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The meteorite collection of the National Museum of Natural History in Paris, France

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Abstract: The French national meteorite collection of the Muséum National d'Histoire Naturelle (MNHN) represents one of the richest collections in the world in terms of its historical heritage and scientific value, particularly for samples of observed falls (512). In fact, early meteoritic research was dominated by French 18th and 19th century scientists such as René Just Haüy, Auguste Daubrée, Stanislas Meunier and Alfred Lacroix. They all contributed, along with Jean Orcel and Paul Pellas in the last 80 years, to form this exceptional collection. The fall at L'Aigle in 1803 led to the recognition of the nature of meteorites and the promotion of the science of meteoritics by Jean-Baptiste Biot. The first catalogue of the meteorite collection elaborated by Cordier in 1837 contained 43 specimens. The collection now contains about 3385 specimens representing 1343 distinct meteorites, to which can be added at least 3000 tektites and numerous specimens of impactites, casts, artificial samples and thin sections. France has the greatest number of meteorite falls by surface unit and by number of inhabitants, with 70 distinct meteorite falls recovered. The collection offers a diverse range of meteorites such as those containing rare presolar grains, the famous carbonaceous chondrite Orgueil (fall, 14 May 1864), the first martian meteorite, Chassigny (fall, 3 October 1815) and Ensisheim (fall, 7 November 1492), which is one of the two oldest observed and documented meteorites and the first meteorite to be registered in the catalogue. The MNHN collection represents a resource that is particularly appreciated by the scientific community.

The origin of the collection of the French Musée National d'Histoire Naturelle (MNHN) officially goes back to the middle of the 19th century. It was significantly expanded and enriched due to the great interest and curiosity of several naturalists and scientists, and particularly by Auguste Daubrée and Alfred Lacroix. However, René Just Haüy, a mineralogist of the MNHN, and other unknown or eminent private collectors had already gathered aerolithes or meteoritic irons in their private collections before the well-known and widely observed fall at L'Aigle in 1803. The thousands of brecciated (L6) stones from this famous fall contributed greatly to the recognition of the nature of meteorites, as well as to the efforts of Jean-Baptiste Biot to officially promote the science of meteoritics.

In recent years some collections have dramatically increased their number of distinct meteorites after systematic campaigns of both search and sampling organized in cold and warm deserts (see Bevan 2006; Kojima 2006). Nevertheless, the Paris MNHN collection has remained the third of its kind in importance in terms of samples of observed falls (512) (Appendix 1) compared with the collections of the British Museum in London and that of the Smithsonian Institution of Washington, DC, excluding the hot- and cold-desert collections. France has become the country with the greatest number of meteorite falls by surface unit and by number of inhabitants, with 70 distinct meteorites today excluding those that were lost over the years (Fig. 1). The collection offers a diversified range of rare meteorites containing presolar grains or evidence of the birth of the Sun and its family of planets. Some stones, like the carbonaceous chondrite Orgueil (fall, Département of Tarn and Garonne, on 14 May 1864) and the first martian meteorite fall Chassigny (fall, Haute Marne, on 3 October 1815) and many others, are of great value and represent a resource particularly appreciated by the scientific community. The well-preserved stone from Ensisheim that fell in Alsace, France on 7 November 1492 represents one of the two oldest observed and documented meteorite falls (see Marvin 2006) and the first meteorite registered in the catalogue.

From: McCall, G.J.H., Bowden, A.J. & Howarth, R.J. (eds) 2006. *The History of Meteoritics and Key Meteorite Collections: Fireballs, Falls and Finds*. Geological Society, London, Special Publications, **256**, 163–204.
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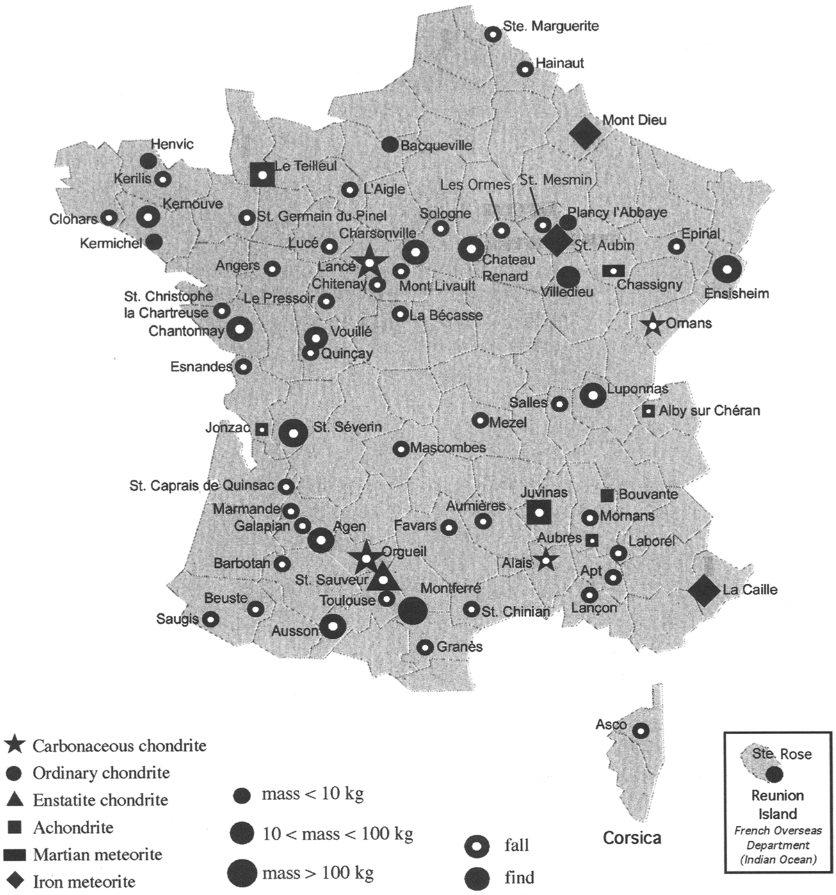

Fig. 1. Map of all meteorites collected on the French territory. Observed falls like Nicorps, Mont Vaiser or Aire sur la Lys whose samples do not exist or have disappeared (Carion *et al.* 2003), as well as new acquisitions that have been described but not yet catalogued, are not shown on this map. St., Saint; Ste., Sainte.

The La Caille iron meteorite (found in the Alpes Maritimes in 1828) is the biggest meteorite of the collection and weighs 625 kg (Fig. 2). In the past, the collection has been shown in permanent or temporary large exhibits. The last spectacular exhibit took place in 1996–1997 (over 1000 m^2) in the renovated Grande Galerie of Evolution of the MNHN. A few slices of exceptional beauty, and unaltered samples, have been exhibited safely since 1987 in the armoured Treasure Room located underneath the giant-crystals room of the Mineralogy Gallery. Most of the other samples are actually no longer permanently displayed because of curational and financial concerns, but there are plans to create a new permanent exhibit in the near future. At any time, a small number of meteorites are lent

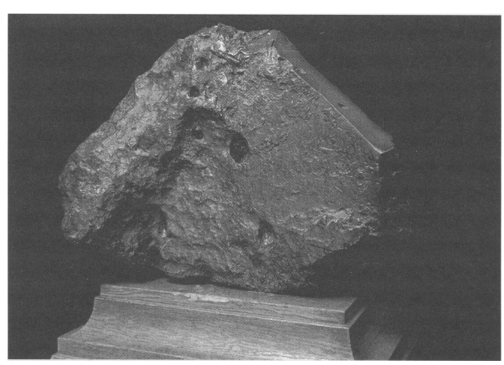

Fig. 2. The largest French meteorite La Caille (626 kg) on its stub. This iron meteorite measures 60 cm in the largest dimension (© L.E.M.E., MNHN).

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for temporary exhibits, public outreach activities and educational purposes (school exhibits, conferences, interviews and media articles).

Historical background

The 'Jardin Royal des Plantes Médicinales' ('Royal Garden of Medicinal Plants') was founded in 1626 by King Louis XIII, who authorized its foundation in a patented letter to Guy de La Brosse, his ordinary physician who became the first intendant of collections (Plouvier 1981). Although the 'Jardin du Roy et de son Droguier' ('Garden of the King and his Pharmacy') was effectively founded in 1626 by King Louis XIII, it was Louis XIV who officially defined its administrative structure by a declaration in 1671. The 'Droguier du Roy' was a distinct entity, consisting of a random collection of all the different substances used at that time for official chemistry classes and experiments open to the public, as well as those substances with curative properties used by the royal family and for hospitals in Paris. As such, it contained various blown-glass vials containing drugs and medicinal plants, as well as precious stones, minerals, salts, natural rock powders and various ores that were known for their true or supposed curative properties. The minerals and ores of the 'Droguier du Roy' thus constitued the first collection of mineralogy and geology in France, and one of the first in the world. In fact, the collections of the current MNHN, founded in 1793, began with those of the 'Droguier du Roy'. With time, the collections were progressively enriched with new acquisitions, donations, royal gifts, and objects from world travels and discoveries.

At the time of the death of Louis XIV in 1715, the 'Droguier' contained, in addition to its initial collections, a vast number of natural curiosities belonging to the animal, vegetable and mineral kingdoms. A multitude of objects that were not displayed at the King's court in Versailles continued to join the collections. Bernard de Jussieu (1699–1777), a botanist and physician who elaborated upon a method for classifying plants, became keeper of the collections in 1722 and undertook the first systematic classification of the Droguier's numerous and diverse collections. Georges Louis Leclerc, comte de Buffon (1707–1788), the famous French naturalist and author of the first 'Histoire Naturelle' (natural history) in 40 volumes (1749–1804), reorganized the collections of the 'Droguier du Roy' into the 'Cabinet Royal d'Histoire Naturelle' around 1739. All the objects it contained had by now become objects of collection and research, and the starting point of systematic classifications. In 1745 Buffon and Louis Jean Marie Daubenton (1716–1800), his collaborator and another famous French naturalist who specialized in zoology, mineralogy and rural economy, opened the 'Cabinet Royal' to the public, exhibiting its minerals in 99 glass showcases. Daubenton then greatly enhanced the collection of precious stones, transforming it into a true collection. In recognition of the vast reputation of his scientific work, Buffon received numerous minerals as presents from such famous royal admirers as the King of Poland in 1772 and Catherine II, Empress of Russia, in 1785.

In contrast to many cultural objects and monuments that were destroyed, stolen or vandalized during the convulsive events of the French Revolution in 1789, the collections of the 'Cabinet du Roy' surprisingly survived. In fact, they were enriched to include some of their most valuable objects, such as numerous precious stones and engraved gems that were arbitrarily confiscated during the Revolution. In 1793 a complete reorganization of the 'Jardin du Roy' and the 'Cabinet Royal' led to the foundation of the Museum National d'Histoire Naturelle (MNHN) by a decree of the 'Convention Nationale' (in Jaussaud & Brygoo 2004), the executive and legislative ruling assembly at that time. The MNHN was divided into 12 scientific departments or Chairs (Hugard 1855). The division of mineralogy and geology now began a rapid increase of its collections, which now, in 2005, consists of approximatively 1 million objects, including about 245 000 sets of minerals, 2500 precious cut-gems and 600 000 rock specimens, in addition to 3385 specimens of meteorites, more than 3000 tektites and 1500 specimens of synthetic minerals (E. Vennin & P.-J. Chiappero, MNHN pers. comm.).

The French geologist and volcanologist Barthélémy Faujas de Saint Fond (1741–1819), who was the associate curator of the 'Cabinet du Roy' as of 1787, was promoted to the position of Professor and Chair of Geology at the MNHN in 1793, which he retained until he retired in 1818. Although he made a major impact on the recognition of the volcanic origin of basaltic and other eruptive rocks, he essentially only collected volcanic rocks and minerals, and, in general, did not expand the collection significantly (only 1500 specimens were recorded in 1819). There are no preserved documents from his time that refer to meteorites (Faujas de Saint Fond 1809).

However, from 1800 onwards, the mineralogy and geology collections of the MNHN were greatly enriched by the acquisitions on behalf

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of two of the most famous French geologists and mineralogists, Déodat-Guy-Silvain-Tancrède de Gratet de Dolomieu (1750–1801) and the Abbé René Just Haüy (1743–1822).

