Marsala. Even if doubtful meteorites have been discarded because they were not followed by the recovery of any meteorite samples and, in some cases, there is no certainty whether they really occurred, this research has found that their investigation may reveal interesting historical and scientific data. Although the current study is based on the analysis of a single doubtful meteorite, the findings revealed interesting aspects relative to the early stages of meteorite research, to the dissemination of science news, and to meteorite collecting over the centuries.

Future research will be conducted in a cross-national dimension to investigate the cases of other doubtful meteorites, and the role they played in the development of meteoritics in their countries.

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