Molina de Segura: the largest meteorite fall in Spain

Jesús Martínez-Frías and Rosario Lunar provide a historical and scientific perspective of the outstanding fall and main features of this ordinary chondrite, in the context of its 150th anniversary.

Unfortunately, Spain does not have a strong scientific tradition of the study of meteorites, unlike many other European countries. This is probably the main reason why none of the Spanish meteorite collections appears in the noteworthy compilation carried out by McCall et al. (2005), as a special publication of the world’s oldest national scientific and professional society for earth scientists (The Geological Society of London). Thus, whereas the meteorites from the Natural History Museum of Vienna, the Museum für Naturkunde, Berlin, the Natural History Museum, London, the National Museum of Natural History in Paris, and the Vatican are well represented in such publication and named as “key meteorite collections” by McCall et al., there is a conspicuous absence of Spanish collections. However, the limited Spanish scientific background in meteoritics – which has, sadly, run in parallel to that of science as a whole in the country – does not imply that remarkable meteorite collections do not exist in Spain’s museums; on the contrary, some of them host extraordinary meteorite specimens with added historical value – for example, Museo Nacional de Ciencias Naturales (MNCN, the National Museum of Natural Science, figure 1). This institution hosts the best Spanish meteorite collection and the largest piece in the world from Molina de Segura (figure 2).

This year is the 150th anniversary of the largest meteorite fall in Spain and, indeed, one of the largest falls of a stony meteorite in Europe: the Molina ordinary chondrite. In this context, this paper aims to:

- offer an overview of the social-scientific context of 1858 and the evolution of the research on meteorites in Spain, from both a general perspective and focused on the particular framework of the collection of the MNCN;
- discuss and justifiably propose a minor change of the name with which this meteorite appears in the international Meteoritical Bulletin Database;
- bring to the attention of the international scientific community this emblematic meteorite event, explaining the circumstances surrounding the fall and describing its main mineralogical, petrologic and geochemical features.

**ABSTRACT**

This year is the 150th anniversary of the largest meteorite fall in Spain: the Molina H5 ordinary chondrite. This paper aims to bring to light this emblematic and remarkable meteorite event in the social-scientific context of 1858 by: giving a brief overview of the evolution of research on meteorites in Spain; explaining the circumstances surrounding the fall, recovering unique historical documentation about the event; and describing its main mineralogical, petrologic and geochemical features. Finally, a minor change of the meteorite’s name is proposed, in line with the renaming of the locality of the fall.

**The MNCN’s meteorite collection**

It is well known that how a society makes sense of an amazing natural phenomenon depends on the socio-cultural context. Thus it seems appropriate to offer some historical scientific snapshots to characterize the period in which the meteorite fall took place.

The year 1858 was an exciting and vigorous one for science. Probably one of the most significant scientific events that shaped our current view as human beings was the memoir that the naturalist Alfred Russel Wallace addressed to Charles Darwin (see, among others, Raby 2002, Shermer 2002). It contained the main principle of his own ideas of natural selection. Persuaded by Charles Lyell and others, Darwin presented the Wallace memoir as well as his own conclusions to the Linnean Society on 1 July 1858 (prior to the publication in November 1859 of The Origin of Species by Means of Natural Selection). More specifically, 1858 saw remarkable scientific achievements related to findings not only on meteorites, but also comets, asteroids and even Mars. For instance, Horace Parnell Tuttle of Harvard College Observatory discovered Comet 8P/Tuttle, which is responsible for the Ursid meteor shower in late December. Friedrich August Theodor Winnecke, in Bonn, Germany, accidentally rediscovered Comet 7P/Pons-Winnecke. James Challis and
James Breen made a series of observations of Donati’s Comet, one of the great comets of the century, with the Northumberland telescope (Jenniskens 2006, Kronk 2007, Brück and Grew 1999). Also in 1858, on 4 February, H. Goldschmidt discovered 52 E uropa, an asteroid with a diameter of 289 km, and on 10 September George Searle at the Dudley Observatory in Albany discovered 55 P andora, a moderate-sized main-belt asteroid with a cycle of 4 years, 211.7 days.