Dolomieu was Professor both at the 'Ecole des Mines' (School of Mines) in Paris and at the MNHN, where he replaced Daubenton in 1800 in the Mineralogy Chair. Dolomieu produced seminal studies on meteorology, astronomy, volcanic phenomena and rocks (including the first hypothesis that volcanoes were linked to igneous bodies that existed at depth within the Earth, and that the Earth's surface crust was cooling), earthquakes and limestones (dolomite was named in his honour). His exceptional personal collections, safely kept in his 'Cabinets' and housed on the island of Malta, were inherited first by his brother-in-law, then by the MNHN and, finally, by the 'Ecoles des Mines'.

The catholic Abbot Haüy (Fig. 3), was Professor at the MNHN from 1802 until his death in 1822. He is recognized universally as the founder of modern mineralogy and crystallography as new scientific disciplines, and he was one France's most renowned scientists of the Napoleonic period (Anon. 1945), who was appreciated by Bonaparte, First Consul at that time. Haüy's impact on material science promoted the development of modern society (Cuvier 1823). He initiated the transition from a 'useful mineralogy' to the science of mineralogy. He also had the main responsibility for the expansion of the mineralogy collection of the MNHN, which tripled during his tenure. He bought the Weiss collection and on the basis of his reputation was able to ensure that many scientists would send him mineral phases. Surprisingly, Haüy had, in fact, no real laboratory. His own work, and that of his students, was carried out using his personal collection and at his home in the Hôtel de Magny, located within the MNHN. Because King Louis XVIII curtailed his support to the MNHN, on Haüy's death in 1822, funds were insufficient to buy his large personal collection (more than 8000 samples) from his niece, his only heiress, for the museum. She sold it to the Duke of Buckingham in 1823 who took it to England. With the support of the new King Louis-Philippe I, Ours Pierre Armand Dufrénoy (1792–1857), the new Chairman of the Mineralogy Department of the MNHN was sent to England in 1848 in order to buy back the collection, at any price, from the heirs of the Duke. Like a few other collections, because of its considerable scientific value the MNHN collection was retained in its ancient organization and display. Its catalogue, one of the few also kept in its ancient format, contained 10 aéroliths (stony meteorites) stuck on wooden bases and incorporating a name label handwritten by Haüy. Seven of those aeroliths were later transferred to the actual collection. In contrast to minerals and rocks, meteorites were never, or very rarely, officially catalogued before their extraterrestrial origin was accepted; nevertheless, several private collections had existed for a long time.

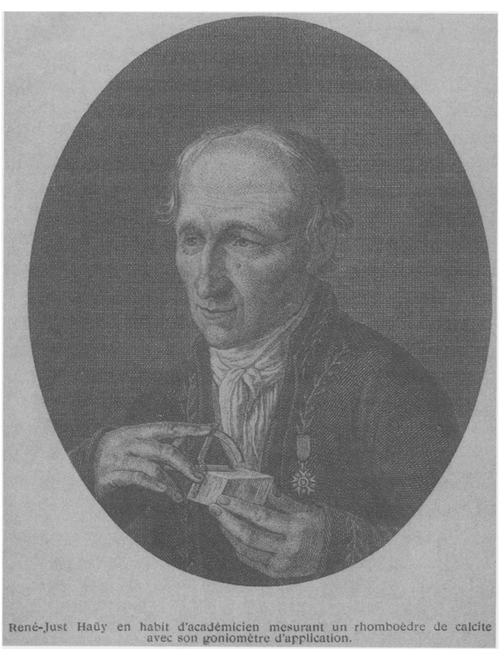

Fig. 3. Abbé René Just Haüy (Archives, © Société Française de Minéralogie).

First famous observed meteorite falls and the concept of their extraterrestrial origin in France

Moses provided the earliest description of the shower of stones at Gabaon, dated at 1451 BC. This as-yet unexplained phenomenon was described subsequently by many other authors including Pliny the Elder (23–79) naturalist, latin writer and author of *Histoire Naturelle*, a vast scientific compilation on natural history in 37 books (Pliny the Elder, in Bigot de Morogues 1812). Nevertheless, the fall at Ensisheim, Alsace, on 7 November 1492 represents the first observed fall from which a stone was recovered and historical documents were kept (in this case, a written letter by Sebastian Brant, a Professor of Literature at Basle University; see

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also Marvin 2006). This first historical fall has ever since been intimately linked with French history and the French people. Indeed, Emperor Maximilian I, Holy Roman Emperor and German King (1459–1519), considered this fall to be a very powerful divine sign, an omen of good fortune for his imminent waging of war. After keeping two pieces for himself, he ordered that the rock, weighing about 150 kg, be displayed in public in front of the church. However, as small samples were also taken by the population as a sign of good fortune, only 127 kg remained. As a result of his victory over the French forces of Charles VIII, King of France, Maximilian was able to recover his daughter and her dowry in the resulting peace treaty.

Following a citizen's request, Maximilian described this fall in a ruling in Augsburg on 12 November 1492. For more than three centuries thereafter, the Ensisheim stone remained hanging by a chain from the vault of the church's main choir, until 1754, when the church's belltower fell down. Following that accident, the stone was kept for 10 years at the Colmar Museum, commencing from year III of the République – French Republican calendar (1794–1795). Later, in 1803, it was taken back to the town of Ensisheim. It was then kept briefly in the school before being returned to the Palais de la Régence in Ensisheim, where the main mass of 55 kg still remains. More than 9 kg of this stone (an LL6 brecciated-chondrite: Fig. 4) were donated by the préfet du Haut Rhin, Baron Félix Desportes, to Count Antoine François de Fourcroy, Professor of Chemistry and then Director of the MNHN (Lucas 1813).

Following this fall, other meteorites were reported, such as the fall of Mont Vaiser, Var, on November 1627 in the Provence region of SE France. The philosopher, astronomer and mathematician Pierre Gassend (1592–1655), known as Gassendi, who like most of the scholars of the time did not admit that this stone could come from 'heaven' (sky), announced that it had been sent by a volcano that had erupted only for the occasion, before having subsequently returned to sleep. Unfortunately, this stone later disappeared.

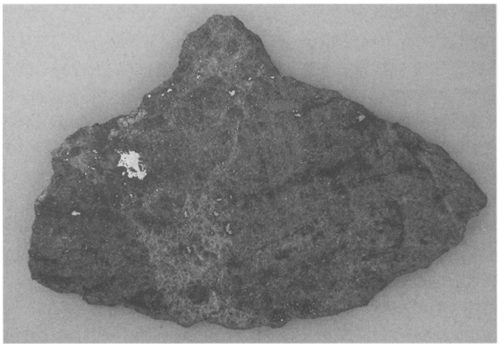

Fig. 4. Slice of the Ensisheim chondrite (about 7.7 cm across) showing the brecciated internal structure of this famous ordinary chondrite that fell in 1492 (© L.E.M.E., MNHN).

The chemist Antoine-Laurent de Lavoisier (1743–1794), together with the naturalist Auguste-Denis Fougeroux de Bondaroy (1732–1789) and another chemist, Louis Claude Cadet de Gassicourt (1731–1799), published the results of the initial chemical analysis of a stony meteorite (L6) Lucé, which fell in Sarthe on 13 September 1768 (Fougeroux *et al.* 1772). These data were first presented as an oral communication based on a manuscript that was preserved at the French Académie des Sciences (Academy of Sciences) in 1769. Because the Académie was reluctant to publish it in its Memoirs, their report was published independently, in a forerunner of the *Journal de Physique* (Poirier 1999). Lavoisier also believed the stone to be a 'grès pyriteux' (pyrite-bearing sandstone) vitrified by a lightning strike.

Thus, at the end of the 18th century, there were few scientists or scholars who believed in the extraterrestrial origin of meteorites.

Comte Jacques Louis de Bournon (1751–1825), who worked with the English chemist Edward Charles Howard (1774–1816), in 1801 described for the first time the silicates, sulphides, magnetic metals grains, strange globules and fine-grained matrices found in these bodies, and de Bournon was one of the few French scholars who was convinced of the extraterrestrial origin of meteorites. Elsewhere, the German physician Ernst Florens Friedrich Chladni (1756–1827) was perhaps the scientist who was most strongly convinced that many iron masses, like Krasnojarsk (found in Russia in 1749 by a Kazakh blacksmith and reported by the renowned explorer Pallas in 1772) or the Otumpa iron (Campo del Cielo, which was found in the Grand Chaco desert of Argentina in 1576), could only originate far away from our planet (Chladni 1818). The Benares fall in Uttar Pradesh, India, in 1798, focused the attention of all of the scholars of the time (see also Ivanova & Nazov 2006; Marvin 2006). de Bournon and Howard compared diverse falls and the Marquis Étienne de Drée, step-brother of Dolomieu, tried to classify the facts relative to each of these falls (Aguillon 1889). Thus, in France, the theory of Chladni was accepted and

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promoted because, following work by the astronomer and physicist Pierre-Simon Marquis de Laplace (1749–1827), the mathematician Siméon-Denis Poisson (1781–1840) had also calculated that a body sent from the Moon at 2314 m s^{-1} in the direction of the Earth would not fall back on the Moon but would reach the Earth with a velocity of 9603 m s^{-1} after 64 days, without taking into consideration the air resistance (Orcel 1962). For Poisson, meteorites were thus not formed in the atmosphere but from bodies moving around the Sun or planets.

Between 1 and 2 o'clock in the afternoon of 26 April 1803 large quantities of stones fell next to L'Aigle village in Normandy. On the initiative of the chemists Antoine François Fourcroy (1755–1809) and Nicolas-Louis Vauquelin (1763–1829), who was Professor of Chemistry at the MNHN and who had already analysed meteoritic material from the Benares fall, the young astronomer and physicist Jean-Baptiste Biot (1774–1862) (Fig. 5) was nominated by the Académie des Sciences to describe and report (Biot 1803*a*, *b*) on the reality of the phenomenon (Biot 1858). During his trip in the Orne Département he found 17 stones. His famous report (Biot 1803*a*, *b*), which included a chemical analysis of the stones deposited in the MNHN by the chemist Louis-Jacques Thénard (1777–1857) showing their compositional similarity to previous analyses of fallen stones, provided the final proof for the extraterrestrial origin of meteorites (see Gounelle 2006).

The constitution of the first catalogue of meteorites by Cordier

The mineralogist Pierre-Louis Antoine Cordier (1777–1861) (Fig. 6) was designated Professor and Chair of Geology at the MNHN in 1822. He was General Inspector of Mines and a former member of the Napoleonic expedition to Egypt (under the leadership of Dolomieu in 1798). He spent much time in the field recording his observations. Cordier was one of the first scientists to apply physico-chemical analytical methods in petrology. When Faujas de Saint Fond passed away in 1819, the collection of geology was almost non-existant, with only 1500 samples

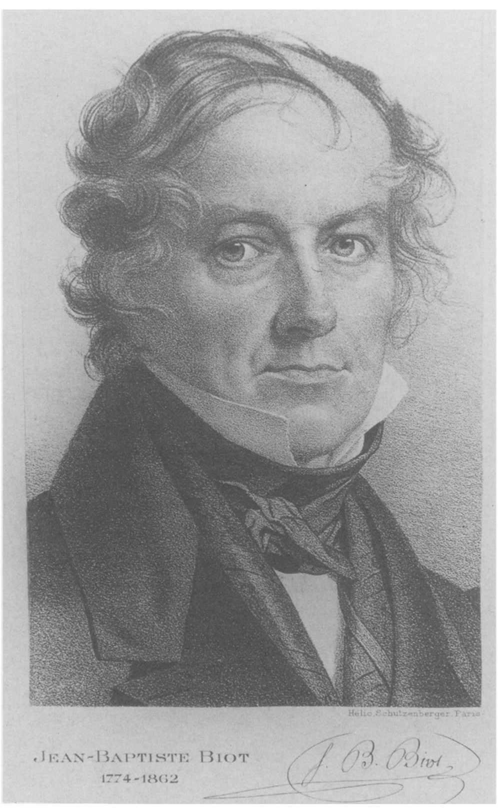

Fig. 5. Paper print from a photographic glass plate of Jean-Baptiste Biot (Archives, © L.E.M.E., MNHN).

Fig. 6. Pierre-Louis Antoine Cordier (lithography of Bailly) (Archives, © Laboratoire de Géologie, MNHN).

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(Lemoine 1921). By the time Cordier died in 1861, although the collection was in great disorder because of his numerous other commitments (for example, he became Director of the MNHN three times in 1824–1825, 1832–1833 and in 1838–1839), it contained about 203 000 samples with 900 illustrated catalogues and tables. Cordier was the real founder of the collection of geology. To accommodate the rapid growth of the collection, a new exhibition gallery was built from 1833 to 1837 by Charles Rohault de Fleury (architect of Charles X) between the actual rue Buffon and the 'Jardin des Plantes', formerly 'Jardin du Roy' (Hugard 1855). This gallery was opened to the public in 1841. In 1837 the collections that crucially lacked space following Haüy's mandate were reinstalled and archived in 192 glass-cased shelves, 12 000 drawers and 192 glass-covered tables. In addition to these collections there was also the private collection of King Louis XVIII (1755–1824), who had been trained by de Bournon, which consisted of 528 drawers in 24 cabinets stored as before at the Collège de France (Fallot 1939).

At that time the meteorite collection represented one of the most valuable galleries at the MNHN and one of the best in the world, as a result of the total number of specimens. There were 43 meteorites when Cordier began the catalogue. The collection was diversified and important because of the multiple places of origin. Cordier is renowned as he specifically studied meteorites and classified them under the following main rock types: lithoids meteorites (i.e. stony), glassy meteorites, carbonaceous meteorites and meteoritical iron.

At the time of his death in December 1861, the geology collection incorporated 64 meteorites while the Laboratory of Mineralogy owned about 14 meteorites. These 14 meteorites stayed in the mineralogy collection because most of them such as Elbogen (fall, Bohemia, Czech Republic, 1400), Brahin (find, Gomel province, Belarus, 1810), Otumpa (find, Grand Chaco, Argentina, 1576), Lenarto (find, Slovakia, 1814), Lexington (find, South Carolina, USA, 1880), Madoc (find, Ontario, Canada, 1854) and Putnam (find, Georgia, USA, 1839) belonged to the 'fer natif' or 'native iron' type. An additional one, from Greenland, was long unidentified as it had been worked into a small axe by Inuit craftsmen. It belonged to the Ovifak (Uivfaq) masses from the strait of Waigatt (otherwise known as the Disko Island, Greenland, terrestrial irons) (Daubrée 1877; see also Howarth 2006). Thus, in 1861, the integrated MNHN meteorite collections consisted of 78 meteorites. Despite the apparently low number of samples, they were of remarkable historical interest. Some specimens had been obtained or donated by renowned scientists. For instance: the naturalist, zoologist and palaeontologist, Baron 'Georges' Cuvier (1769–1832), gave a piece of the (L6) Vouillé meteorite that fell in the Vienne Department on 13 May 1831. Fourcroy gave a wonderful piece of more than 9 kg of Ensisheim (Fig. 4), being the oldest extra-terrestrial stone from which we have an authentic certificate of origin (Marvin 1982, 1992, 2006). Other scientists such as Vauquelin, the German naturalist, Baron Alexander von Humbolt (1769–1859) and Paul Maria Partsch (1791–1856), the former curator of the Vienna Museum (see Brandstätter 2006), appear as official donors on original labels. The chemist Howard, whose research (mentioned above), contributed to the general recognition by science of the meteoritical phenomenon, donated stones from Wold Cottage (fall, England, 1795) and Benares (1798), which he had analysed (see McCall 2006*a*, *b*).

The remarkable expansion of the collection by Daubrée

After the death of Cordier, Gabriel–Auguste Daubrée (1814–1896) (Fig. 7), who was both a mineralogist and geologist, was nominated member of the Académie des Sciences and Professor of Geology at the MNHN in order to reorganize and expand the collection. Born in Metz in June 1814, Daubrée had been trained at the prestigious École Polytechnique in Paris (School of Sciences and Engineering) and at the École des Mines (School of Mines). According to Marcellin Berthelot (1827–1907), chemist and Secrétaire Perpétuel de l'Académie, Daubrée was raised in a wealthy family, had an easy life, and a fulfulling and highly successful career (Berthelot 1905). By the time of his death, Daubrée had made more than 1400 communications to the Académie des Sciences. In 1895, 1 year before his death, he wrote 'I've achieved everything I wanted ...'. Indeed, his scientific work is considered to be among the finest of the great scholars of the 19th century who honoured France Officer of the French 'Légion d'Honneur' (Legion of Honour) in 1858, he was promoted to Commander in 1869; he was awarded the honour of Great Officer in 1881) and the Académie (Ministère de la Défense 2002).

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Fig. 7. Auguste Daubrée in his academician's suit (Archives, © Laboratoire de Minéralogie, MNHN).

The nomination of Daubrée to the MNHN gave him the opportunity to undertake the systematic study of meteorites, and thus embark on a novel and unlimited field of experiments. He proposed a methodical classification, and defined the rules of its nomenclature based on chemical and mechanical examination of the meteorites. In this process he conceived new experiments to unravel the processes involved in the formation of stratigraphically superimposed geological formations as well as the structure and stratigraphy of deeper layers. These discoveries were conceptualized in his new theory or hypothesis that peridot (olivine) represented the 'universal scoria' (slag) because he observed that it was ubiquitous on Earth and within meteorites. He considered that peridot was a major constituent of rocks from the deep Earth, and that it formed by 'scorification' from an iron- and magnesium-rich melt, thus inheriting the name of 'universal scoria'. His classification of meteorites was centred around their chemical composition and particularly on the existence or absence of metal. He developed experiments to study the fusion products of meteorites and, in particular, their crystals (Daubrée 1866*a*, 1879). He obtained textures analogous to those of meteorites by submitting terrestrial rocks to reducing conditions in the laboratory. He thus proposed the theory that meteorites, such as the stone of Ornans (fall, France, 1868: Daubrée 1869), had formed in a hydrogeneous environment. Finally, Daubrée attempted to reproduce iron meteorites and stony meteorites, and in particular their chondritic or globular structure. He concluded that meteorites had textures analogous to mafic silicate rocks, but that meteorites differed in the oxidation state of their iron. Daubrée also studied problems related to the constitution of extraterrestrial bodies and their origin (Daubrée 1886). He described the accretionary process of planetary formation in 1879. He recognized the relevance of the study of meteorites not only for astronomy but also for geology, which thereby acquired a much wider horizon of thinking exemplified by comparative studies on the formation of the Earth and the solar system (Daubrée 1886, 1888; see also Howarth 2006).

The collection of meteorites was really born under Daubrée's direction in 1861, when he reassembled the samples in the Geology Department together with those that had always been in the Mineralogy Department (Fig. 8). At that time 86 samples represented 53 falls and weighed 691 kg, and in 1868 there were 203 falls and 550 samples weighing 1682 kg. In fact, he considered that a collection cannot be restricted to just a suite of falls but that samples can be characterized by a variety of aspects such as shape, structure, external crust, the nature of surface defects or modification, and the main minerals and mineral assemblages. Daubrée (1863) published the first catalogue of meteorites together with a catalogue of artificial experimental products. The first version was complemented by tables which summarized the general circumstances under which falls occurred, such as their hourly and monthly distribution, the geographical distribution, the height of the bolides, their velocity, their trajectories and the spatial distribution of the stones of a single shower. He also enclosed coloured tables of the best-described phenomena. He considered that it was a duty to carefully record, in the first pages of the various catalogues he published, the name of persons whose gifts contributed to the formation of the collection. The first number of the catalogue was given to the meteorite of Ensisheim donated by Fourcroy. Then Daubrée listed Jean-Baptiste Biot, Bonpland, Jean-Antoine Chaptal (1756–1832) (who gave the Apt chondrite, fall, 1803), Nicolas-Louis Vauquelin (1763–1829), the Baron Georges Cuvier, Edward Howard, Alexander von Humboldt, the Emperor of Austria, the Counts

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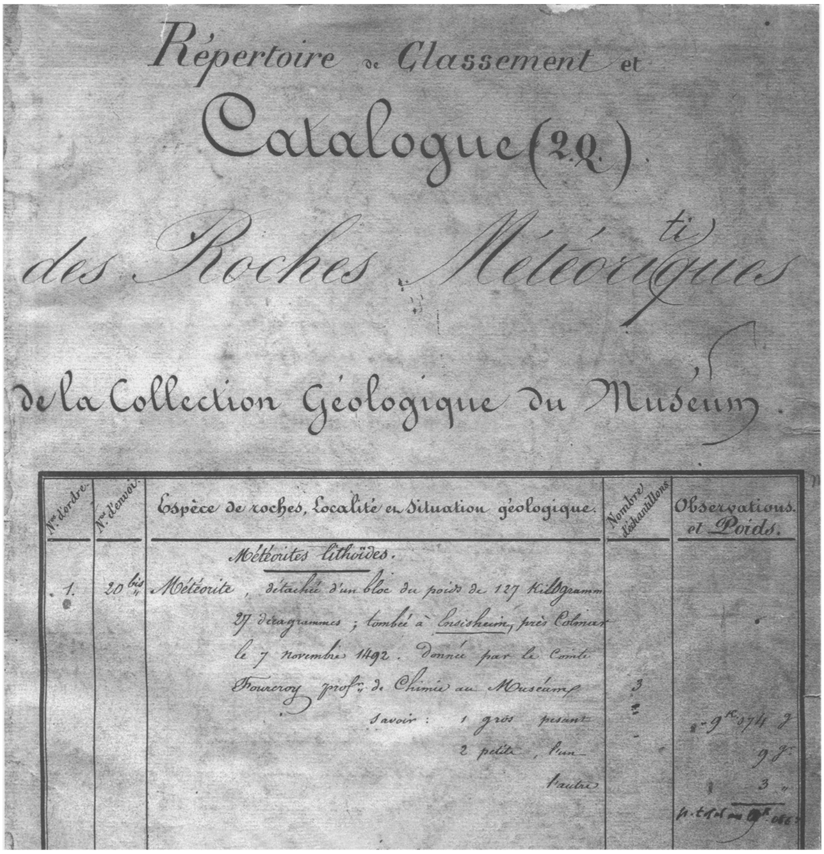

Répertoire de Classement et

Catalogue (2 Q.)

des Roches Météoritiques

de la Collection Géologique du Muséum.

N.os d'ordre.	N.os d'envoi.	Espèce de roches, Localité et Situation géologique.	Nombre d'échantillons	Observations et Poids.
		Météorites lithoïdes.		
1.	20 bis	Météorite, détaché d'un bloc du poids de 127 Killogramm 27 décagrammes; tombée à Ensisheim, près Colmar le 7 novembre 1492. donné par le Comte Fourcroy prof.r de Chimie au Muséum	3	
		savoir : 1 gros pesant		9^{K}.074 g
		2 petits, l'un		9 g
		l'autre		3 "

Fig. 8. First page from the second-hand written copy of the catalogue of meteorites by Cordier 1837 (© L.E.M.E., MNHN).

of Montalivet and of Lasteyrie, l'Abbé de Montesquiou (an abbot and former minister), various counts, dukes, lords, generals, governor generals of French colonies, marquis, former consuls, a former curator of the Vienna Museum, members of the Académie des Sciences de Paris, professors, doctors, city mayors, clergymen, members of the Institut National (which became the Académie des Sciences in 1816), many museums, civil servants of all grades and even laymen who enriched the suite of aerolithes. No weight was given if the specimen weighed less than 1 g.

The second catalogue was produced soon after, on 15 December 1864. He strove to make the collection of the MNHN as complete as possible (various countries, types) and to improve research on the problem of the formation of the planetary system (Daubrée 1864*a*). Indeed, it became comparable to the collections of Vienna and London at the time. In order to further develop this growing collection Daubrée had solicited widely and with great success people in Europe and in many other parts of the world who wished to serve science. The collection of the physicist Jacques Babinet (1794–1872) acquired in 1865, contained 20 falls that included Alais (carbonaceous chondrite, fall, Gard, 1806; considered as very rare at this time), the feldspathic masses (eucrite achondrites) of Stannern (fall, Moravia, Czech Republic, 1808), Jonzac (fall, Charente Maritime, 1819) (Fig. 9), Juvinas (fall, Ardèche, 1821), the particular stone of Renazzo (carbonaceous chondrite, fall, Emilia-Romagna, Italy, 1824), Angers (chondrite, fall, Maine et Loire, 1822) and others. Daubrée was delighted in 1867 when Charcas (iron, find, 1804), which had remained for a long time near San Luis Potosi (Mexico), arrived in France as a gift to Napoléon III Emperor (1808–1873), who ultimately agreed to give it to the MNHN and the Gallery

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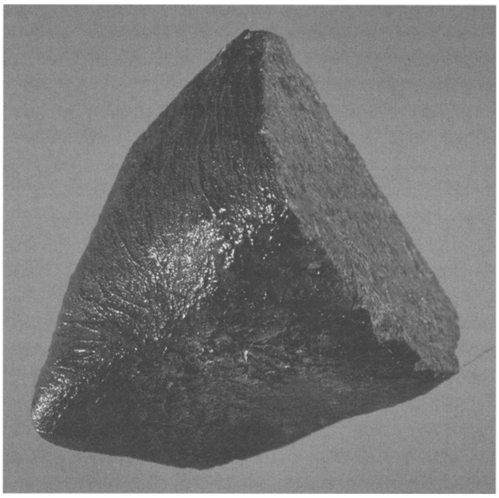

Fig. 9. The largest piece (approximately 5 cm) of the Jonzac eucrite meteorite that fell in 1819 (© L.E.M.E., MNHN).

of Geology (Daubrée 1867*a*). The collection already contained at that time some meteoritic iron from the Caille (La Caille) meteorite, recovered in 1828 by Mr Brard in Caille village (Var Department) from its use as a bench at the entrance of the church and bought by the government (the Vicecount of Martignac was Minister of the Interior). The date of fall is unknown, but is suspected to have occurred 200 years earlier and 6 km south of Caille, on Audibergue Mountain (Fig. 10).