From a more modern astrobiological perspective, two other significant events of 1858 deserve attention. First, the German chemist Friedrich Wöhler identified organic material in meteorites (Wöhler 1858, Kauffman and Chooljian 2001, Kissin 2003), although it is important to stress that he believed at the time that the organics were biological, and thus extraterrestrial life was possible. Second, the Jesuit astronomer Angelo Secchi, director of the observatory of the Collegio Romano in Rome, described “a large triangular patch, blue in colour” on Mars, that he named “Atlantic Canale”, commenting that it “seems to play the role of the Atlantic which, on Earth, separates the Old Continent from the New”. Thus he anticipated Schiaparelli’s use of the term “canali” (Sheehan 1996).

Whereas a remarkable social, scientific and technological transformation was in progress in the world during the beginning of the last half of the 19th century, Spain in particular kept looking back to the past. Only some timid initiatives, related to both the foundation and reorganization of cultural and academic institutions (e.g. re-foundation in 1850 of the Academy of Science as Royal Academy of Exact, Physical and Natural Sciences), and the outstanding body of work of certain individuals, such as José Echeagaray y Eizaguirre, stand out with real historical significance. In 1838 Echegaray was professor of mathematics and physics in Madrid’s School of Engineers and subsequently, in 1904, was awarded the Nobel Prize for Literature. He was one of the principal critics (García Camarero 2000) of the institutionalized lack of interest in science education and research.

Probably the most significant and exemplary Spanish institution of the time was, curiously, the MNCN, whose changes and history reflect the general situation of science in Spain. The MNCN hosts the best collection of meteorites in Spain and houses the world’s largest piece (112 500 g) of the Molina meteorite. The current Prado museum building was initially designed by Charles III to be used as the Natural History Museum, evidencing and emphasizing the significance that it should have had, but since the beginning of the 20th century the MNCN has had around 67% of its total floor space (40 000 m²) taken up by the Technical School of Industrial Engineering with which it shares the former Palace of Industry and the Arts. This situation was denounced in 1999 (García Guinea and Martínez-Frias 1999), with an unsuccessful request that this unusual assemblage of two centres on the same premises be corrected.

A systematic change

The first initiative to systematize the meteorite collection of the MNCN was conducted by the Marquis of Socorro, eight years after the fall of the Molina meteorite, based on several specimens stored in the museum and several later exchanges and acquisitions. According to the last updating of the catalogue, the collection includes 88 stony meteorites, 56 iron meteorites, and 13 stony-iron meteorites, as well as 14 tektites (Muñoz-Espadas et al. 2002).
The first classifications of the Spanish meteorites were made at the end of the 15th century. Then the collection included 68 specimens corresponding to 64 meteorites. In 1916, 99 specimens from 94 meteorites were listed and, by 1923, the collection contained 168 specimens (Fernández Navarro 1923). This total increased in the following decades thanks to private donations. A later inventory of the collection published by King et al. (1986) numbered 217 specimens from more than 155 different meteorites. Three years later an overview focusing on Spanish meteorites was carried out by Martínez-Frías et al. (1989). The petrologic and geochemical features of some meteorites of the collection were characterized by, among others, Sanz and Wasserburg 1969, Sanz et al. 1970, Williams et al. 1985, Keil et al. 1986, Casanova et al. 1990, McCoy et al. 1990. Other studies focused particularly on: the circumstances surrounding some falls (Martín-Escorza 1987, Alcala and Martín Escorza 1996, 2000, Ordaz et al. 1999); the study of selected ordinary chondrites from the Museum’s collection as part of a PhD thesis (Muñoz-Espadas 2003) supervised by the authors; and the general situation of meteoritics in Spain and Portugal (Martínez-Frías and Madero 2004).

From a historical (and scientific) point of view, it is important to stress that, since the impressive meteorite fall of Reliegos in 1947 (Gomez de Llarena and Rodriguez Arango 1948), 50 years passed before a new Spanish meteorite was catalogued in the Meteoritical Bulletin: the Valencia meteorite. The research on this H5 chondrite was carried out both in the MNCN and at the Complutense University of Madrid, although the meteorite is kept not in this collection, but by the University of Valencia (Muñoz Sanz et al. 1998). In 1994 a supposed meteorite struck a car in the town of Getafe (South Madrid). Studies indicate that, although the circumstances surrounding the fall are well documented, the petrologic and geochemical characteristics of the material (a larnite-rich ultra-refractory rock) do not match any of the previously classified meteorites or clearly terrestrial rocks (Martínez-Frías 1999, Martínez-Frías et al. 1999). Thus, we included this in the catalogue as a pseudometeorite (Muñoz-Espadas et al. 2002) and a special statement was made about it by the Nomenclature Committee of the Meteoritical Society (http://tin.er.usgs.gov/meteor). Further information about the Getafe pseudometeorite – probably a piece of electric arc furnace slag – can be found at http://tierra.rediris.es/merge/getafe.html.