Daubrée noted that many real falls of aerolithes remained totally unknown at places a long way from the fall locality. For example, Mascombes was a fall (31 January 1836) in the Corrèze Department, which did not receive widespread publicity (Daubrée 1864*b*). Nevertheless, they were also plenty of false reports of meteorites finds. He also compared meteorites (such as the stone (ordinary chondrite) with its globulous structure, which fell at Vouillé, Vienne Department, on 13 May 1831) with analogous meteorites, which had been named chondrites by Gustave Rose, such as that which fell on 12 June 1841 at Château Renard, Loiret Department, and was described by Armand Dufrénoy Chair of Mineralogy from 1847 to 1857 (Dufrénoy 1841) Daubrée believed that meteorites should not stay in small provincial museums (for example, Vouillé had remained for 30 years in Poitiers and the 180 g of L'Aigle stayed in Le Mans) because this was 'against the general interest'. The collection also received 1.3 kg of the Chantonnay ordinary chondrite, which fell in the Vendée Department on 5 August 1812. Daubrée insisted on returning frequently to the site of any fall to collect eyewitness accounts, as he did for the fall of a chondrite at Saint Mesmin (Aube Department) on 30 May 1866.

Daubrée reported on many falls and particularly wrote many notes, published in the *Comptes Rendus de l'Académie des Sciences*, regarding the very special fall of the Orgueil meteorite (Fig. 11) (a very fitting name meaning 'pride') on 14 May 1864 (Daubrée 1864*c*, 1866*b*). Many letters described the wonderful fireball that was visible above many SW French regions. It appeared 90 km above the ground and was seen from more than 600 km away. About 100 stones (Fig. 12) were recovered from this fall (Meunier 1909). Daubrée described the appearance of the Orgueil meteorite (carbonaceous chondrite) as being similar to that of dull and earthy lignites. At that time only three stones of a similar type were known: Alais, which fell in Gard in the south of France on 16 March 1806; Cold Bokkeveld, which fell in Cape Province, South Africa, 13 October 1838, and was given to the MNHN collection in 1965; and Kaba, which fell in Hungary on 15 April 1857. Orgueil, however, contained much greater amounts of carbon than those meteorites (Cloetz 1864). A large 2 kg-piece exhibiting a black fusion crust with a varnished appearence showing rills and folds was given to the MNHN by Marechal Vaillant. Daubrée described Orgueil as a remarkable meteorite, which, unlike many others, disaggregated in both water and alcohol, thus necessitating very special curation. Indeed, as surprising as it might be, Orgueil was even enclosed in ice boxes where each specimen was stored in dried air (Meunier 1893). Such factors meant it was very difficult for it to be made available for study by other workers.

In 1867 new furniture was acquired to house the meteorite collection in the gallery. Daubrée now replaced the chronological arrangement previously adopted with a classification (Daubrée 1867*b*) that followed general and particular divisions that existed among the already numerous samples of the suite of planetary samples. Daubrée believed that some gaseous or liquid materials of the same origin accompany the solids but that they do not arrive on the ground. He therefore defined four divisions for *solid* material, each with a specific name. He considered that the absence of metallic iron from terrestrial rocks, but its almost ubiquitous presence in meteorites, constituted a means to establish the divisions between different types, as well as other criteria, such as the nature of the iron's

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Fig. 10. The gallery between 1931 and 1967 with the La Caille iron meteorite on its pedestal in the foreground (Archives, © Laboratoire de Minéralogie, MNHN).

association with the remaining stony material and its relative proportion. *Sidérites* form a family of meteorites that contain metallic iron. These he divided into those that do not contain stony material (1, *-holosidères*), and those that contain both metallic iron and stony material either as a continuous mass (2, *-syssidéres*) or as disseminated grains (3, *-sporadosidères).* A fourth group, *asidérites*, like the carbonaceous meteorites Alais or Orgueil, do not contain metallic iron. Classification was achieved on the basis of measurements of density of the meteorite. In collaboration with his valuable aide, the chemist and geologist Stanislas Étienne Meunier (1843–1925), Daubrée attempted to characterize the inner parts of meteorite masses in order to better understand the distribution of metal (Daubrée 1867*c*). This analysis of the

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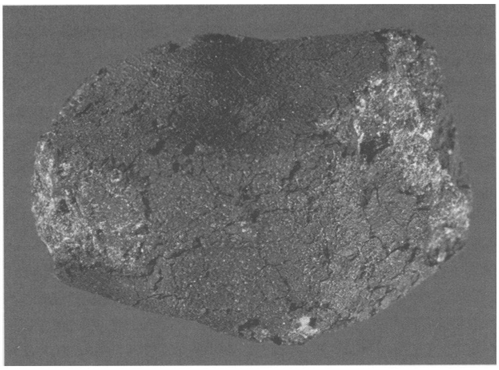

Fig. 11. One stone of the famous carbonaceous chondrite (CI1) Orgueil measuring about 3.5 cm across, showing fusion crust and alteration in white on the side. This 20 g stone (number 225 in the catalogue) fell in Monbéqui and was given to the MNHN by M. Soulié, the school teacher in this village (© L.E.M.E., MNHN).

inner structure of meteorites was achieved using only chemical and physical techniques (see Daubrée 1868*b*; Howarth 2006).

The third catalogue was produced on 31 March 1868 following the arrival in the MNHN collection of numerous new specimens on the occasion of, and after, the Exposition Universelle of 1867, such as an iron given by the Chilian government that weighed 104 kg, found in Rio Juncal (High Andes cordillera) in 1866 (Daubrée 1868*a*, *c*).

In August 1878 Daubrée wrote the fourth catalogue in which he mentioned the gifts or exchanges with large foreign collections in England, India or Australia. He obtained numerous falls. For example, he acquired about 900 stones (540 were included in the collection) from the ordinary chondrite fall ('grêle de pierres' or hail of stones) of Pultusk, Poland, on 30 January 1868; and 15 kg of the Kernouvé ordinary chondrite, which fell on 23 May 1869 in Brittany, and which had been broken into many pieces because the peasants believed they were in possession of a piece of the moon.

The production of the fifth catalogue on 15 July 1882 marked an important new period in the MNHN collection. The catalogue list was replaced by a booklet entitled 'Guide dans la collection de météorite du Muséum d'Histoire Naturelle (Masson editeur)' – with an enumeration and general notes on meteorites. This new catalogue contained descriptions of 54 types from 306 localities (90 holosidères, 9 syssidères, 195 sporadosidères and 12 asidères). It is worth noting the presence in the collection at that time of a 250 kg block and a 7 kg plate from an iron meteorite from Cohahuila (Mexico) given by the American chemist and geologist John Lawrence Smith (1818–1882) of Louisville, in which Smith in 1876 discovered and newly named 'daubréelite', a sulphide mineral absent on the Earth.

On the occasion of another Exposition Universelle, Daubrée published the sixth edition of the catalogue on 15 April 1889 (Daubrée 1889). This included a very complete synoptic table which provided an easy access to the mineralogical characteristics of all the types of cosmic rocks. This catalogue included 367 falls (110 holosidères, 21 syssidères, 219 sporadosidères and 17 asidères). Donors from private collections and foreign museums gave Angra dos Reis (the, then, unique angrite achondrite, fall, Brazil, 1869), Chandpur (ordinary chondrite, fall, Uttar Prasdesh, India, 1885; donated by the Indian Geological Survey) and the Adalia, eucrite that fell in 1883 in Asia Minor (Turkey). The presence of a sample of Nuevo Urey (Novo-Urei), the ureilite achondrite stone that fell on 5 September 1886 in Russia, is particular noteworthy because the peasants who witnessed the fall had wanted to make it famous after they discovered it contained very small diamond grains (see Ivanova & Nazorova 2006).

The seventh catalogue was published the year after and included 423 localities (134 holosidères, 26 syssidères, 244 sporadosidères and 19 asidères), including many meteorites from South America, and from American collectors and scientists.

The contribution from Meunier

Stanislas Etienne Meunier (1843–1925) (Fig. 13), who was Daubrée's 'assistant naturalist' from 1864 to 1892 (Laboratoire de Géologie 2004), played a significant role because Daubrée was constantly occupied elsewhere. Meunier was the real manager and curator of the collection. When Auguste Daubrée passed away in 1892, Meunier held the Chair of Geology and was promoted to Professor. He continued the research of Daubrée, and pursued comparisons between the geology of meteorites and experimental geology. He was the first scientist to teach experimental geology as a distinct branch of science. He also was responsible for the first general and experimental study of natural phenomena in the Paris Basin. Meunier was a prolific writer, with more than 570 publications, including about 30 books. He was a courteous man gifted with a youthful alert mind, but was also a keen and cordial teacher. Meunier became the adjunct to the Director from 1910 to 1919, when he

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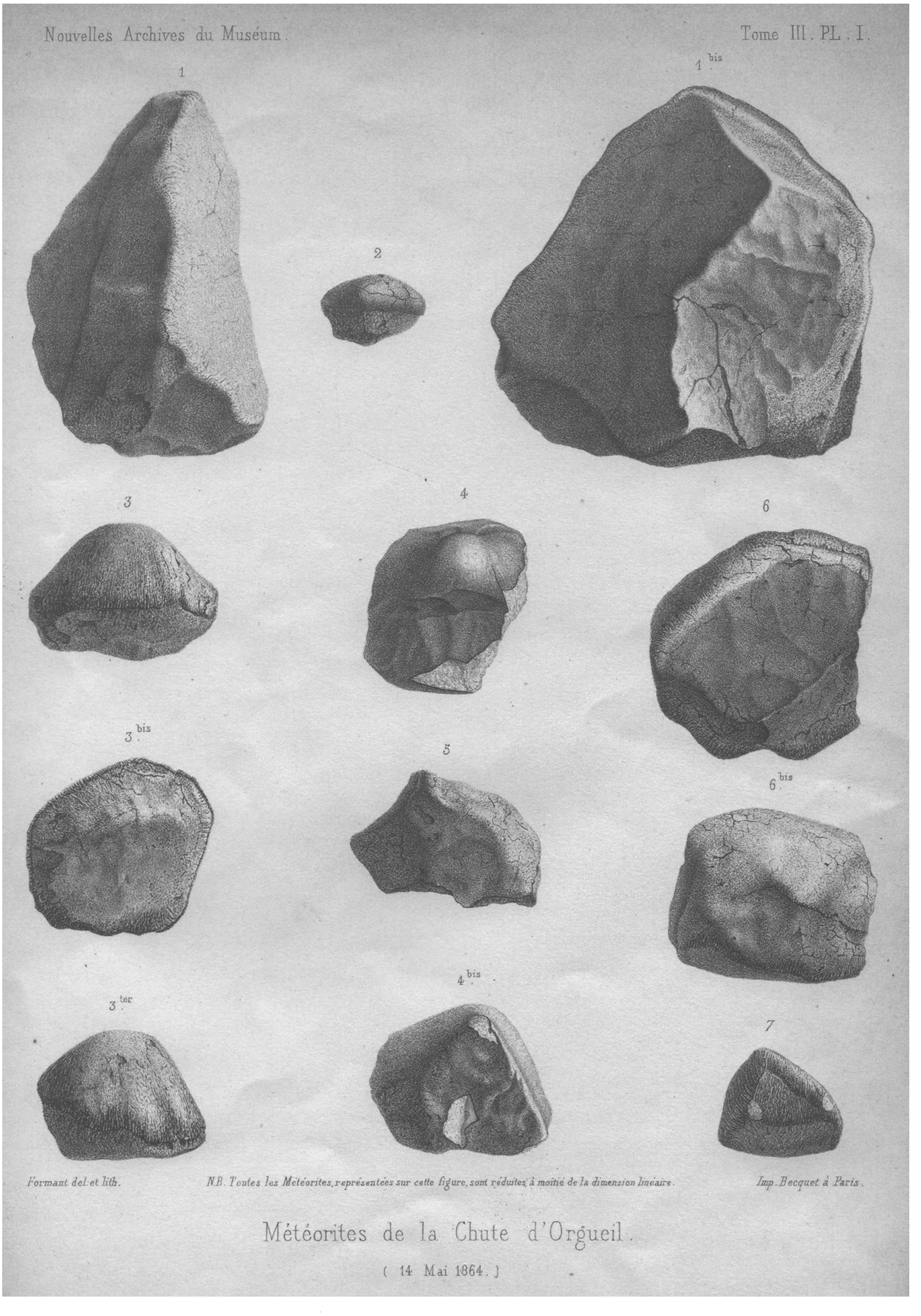

Fig. 12. Reproduction of line drawings showing a variety of specimens from the Orgueil meteorite displaying nice fusion crusts (in Daubrée 1867*d*) (Archives, © MNHN).

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Fig. 13. Stanislas Meunier (Archives, © Laboratoire de Géologie, MNHN).

retired after a long career. He died 6 years later without, in fact, having ceased to work.

Meunier thought that the series of rocks which fell from heaven had an exceptional and widespread value. For him, each type of rock was characterized by its mineralogical composition and by its structure. So rocks with identical composition and different structures formed distinct types belonging to the same group. For each of the 67 perfectly defined lithological types known as of 1909, he gave a rapid enumeration of their external characteristics, density, mineralogical composition and a chronological indication of the main falls in the great French collection. He presented them in three synoptic tables (Meunier 1897, 1909).

Meunier considered the MNHN collection to be one of the two or three richest collections in the world, based on the total number of the localities represented, on the volume and beauty of the samples, and on the MNHN's unique holding of certain specimens. In 1898 there were 463 distinct meteorites listed in the catalogue (Meunier 1868), and in 1909 the collection contained 532 meteorites, weighing a total of 2259 kg.

At that time the collection was stored in furniture located in the centre of the gallery (Fig. 14), except for some huge samples (such as La Caille,

Fig. 14. Furniture housing the meteorite specimens in the middle of the gallery in 1885 (photograph by P. Petit) (Archives, © Laboratoire de Minéralogie, MNHN).

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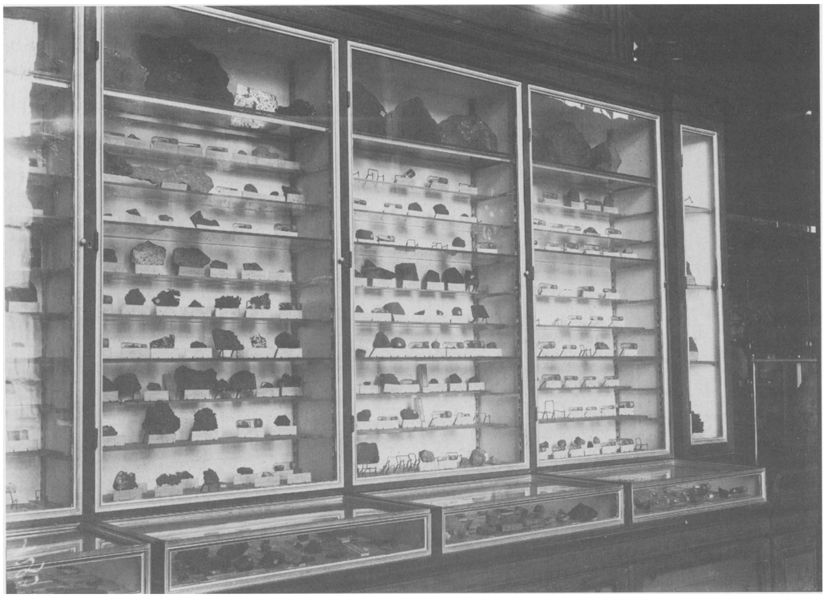

Fig. 15. Glass showcase with meteorites in the gallery before 1931 (Archives, © Laboratoire de Minéralogie, MNHN).

Charcas, Coahuila (iron, find, Mexico, 1837) or the aluminous meteorite of Juvinas) that were displayed on independent pedestals (Fig. 10). By 1893 the samples from diverse falls did not entirely fill the glass showcases (Fig. 15). Therefore, he began to present polished surfaces showing the regular network of Widmanstätten patterns. They were generally revealed by acid etching, but he also applied to the surface copper sulphates, mercury bichloride, gold chloride, molten potash and a variety of other liquids chosen on the basis of their behaviour under the influence of battery current. The MNHN collection also contained plaster casts of meteorites for which no sample existed in the collection.

Meunier also exhibited general features and minerals in meteorites such as: nickel iron in the holosiderite Charcas; the mineral shreibersite in the Toluca iron ('rhabdite'), which fell in Mexico in 1776; pyrrhotite (troilite) as globular assemblages in the irons of La Caille and of Sainte Catherine; and the minerals daubréelite, chromite, graphite in Coahuila, peridot in Krasnojarsk, colourless enstatite (victorite) in the iron Deesa (or Copiapo, find, Atacama, Chile, 1863), and brown enstatite (bronzite) in the iron Breitenbach (or Steinbach, find, Sachsen, Germany, 1724), augite and, finally, anorthite in Stannern.

Meunier also emphasized in the gallery the experimental work carried out with Daubrée which showed various opaque minerals and/or radiating chondrules. The collection contained a large set of experimental products resulting from the fusion of several meteorites, including that of siderites and lithites, pieces of slag, fragments of metal shots or slugs obtained by reduction of various terrestrial rocks, fragments from experiments producing metal alloys (either by fusion of appropriate mixtures or by reduction of heated samples in hydrogen), as well as pieces of artificial minerals.

Because of Meunier's particular interest in comparative geology, a large part of the collection was devoted to samples that showed evidence of meteoritical metamorphism, and samples that resulted from experiments to reproduce the texture of chondrites, as well as samples with brecciated textures that indicated that they formed as a result of complex and multiple processes (Meunier n.d.). For example, Meunier described the brecciated structure of St Mesmin, a chondrite that fell in Aube in 1866 and was given to the MNHN by Mr Savage, Director of the French Eastern Railway.

Meunier made several hundred thin sections of meteorites that were displayed and which can now be considered to form a collection of its own exceptional value. Some photographs of the textures were shown in one of the guides to the collection of meteorites that he published in 1898. They illustrated the various types of meteorites. For him 'stratigraphy' described the mutual spatial relationship of the meteorites.

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Some meteorites were monogenetic, others polygenetic, yet others were qualified as 'eruptive' or 'metamorphical'. In fact, Meunier's typology was too complex, and the multiplication of types was confusing to some people unfamiliar with his classification (Meunier 1871).

Nevertheless, Meunier (1902) correctly denounced the habit of some entrepreneurs without scruples who dishonestly tried to sell to potential clients 'meteorites' that, in fact, were terrestrial samples (residual slag from metal foundries).

Before 1861 there were three French meteorites already of extreme historical interest in the collection. The first one fell in Chassigny, Haute Marne (Fig. 16), on 3 October 1815 and played an important role in the history of the science of meteoritics. Meunier wrote in 1893 in a commemorative chapter on the collection that it represented the 'first common term between the terrestrial and the cosmic lithology'. He considered that this meteorite showed physical characteristics similar to a terrestrial dunite in contrast with the composition of ordinary aeroliths. In fact, the MNHN has more than 400 g of Chassigny, still by far the greatest amount found in any collection. Meunier compared Juvinas, the second unusual meteorite that fell in the Ardèche Department on 15 June 1821, to terrestrial volcanic lava. This meteorite is now regarded as a monomict brecciated eucrite. Caille (the third unusual meteorite to fall in France, which was found in the Alpes Maritimes in 1828), an iron that exhibits the regular network of the octahedral structure of the mass; Meunier (1893) wrote that 'The uniform orientation of all its triangles proves that not only the part that shows this structure is crystallized but that it represents a fragment of a unique crystal with gigantic dimensions'. Meunier also studied another important meteorite, namely Nakhla, just after its fall in Egypt in 1911 (Meunier 1913; see also Grady 2006). This achondrite was acquired by an exchange with a piece of Aumale meteorite from M. Hume, Director of the Geological Department of Cairo.

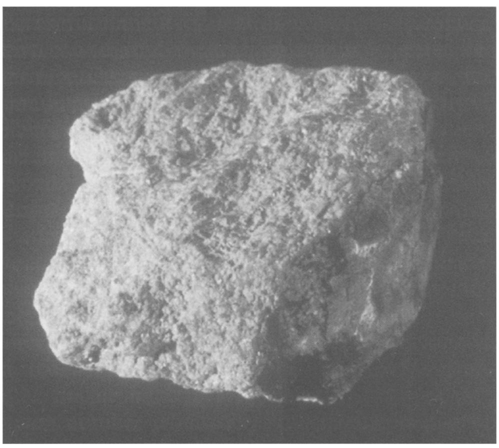

Fig. 16. The unique French martian meteorite fall Chassigny (about 5 cm across) showing a shiny fusion crust contrasting with the white inside (© L.E.M.E., MNHN).

Meunier (1867) identified 30 different chemical elements contained in meteorites that could also be found in terrestrial rocks. In this work he referred to the spectral analysis of the Sun by the German physicist Gustave-Robert Kirchoff (1824–1887) and chemist Robert Wilhelm Bunsen (1811–1899), and said that there is a unity of chemical composition among the different members of the solar system. In *Promenade géologique à travers le ciel* (*A Geological Stroll through the Skies*) Meunier (1875) even described the position of the orbit from which the meteorites came. He thought they belonged to the inner solar system, that they were not from a comet nor a planet but that meteorites were to be considered as satellites of the Earth, although different from the Moon (Meunier 1869). The faults on the Earth, the lunar grooves and the fragmental nature of planets led him to speculate on the demolition of a celestial body. In his theory, meteorites would thus come from one or many celestial bodies that had been in contact at some point in their evolution in order to produce brecciated aggregated masses. He could find in the series of meteorites all the essential elements of a celestial body built on the same general plan as the Earth. Meunier even described in his 1909 guide different types of extraterrestrial dust particles, such as the minute ferruginous globules found in the snow, atmospheric dust particles or even microscopic deep-sea metallic spherules similar to those first discovered in 1876 by the Scots-Canadian oceanographer and marine biologist John Murray (1841–1914) during HMS *Challenger's* expedition (Murray & Renard 1891). He concluded by discussing all the 'extraterrestrial fossils' (meteoritic fossils) that ought to have persisted in stratified rocks of all geological periods.

For Meunier (1893), meteorites were 'powders of worlds that had disappeared bringing us from the abyss of space positive and unexpected revelations on the nature of the inaccessible depths of our globe and the prophetic theories on the future of our planet'.

Meunier made the interesting observation that iron meteorites were rarer in Europe and in 'India' than in the New World, probably

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because they had been used to make a variety of objects or had been worked for iron. He seemed to think that they came only from geological formations younger than the Tertiary (Meunier 1869).

Finally, Meunier reported in his works on problems that are still very acute nowadays, namely the impossibility for the MNHN to acquire meteorite samples brought to the museum for expert examination because of the considerable price they fetched, and also the fact that foreign establishments were far richer that the MNHN. Fortunately, at the time of Meunier there were still large donations and wealthy people such as Adrian-Charles, Marquis de Mauroy (1848–1927) who gave 33 falls (Meunier 1898; Mauroy 1909; see Consolmagno 2006). Later, the collection of the Marquis contained 708 samples in 1909 with 381 falls (Meunier 1909). Some samples were bought by the museum, however, most were acquired as gifts from generous laymen or as a result of exchange with scientists, for whose generosity he was very thankful. Dr Labat, who was known for his work on mineral springs, helped the MNHN in financing the brochure edited by Meunier in 1909.