A recent review of the meteorite collection (Garcia-Guinea et al. 2006) includes the new acquisitions of Spanish meteorites (Villalbeto de la Peña and Puerto Lápice) (Llorca et al. 2005), which correspond to finds that have been related to the bolides of 4 January 2004 and 10 May 2007. (It is important to note that, whereas the bolides were widely observed in different parts of the Iberian Peninsula, there were no direct witnesses of the meteorite falls, and no pieces were collected coinciding simultaneously with the observation of the bolides.) The first fragment of Villalbeto de la Peña was found seven days after the bolide event and the first fragment of Puerto Lápice after 24 days. Other fragments were found subsequently, which were assigned to these bolides (see http://tin.er.usgs.gov/meteor/).

The Molina (de Segura) meteorite

Molina is an H5 ordinary chondrite which is included in the MNCN’s meteorite collection as the only specimen (figure 2) of a total fall mass of 144 kg (Muñoz-Espadas et al. 2002). It is one of 5763 approved meteorites (plus 11 unapproved names) classified as H5 chondrites, one of 27 approved meteorites from Spain and, along with the Cabezo de Mayo meteorite, one of two approved meteorites from the Murcia province in Spain (http://tin.er.usgs.gov/meteor).

The official name “Molina”, as the meteorite is listed in the international Meteoritical Bulletin Database, is not currently exact (although it was in 1858 when the fall occurred), and could lead to confusion. On 27 June 1916 there was a proposal from the Royal Geographic Society to change the names of 573 Spanish towns. The initiative attempted to avoid the confusion caused by the fact that more than 1020 Spanish towns shared the same name – for example: Molina de Aragón, Guadalajara province; La Molina de Ubierna, Burgos province; La Molina, Gerona province; and, of course, Molina de Segura, Murcia province. The Royal Geographic Society advocated the addition of the name of the town’s local river, to the name of the locality, so that it changed from “Molina” to “Molina de Segura”. Thus, in order to avoid any misunderstanding in the context of meteorites’ nomenclature, it would be appropriate to take into account this geographic modification, updating “Molina” into “Molina de Segura” in the international Meteoritical Bulletin Database. This proposal has already been suggested by Muñoz-Espadas et al. (2002).

The fall of the Molina meteorite occurred on 24 December 1858 at 2.45 p.m. (38°7’N, 1°10’W). The circumstances surrounding the event are extraordinarily well documented thanks to the detailed report given by Rafael Martinez-Fortún (Moreno López 1862), which is recorded in the archive of the MNCN. It is important to note that an error in the Museum archive number related to this documentation has been spotted, thanks to the help of the Museum’s staff. This error is present in all previous historical articles: the archive number is not 169 but 258/004 (http://aleph.csic.es).

This report of exceptional historical value is presented for the first time (figure 3), and it is transcribed verbatim here, translated in a manner intended to maintain the original writing style of the Spanish of the period:

“A big noise was suddenly heard resembling that produced by the electricity in the clouds, and the people who were in the street, in pathways and in the field, saw a magnificent globe of fire to appear with an extraordinary and dazzling brilliance which, boasting the colours of the rainbow, overshadowed the light of the Moon and descended majestically from the aerial regions, crossing our horizon in oblique direction of the Northern noon. It passed over this city at so short a distance from the tower of the cathedral, that those who observed it from its interior thought that it was touching the light of the tower, but it does not happen so. On the contrary, it travelled around three more leagues, went beyond this city and its boundary and was to fall on a farm. The impact against the ground produced a shaking and vibration