Lacroix requests that the collection returns to the Laboratory of Mineralogy

Born on 4 February 1863 into a family of pharmacists and medical doctors, Alfred François Antoine Lacroix (1863–1948) was early imbued with a taste for chemistry and mineralogy shared with his grandfather who was 'préparateur' (laboratory assistant) to Vauquelin at the museum. Young Lacroix who liked to play and built castles with pyrite cubes from Barcelonnette, became a first-class pharmacist and pharmacist's assistant at the Collège de France. However, he preferred mineralogy and eventually became Professor at the Museum on 1 April 1893, when, at the age of 30, he succeeded Alfred Louis Olivier Legrand des Cloiseaux (1817–1897) in the Chair of Mineralogy. He became one of the most renowned French scholars (Fig. 17) and had an extraordinarily fruitful career characterized by its precocity (he already had 60 publications before he obtained his Bachelors of Sciences degree (Licence)) and by its breadth. His successor Jean François Orcel wrote (unpublished speech) of 'A considerable and varied scientific production, embracing almost the entire domain of Earth science'. Lacroix produced more than 650 works, a multi-volume series on the Mineralogy of France, and lectures, official speeches and oral communications at the Académie des Sciences (Courrier 1948; Orcel 1950). His

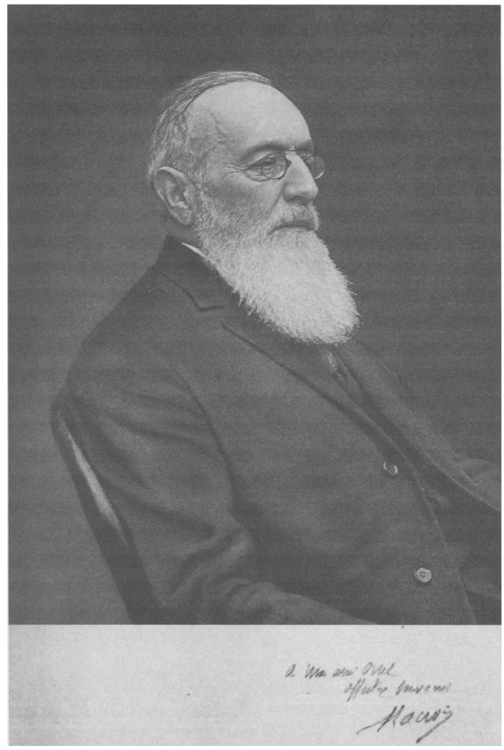

Fig. 17. Alfred Lacroix with a word dedicated to his friend Jean Orcel (Archives, © Laboratoire de Minéralogie, MNHN).

works remains as a world reference for the inventory and study of the mineralogy of France and its colonies.

This great collector devoted his mind and soul to mineralogy. He managed to present up to 36 oral communications in a year, and wrote seminal works in mineralogy and volcanology (14 volumes). He considered that mineralogy lay at the point of convergence of mathematics, physics, chemistry and natural sciences. As a petrologist and mineralogist (trained in the naturalist tradition), the discovery of a new rock or mineral procured him a sense of bliss. His memory was prodigious, his work ability exceptional and his shrewdness well established. He substantially increased the number of known minerals by describing 47 new mineral species, in addition to 85 new rock types (Courrier 1948).

Lacroix travelled frequently in the United States, Japan, Indochina, Indonesia, Madagascar and Equatorial Africa. He had a vast number of occupations. In the laboratory (Fig. 18) he observed carefully, and described all the characteristics of minerals that lead to the identification of a rock and the understanding of its formation. In the field he studied the

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Fig. 18. Lacroix looking through his microscope in the Laboratoire de Minéralogie, rue Buffon, Paris. This photograph was probably taken in 1896. (Archives, © Laboratoire de Minéralogie, MNHN).

characteristics of an ore as a key to understanding its genesis and its evolution in nature. He wanted to cover all aspects.

He also wanted to establish a rational inventory of the mineralogical wealth of France and its colonies. He thus obtained all the laboratory equipment necessary to undertake modern mineralogical research, and transformed the Laboratory of Mineralogy into a research centre that enjoyed a widespread reputation of excellence and openness to all. In 1893 he started a catalogue of instruments, which had never existed previously. He divided it into two parts: the first was devoted to scientific instruments, bought with his equipment funds; whereas the second concerned the non-scientific material.

Lacroix's nomination on 8 June 1914 as Lifetime Secretary of the Académie des Sciences brought him an immense satisfaction and honour. He became keenly interested in the development of several institutions (Orcel unpublished speech). He was awarded the honour of Great Officer of the Legion d'Honneur in 1935 and received Doctor Honoris Causa degrees from more than 60 universities.

Lacroix's study of terrestrial rocks led him to also examine those with a cosmic origin – meteorites and tektites. He studied stony meteorites with the same chemico-mineralogical concepts he used for terrestrial rocks and classified them rationally. He had a profound interest in the MNHN's meteorite collection from both a historical and a scientific perspective. He undertook the long and laborious work of completing the chemical studies of meteorites. His research on meteorites expanded dramatically after 1926, when he obtained the transfer of the collection of meteorites (Lemoine 1924) from the Geology to the Mineralogy Department (i.e. the opposite to what Daubrée had achieved) following a successful negotiation with Paul Victor Antoine Lemoine (1878–1940), Professor of Geology, who at the age of 42 succeeded Meunier in 1920 (Abrard 1943) and later became Director of the MNHN from 1932 to 1936. Lacroix's passion for meteorites thrived as he wrote more than 30 books or papers on the subjects.

Lacroix considerably enriched the collection with samples from new falls that occurred within the territories of the Union Française or by acquiring fragments of older falls. Some people still continued to enrich the collection. For example, Dr Latteux, correspondent for the MNHN and Head of the Histology Laboratory of the Faculté at Broca Hospital, who in 1913 owned 304 distinct meteorites and who had already exchanged many meteorites with the MNHN at the time of Meunier (Latteux 1913). Lacroix particularly described: the iron of Tamentit (find, Algeria, 1864) (Fig. 19); the diogenite of Tatahouine (fall, Tunisia, 1931); and the eucrite of Béréba (fall, Haute Volta, 1926, now Burkina Faso) (Lacroix 1926). He developed the principles of his classification of these cosmic products. Tamentit (Fig. 20) was first kept in a Ksar (a fortified village) and worshipped by the indigenous tribes. It was then sold to the Gouverneur Général of Algeria, Mr Viollette, who gave it to the MNHN in exchange for its cast. Oral traditions said that this iron, weighing more than 500 kg, fell in the 14th century, south of the Tamentit oasis. In the first (1896), second (1900), the rare third (1915), and the fourth (1931) editions of the *Guide du visiteur*, which he wrote to guide people round in the gallery (Lacroix 1896, 1900, 1915, 1931), Lacroix explained that he had placed the meteorites in the centre of the gallery but only after a total logistical and scientific reorganization. Information cards were available for the public. The meteorites were displayed in elegant showcases, which were more accessible to the public, and contained a detailed inventory. For all the samples

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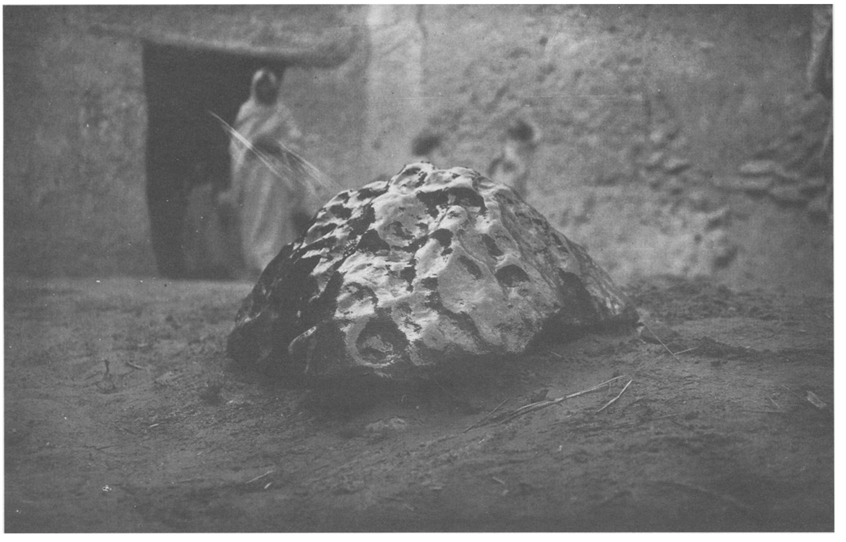

Fig. 19. The 500 kg meteorite of Tamentit in the Ksar (Algeria) (Archives, © Laboratoire de Minéralogie, MNHN).

Fig. 20. Cutting the Tamentit meteorite with a soldering torch in the gallery of the MNHN under the watchful eye of Prof. Lacroix (Archives, © Laboratoire de Minéralogie, MNHN).

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he made thin sections, thus complementing the hundreds of sections made by Meunier. There were now 1000 meteorite thin sections, in addition to some 200 000 terrestrial rock thin sections, that today make up the collection of the MNHN. Many of these are as yet uncatalogued (G. Carlier pers. comm., Mineralogy Laboratory, MNHN).

Lacroix adopted a new classification that followed the actual state of science. He thought that the classification should be based on the chemical and mineralogical composition and the structure of meteorites, but that it was indispensable to make a distinction between primordial characteristics of general importance (i.e. linked to initial magmatic conditions) and secondary characteristics that resulted from the 'adventures' that the samples studied had experienced. Secondary characteristics were regarded as essentially of a physical nature, like those resulting from some superficial oxidation phenomena and produced for example, in the very thin fusion crust area.

On a chemical and mineralogical basis, Lacroix distinguished three major groups: (1) the sporadosidères or aérolithes, with predominant silicates and nickel iron distributed as metal microballs resembling slag residues; (2) the syssidères or lithosiderites, in which iron occurs as a continuous framework; and (3) the holosiderites, in which nickel iron exists alone or essentially less so. Each major group was further subdivided on the basis of its structure into: (1) the rare ophititc texture of feldspathic meteorites (eucrites); and the granular texture of meteorites devoid of feldspar; and (2) the texture characterized by the presence of typical chondrules.

Although Lacroix noted large textural variations for a given chemical composition, he removed the divisions introduced by Meunier and especially some particular names that were devoid of interest for the general user. He retained only the suffixes holo-, poly-, oligo- and micro-chondritic, which are self-explanatory. Lacroix noticed that some meteorites were very crystalline and that chondrules can disappear under pyrometamorphism. One showcase was therefore devoted to generalities; four were for the systematic series, the stones and irons; and two showcases contained meteorites that fell in continental France or overseas (Lacroix 1927).

The ecologist, marine biologist, biogeographer, palaeontologist and desert researcher André Théodore André Monod (1902–2000), one of the most famous French scholars of the last century (Jaussaud & Brygoo 2004) who described the geology, zoology and botany of the most arid parts of the Sahara (Billard *et al.* 1997), had already been working at the MNHN since 1921, in the time of Alfred Lacroix. A militant naturalist, Monod fought with strong convictions for the defence of human rights, the defence of animal rights and the protection of the environment.

Monod looked for the giant meteorite of Chinguetti (Monod & Zanda 1990), found in Mauritania in 1920 (Lacroix 1924), but instead found another meteorite. In a note sent to his colleague in 1963, Monod carefully described the discovery of many fragments of the stony Ouallen meteorite (probably a recent fall based on eyewitness accounts; Tanezrouft, Algeria, find, 1963). Two broken blocks of this ordinary chondrite were found on 12 February 1986 on the Central Tanezrouft desert stone pavement. Many pieces were found and reassembled.

Lacroix noted that, excluding the period of observation of great shooting stars in August and November, the maximum number of falls was observed between the months of May and September, and between 5 a.m. and 9 p.m. which corresponds, with the exception of August, to the period when French farmers are in the fields. No meteorite was ever collected from the montainous area of Massif Central or the Alps (Fig. 1), which are both characterized by low population density. At that moment (and still today) the MNHN collection contains at least a fragment of all the meteorites collected in France except for the Asco ordinary chondrite which fell in Corsica in 1805 and, perhaps, some meteorites kept by people (Appendix 1).

Lacroix actively studied tektites (see McCall 2006*b*), to which he devoted 50 pages of the second manuscript catalogue of the MNHN. They were collected over 3 years with the assistance of numerous people in Indochina (Lacroix 1932), Australia, Malaysia, Java, the Philippines, Ivory Coast (Lacroix 1935) and, not least, in Bohemia. The Museum now owns one of the richest collection of tektites in the world, with 1281 sets of tektites that contain altogether thousands of smaller tear-, pear- and disc-shaped samples that show internal gas bubbles (Fig. 21). Lacroix observed that indigenous tribes made small talisman objects from tektites considering them as 'Moon balls' or 'star excrement'. Although criticized by Spencer (1933), Lacroix proposed the original hypothesis that tektites had formed in the Earth's atmosphere by violent high-temperature oxidation of a uniquely metallic meteorite.

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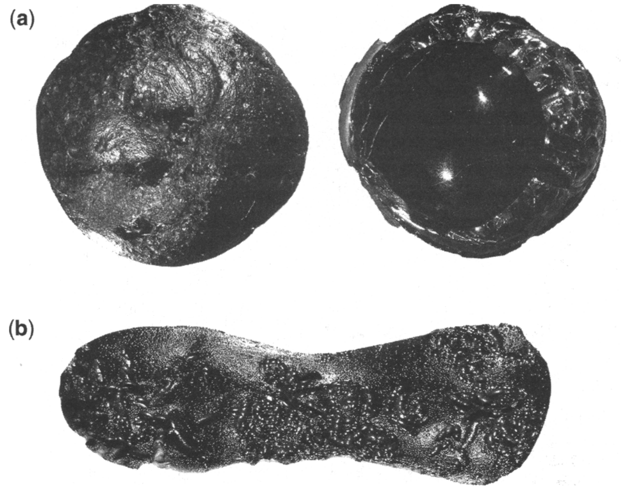

Fig. 21. Two tektites from the large collection of the MNHN. (**a**) Tektite (catalogue number 1608 bis) from Malaysia broken in half (6 cm in diameter) showing a voluminous bubble inside. (**b**) Tektite, 10 cm long, collected on the Tan-Hai island in Indochina (© L.E.M.E., MNHN).

Curating Lacroix's legacy: the collection under Orcel

In 1937, at the age of 40, Jean François Orcel (1896–1978) succeded his master Alfred Lacroix, who died 4 days after a last visit to his laboratory in 1948. Lacroix had initially invited Orcel in 1920 to second him for the preparation of samples, and then as his assistant in 1927, and as the Assistant Director of the Mineralogy Laboratory in 1932. Orcel remained in the Chair of Mineralogy for 30 years (Fig. 22). Orcel attempted to maintain the tradition of friendly trust and enthusiasm that Lacroix had managed to instill. He was associated with many prospectors who enriched the collection and donated

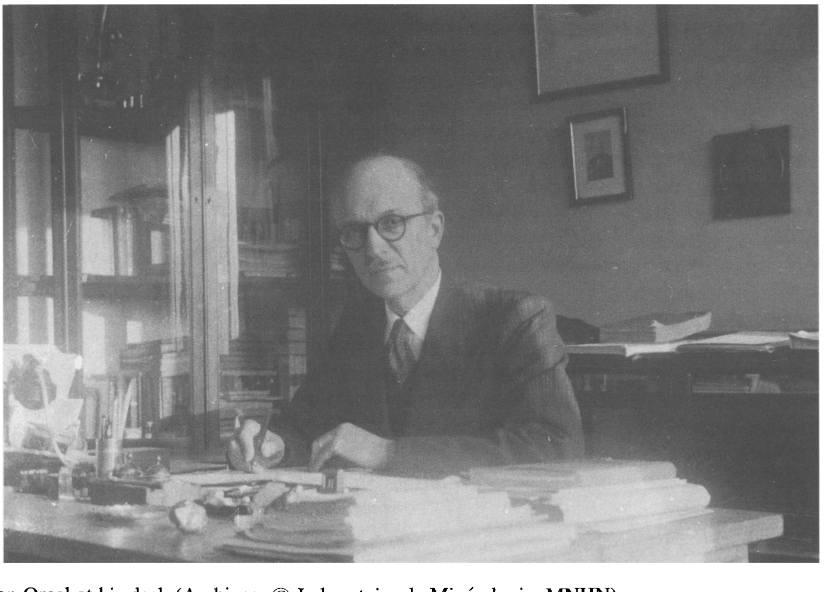

Fig. 22. Jean Orcel at his desk (Archives, © Laboratoire de Minéralogie, MNHN).

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many minerals after the First World War. He successfully obtained a bequest from the largest collector of minerals in the world, Colonel Vésigné (1870–1954), of the choicest pieces of his collection to the MNHN. Indeed, he offered 5000 of his best minerals, collected with passion for more than 50 years of his life. Later the MNHN bought three times as many specimens in 1955 from his heirs. Among these great specimens, the MNHN also acquired more than 700 meteorite samples. Named in his honour, the 'Salle Vésigné' (located within the Gallery of Mineralogy) displayed, over a period of approximately 7 years, hundreds of the 20 000 minerals existing in the collection.

In 1939, the Second World War interrupted all the activities of the Laboratory of Mineralogy, whose only urgent objective became the protection of the most precious samples of the collection. Several tonnes of samples were stored safely in the countryside and in secluded castles, such as the Château de Ris, at Bossay-sur-Claise in the Loire Département, which belonged to the Académie des Sciences.

In 1962 the Laboratoire de Minéralogie was the only one in France to dedicate a large part of its activity to the systematic study of meteorites. The MNHN collection was then considered the third in the world on the basis of the number of represented falls (720) and by the quantities of specimens (Fig. 23). Stony meteorites represented 93.5% of the world's observed falls in 1953. At this time, according to a survey by E.L. Krinov, there were 1700 distinct meteorites in the world (Orcel 1969*a*). Moreover, some specimens in the MNHN collection are, in fact, the largest known recovered samples for several specific meteorites.

Two important new acquisitions were obtained during Orcel's tenure in the laboratory: the octahedrite of Henbury (find, Australia, 1931 and associated with craters) and the Douar M'Ghila ordinary chondrite (fall, Morocco, 1932) (Fig. 24), with its strikingly beautiful outer fusion crust (Orcel 1953). Orcel particularly liked the iron of Tamentit (find, Algeria, 1864), which was for him one of the nicest pieces in the collection (Orcel 1962). He made many

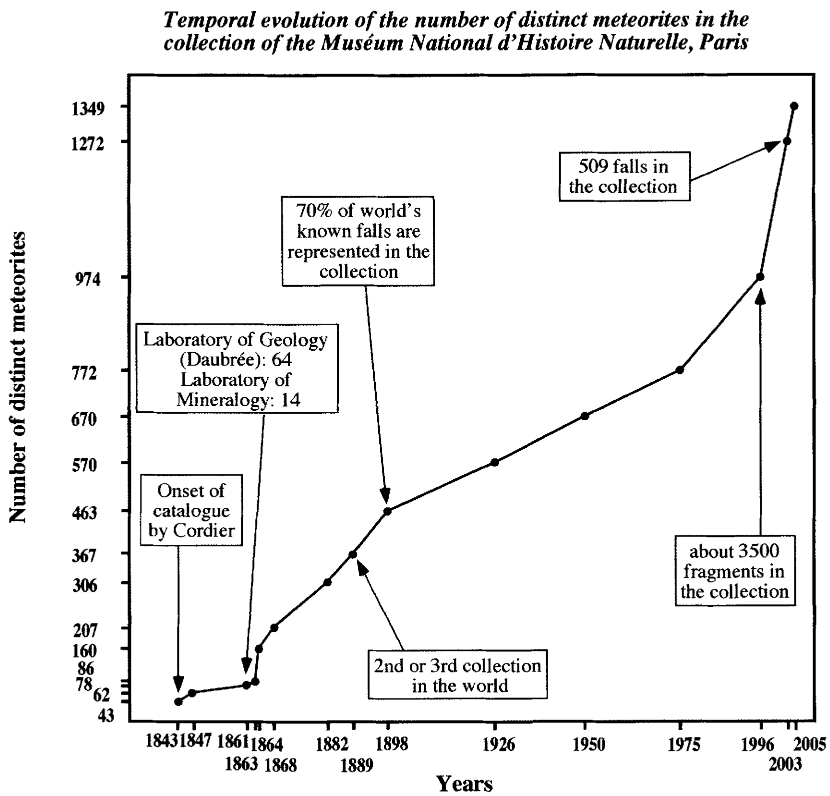

Fig. 23. Evolution of the number of distinct meteorites in the MNHN collection from the onset of the catalogue by Cordier in 1843 until 2005 (in Cordier 1837–1861).

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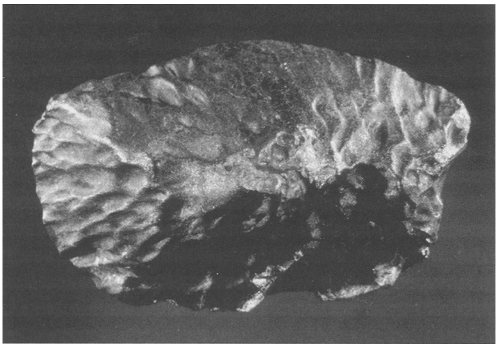

Fig. 24. Douar M'Ghila meteorite showing a beautiful fusion crust (10 cm across) (©L.E.M.E., MNHN).

useful exchanges with his scholarly contacts in Europe and across the globe to increase the number of distinct meteorites in the collection.

Professor Orcel was a prolific correspondant. He was a humanist, a tireless labourer who published more than 160 scientific papers and two books, and an astute experimentalist (Jaussaud & Brygoo 2004). He enjoyed and was adept in politics, enjoyed oral discourses, and wrote many notes and letters on meteorites. Orcel actively developed research on: chemical mineralogy, particularly on chlorites; differential thermal analysis applied to mineralogy (clays, natural hydroxides, and other mineral species); the optical properties of opaque crystals; the genesis of ore minerals; metamict minerals; petrography; geology; and meteorites at the end of his career (Orcel 1956, 1958, 1961*a*, *b*, 1963).

At the request of Jean Frédéric Joliot-Curie (Chemistry Nobel prize winner in 1935 together with his wife Irène), Orcel, who had become his close personal friend, organized the first prospective surveys for uranium ore, both in France and in the French Overseas Territories. In those years there existed a close collaboration between the MNHN and the Laboratoire des Faibles Radioactivités of the French Atomic Energy Commission (CEA). Hence, Jean Teillac, fourth High Commissioner of the CEA, once said 'Orcel could make rain or shine in the geological services of the CEA although he did not even belong to the institution' (Picard 1987).

He discovered new ore localities, and taught classes on meteorites and ore genesis. He published on the new mineral hibonite (Curien *et al.* 1956). In 1963 Orcel was elected to the Académie des Sciences and, on 20 October 1964, he received the sword, the highest academic award for a scientist (Laboratoire de minéralogie 1964).

The MNHN's Mineralogy Laboratory collaborated and contributed actively to the projects of the Permanent Committee on Meteorites of the International Union of Geological Sciences. The International Commission of Meteorites undertook an inventory of meteorites in different world collections. Orcel established the French working group on meteorites, which met for the first time at the UNESCO headquaters in Paris on 25–27 February 1964, and included, among others, Brian Mason from New York, Max Hey from the British Museum in London and K. Sztrokay from Budapest (Orcel 1964).

Over the years Orcel made more than 4000 polished thin sections of rocks, including many for his studies of opaque minerals, as well as for his work on meteorites. In particular he studied polished thin sections of Orgueil in order to overcome the difficulties of observing this very porous carbonaceous meteorite without causing contamination. He even analysed the chemistry of its mineral phases using the Castaing microprobe, the ancestor of the electron microprobe analyser we know today (Orcel 1969*b*).

Orcel was first assisted by Simone Caillère (1905–1999), who joined in the team of Alfred Lacroix in 1929, was Assistant Director of the Laboratoire de Minéralogie and then Professor in 1965, and became famous for her work on clays. Among her 200 publications, her work on clays led to the remarkable development of applications of these minerals in all domains (Rautureau *et al.* 2004), starting with those found in Orgueil meteorite. She participated with the French Clays Group and the International Association for the Study of Clays. She launched the first great renovation of the gallery, concentrating on paintings and then parts of the roof, which eventually itself served for partial repairs to the metal roof of the spire of the Cathedral of Chartres.