3: First page of the historical document 0258/004, which includes a description of the meteorite fall. (MNCN)
so strong that it could be felt not only in the vicinity of that site, but also in this city, from whose noise and shaking many people who were sleeping woke up, and all, except those who observed the phenomenon outdoor, thought that it was one of those storms so frequent in this locality filling them with terror. The residents who met at the site, got all confused without knowing who could have produced that or with what object, as neither marks left by people or animal were left around the area, nor marks of hoes or other tools. They scratched superficially but found nothing. Later on, cutting barley, one of the harvesters noticed the hole and scratching with the sickle touched a hard and resistant body, which he communicated to the farm labourer and his co-workers; all arrived and, scratching at that point at a depth of stick, they found a quadrangular-shaped stone of blackish colour and an extraordinary weight compared with its volume, as it weighed more than 250 pounds. This fact, together with that the rock did not resemble any one they had seen since then in the surrounding areas, called their attention, one of them taking out a fragment from one of its corners by a bit that he gave with an iron mallet. ” Although small fragments of Molina are hosted in different museums and collections (e.g. Natural History Museum, Langenheimrich Museum, Field Museum, Marmet meteorites, Vatican meteorite collection), the MNCN houses the largest piece in the world. A reproduction of the meteorite was made and can be visited in the “Aula de la Naturaleza” (Nature’s Hall), which is managed by the Environment Department of the Ministry of the Environment (see http://www.molinadesegura.es). At present, the area related to the meteorite fall (locally and officially named as “Alrededores del Rellano y Molina de Segura meteorite”) is one of the 75 “sites of geological interest” in the Murcia region (Arana et al. 1999, Arana 2007).

To our knowledge, the best and most complete research on Molina was carried out by McCoy et al. (1990) in the context of a series of systematic studies of meteorites from the MNCN. These authors point out that, due to an error of mislabelling in the American Museum of Natural History collection, this meteorite was originally classified as an L group chondrite (see Mason 1963, Van Schmus and Wood 1967). In accordance with McCoy et al. (1990), Molina is classified as an H5 chondrite (olivine: Fa18.5, σ=0.6, N=30; and low-Ca pyroxene: Fs17,1, σ=1.2, N=20), also including plagioclase (An4≥Al4–An15; N=3), troilitie and chromite. In addition, hydrated iron oxide also occurs as a pigment in the silicates and as an alteration at the edges of some metal grains. This error has still not been corrected in the MNCN label of the meteorite, and it is wrongly presented as an L5 chondrite.

Molina was the last meteoritic fall recorded in 1858 (24 December), but not the only one. According to the excellent catalogue of meteorites of the Natural History Museum (Grady 2000), nine other meteorites were recorded: three falls (Aussyon, France; Kakowa, Romania; Zmenj, Belarus) and six finds (Augusta County, Trenton and Wooster, USA; Caparrosa, Mexico; Joel’s Iron, Chile; and Swindnica Gorna, Poland). Although it is not confirmed, another meteorite (the Salla chondrite, Finland), which was found in 1963, may also have fallen in 1858 (Moilanen 2003).

The historical-scientific anniversary of this significant Spanish fall will be marked with scientific and public outreach activities (talks, seminars, round tables, etc) as developed for other similar events commemorating meteorite falls (e.g. Sikhote-Alin meteorite shower, Westton meteorite, “Hodges meteorite”). The specific topic of Molina will be specially addressed in the context of the round table entitled “Geology and planetary exploration” (Martinez-Frias et al., 2008), which, for the first time, will be organized as part of the Geological Congress of Spain. Today, 150 years after the event, we believe that further attention and scientific investigation should be devoted to Spanish meteoritics in general and, in particular, to this historically remarkable and scientifically interesting H5 chondrite.

Jesus Martinez-Frias, Planetary Geology Laboratory, Centro de Astrobiología, CSIC/INTA, Associated to the NASA Astrobiology Institute, Ctra de Ajalvir, Km. 4, 28850 Torrejón de Ardoz, Madrid, Spain; martinezfj@inta.es.

Rosario Lunar Hernández, Departamento de Cristalografía y Mineralogía, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, 28040 Madrid, Spain; lunar@geo.ucm.es.

Acknowledgments. Special thanks to the Spanish National Museum of Natural Science (MNCN), in particular to M. Carmen Velasco (Head of the Archive), Manuel Parejo and Noela Cejuela, and Isabel Monem Merchant (Head of the Service of Documentation), for their help in relation with the historical report about the Molina meteorite. Also thanks to Dr David Hochberg for his revision of the English version.

References

Alcalá L and C Martín Escorza 1999, Boletín de la Real Sociedad Española de Historia Natural Suppl. 471–474.