Many assistants were involved in the study of extraterrestrial samples. Among these, Elisabeth Jerémine (1879–1964), whose maiden name was Tschernaieff, was born in Russia. After finishing her studies in the laboratory of Maurice Lugeon in Lausanne, Switzerland, she left Russia in 1917 under a false name in the wake of the October Russian Revolution and eventually reached France. The registry of scientific workers of the Laboratoire de Minéralogie that was kept up-to-date by Lacroix mentions E. Jerémine for the first time in 1920. At first she was assistant to Albert Michel-Lévy and helped initiate students in the study of rocks in thin sections under the microscope for his classes at La Sorbonne University. Energetic,

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tireless in the field and in the laboratory, Jerémine was a tremendous help to Lacroix in his studies of meteorites. She then continued on and became a trusted assistant to Orcel, despite the limited resources in personnel and funds that he could use for curating the collection of meteorites. (In fact, Orcel was very frustrated that he could not have access to more resources to pursue his goals of developing mass spectrometry and gas analyses.)

In 1948 Jerémine and Orcel were designated as the French delegates to the Permanent Committee on Meteorites at the International Geological Congress held in London. Jerémine described more than 10 new meteorite falls that occurred in France, Portugal, Morocco, the Sahara, Cameroun (Galim: association of a chondrite and a lithosiderite, fall, 1952), Sudan and Niger. She also reinitiated the study of Chassigny (Orcel *et al.* 1962; Orcel 1965*a*). Orcel and Jerémine, who had a strong energetic personality, conducted vivid, passionate and contradictory discussions on the processes of chondrule formation. Jerémine developed the classification and organization of the large collection inherited from Colonel Vésigné. She intensely devoted all her life to petrography and remained in the Laboratoire de Minéralogie for 40 years. Very attached to the work of Lacroix she told Orcel: 'I do not work by devotion to research or to the laboratory but only because I enjoy it' (Orcel 1965*b*).

On the death of Jerémine, François Kraut, who was of Hungarian origin and had worked earlier on the French impact crater of Rochechouart in the Haute Vienne Département (Kraut 1935), joined the MNHN to continue her work. He continued to gather many rocks from impact craters. Kraut became Assistant Director of the Laboratory in 1963. He was mandated by Orcel to manage the collection from 1967 to 1969, and also worked on tektites in co-operation with scientists of the Max-Planck Institut für Kernphysik in Heidelberg.

At this time meteorites were classified in three large groups: (1) meteoritic irons (octahedrites, hexahedrites, ataxites); (2) siderolites (pallasites and lithosiderites); and (3) aeroliths (chondrites, feldspathic and non-feldspathic achondrites).

Orcel organized a large exhibit called 'Les météorites messagères du cosmos (et les expériences spatiales)' and later published in 1969 the exhibit's visitors guidebook (Orcel 1969*a*, *b*). The exhibit and its 43 panels were displayed in the Gallerie de Botanique of the MNHN from July to November 1968 and from March to April 1969. This exhibit showed several of the first pictorial representations of the fall of meteorites, e.g. a 15th century engraving showing the fall of Ensisheim in 1492 in Alsace. A travelling exhibit that summarized the larger exhibit was also conceived.

A new impulse for the collection under Pellas' charismatic leadership

In 1968 Jacques Louis Fabriès (1932–2000) (Fig. 25) became Director of the Laboratoire de Minéralogie, and rapidly decided to improve the management of the two very important and historical collections of the Laboratoire de Minéralogie of the MNHN. Fabriès, recognized for his scientific integrity and his strong personality, focused his research on rocks from the deep Earth. He immediately nominated Paul Pellas to be in charge of the French national meteorite collection and Henri-Jean Schubnel as curator of the huge mineral collection.

Paul Nicodème Félix Pellas (Fig. 26) was born in Marseille on 24 July 1924. His Italian family had chosen his first names to honour the 'Partito Nazionale Fascisto'. His rebellion against fascism in Italy pushed him to go to Switzerland where he studied chemistry at the University of Geneva and to join the communist resistance of the 'Francs Tireurs et Partisans' in 1943. Although he was critical of the Communist Party, he remained a member for more than 20 years.

Pellas worked from 1948 to 1952 at the French Atomic Energy Commission (CEA founded in November 1945 by Jean Frédéric Joliot who was Director of CNRS) until he had to leave because of political reasons and the onset of the 'witch hunt' and systematic eviction of communist activists. During the paranoia and ideological conflict in the years of the Cold War, Pellas studied acting. He became a film and television actor as well as a writer. Nevertheless, he joined the CNRS in 1953 and received support from Orcel, who also had sympathy for the communist ideology.

In 1965 Paul Pellas (1924–1997) became Assistant Researcher in the Laboratoire. At this time Orcel gave classes on tektites that Pellas would eventually study, in addition to all the problems related to geochronology. Nevertheless, Pellas continued Orcel's research on the metamict state of radioactive minerals (Pellas 1951, 1954) and continued the study of their recrystallization under the action of heat that had been initiated by Orcel in the mineralogical laboratory at Fort Châtillon (now the centre d'Etudes Nucleaires de Fontenay-Aux-Roses) on the outskirts of Paris. Clearly, over the years, cosmomineralogy

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Fig. 25. Professor Jacques Fabriès when he was Director of the MNHN (between 1990–1994) and Director of the Mineralogy Laboratory, a few years before his death. Like his famous predecessors Fabriès was 'Chevalier' (1993) of the French 'Légion d'Honneur' (see in 'Ministère de la Défense 2002') and of 'palmes académiques' (© Laboratoire de Minéralogie, MNHN).

and cosmolithology had developed significantly into two new scientific disciplines. Orcel considered that they were the bases of cosmochemistry itself – the prolongation of the methodologies, theories and data acquition techniques of geochemistry to the entire cosmos. Following his mineralogy studies at Paris University, Pellas was hired by the CEA in 1948 to work under Irène and Frédéric Joliot-Curie.

Apparently only one of Kraut's notebooks, in which he noted samples taken from meteorites in the collections, has been kept, detailing exchanges between 1967 and 1969. Pellas sometimes added comments in the notebooks that

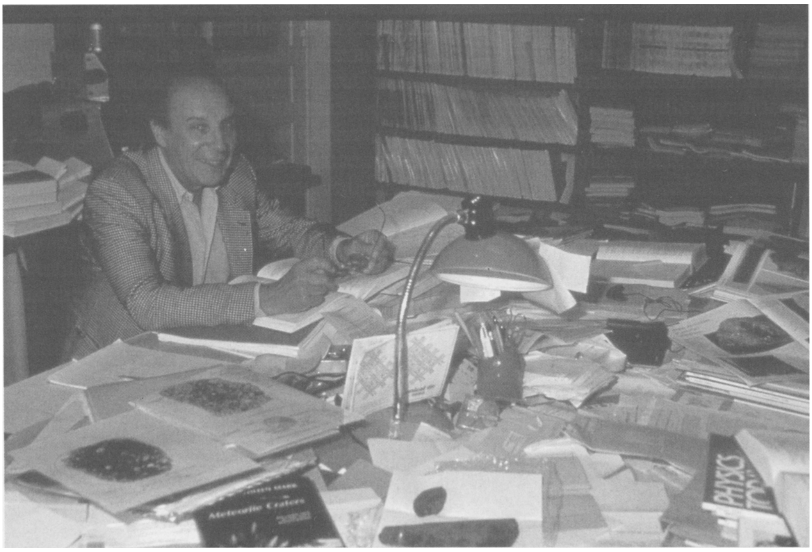

Fig. 26. Paul Pellas in his office (© L.E.M.E., MNHN).

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emphasised, for example, when well-known people or close colleagues had borrowed a sample but had returned it with too many grammes of precious material removed. Pellas judged that this was very detrimental to the collection and was keen to develop a vigilant protocol of exchange.

On 30 June 1966 Orcel officially mandated Pellas, then a research assistant at the Centre National de la Recherche Scientifique (CNRS) and French Secretary for the study of meteorites, to collect all information and transfer to the MNHN a large specimen (113 kg) of the meteorite that fell on 27 June 1966, near Saint Séverin in the Département of Charente. He requested the civil and military authorities to provide all assistance necessary to Pellas for this mission.

Many small craters were also discovered. Pellas was careful in reporting their orientation and inclination. Some of the craters were as much as 30 cm deep and thus indicated an E–W trajectory $\pm 15^{\circ}$ and an inclination of about 65° with respect to the horizontal. This reconstructed trajectory led to the discovery of new fragments.

In order to improve the knowledge of cosmic radiation from outer space, there was a systematic search for short-lived radioelements whenever a new meteorite was discovered. Pellas and his co-authors were particularly proud to discuss in a paper (Cantelaube *et al.* 1969) how the fragments of the meteorite were all recovered and pieced back together, as they were before the rupture in the atmosphere, using measurements of the activity of short-lived elements that emanated from the meteorite. In fact these results were compatible with those from studies of the density per cm^2 of fission tracks produced by iron ions from the primary cosmic radiation measured in pyroxene crystals (hypersthene).

Pellas had calculated which Saint Séverin (LL chondrite fall, Charente, 1966) was amongst the meteorites whose ablation rate (25% of its pre-atmospheric mass) was the lowest. Because there was more ablation on the front face, Saint Séverin was thus orientated.

Pellas was a charming and passionate scientist who became entirely associated with the MNHN meteorite collection which he curated for over 25 years, following on from the traditions of the great scholars of the 18th and 19th centuries that had expanded its scientific value and impact. He never hesitated at international meetings to embark on profound debates on data and their interpretation, in which he convincingly relied on his skills as an actor and passionate orator to propose and establish innovative concepts.

In 1973 he appointed Dieter Storzer to work on cooling rates in meteorites and on palaeothermometry studies of apatites with the objective of applying the results to the study of meteorites (Pellas & Storzer 1975). Storzer became Assistant Researcher in 1976 and then Researcher. Although he collaborated over a short period with Pellas on the study of tektites, they both rapidly developed a disharmonious working relationship.

Pellas developed and maintained numerous international collaborations that typically led to exchanges of meteorites and thus to the expansion of the collection. He often exchanged with Robert Hutchison from the Natural History Museum in London, Martin Prinz at the American Museum of Natural History in New York and Gary Huss at the American Meteorite Laboratory in Denver. He also interacted with the Mineralogical Collection in Denver, the Victoria Museum in Melbourne, Australia, and various American and German collectors. He always discussed proposals with international scientists who were interested to work with samples from the collection and made judiceous allocations for research. About 7.5 kg of the famous CV3 Allende were acquired after its fall in Chichuahua, Mexico, on February 1969. Murchison another unique carbonaceous chondrite fall Victoria, Australia, 28 September 1969) was acquired in November 1969. The MNHN acquired in 1978 almost 6 kg of Bouvante, the new French eucrite (find, Drome, 30 July 1978). Among other ordinary chondrites we can emphasize the acquisition in March 1990 of more than 4.5 kg of the fall of Tuxtuac (LL5, fall, Zacatecas, Mexico, 1975) in an exchange with Robert Haag (an American meteorite dealer and collector). Pellas also obtained from the Préfet des Ardennes many specimens of the French Mont-Dieu iron (IIE) meteorite, found in 1994. About 185 kg was acquired by the MNHN from the 360 kg collected. About 21 kg of the Chinese (IIIC) Nantan iron meteorite, found in 1958, were acquired in March 1994. A slice weighing 4 kg of Rio Limay meteorite, which fell in Argentina on 5 August 1995, was also exchanged. Pellas wrote in an internal activity report in 1989 that from 1980 to June 1989 the collection expanded at a rate of 25%. Pellas' objective and dream was to get more than 1000 distinct meteorites before his death (M. Denise pers. comm.).

Moreover, he would have liked the MNHN to host and further develop the curation of micrometeorites that began to be collected in Arctic and Antarctic regions and hot deserts of the globe by French surveys under the leadership

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of Michel Maurette at the University of Orsay in the early 1980s in the framework of the EUROMET research programme.

He started working on fission tracks generated by cosmic rays in meteorites and became one of the pioneers in the use of fission-track geochronological dating, as well as on the thermal history of chondritic asteroids. He collaborated with Bob Walker and Michel Maurette in the first discovery of tracks generated by cosmic-ray tracks (Maurette *et al.* 1964).

Although he was barred from entering the USA for many years, because of his political ideologies, he nevertheless became a NASA Principal Investigator for the study of lunar samples and was then also responsible for allocating the USSR lunar samples in France as part of collaborative research projects with the USSR.

Pellas curated and promoted the evolution of the MNHN's meteorite collection at a crucial time in its history and that of the science of meteoritics. Indeed, it was the study of the geochemistry and mineralogy of meteorites that vastly expanded our knowledge of the cosmic distribution of chemical elements and their isotopes (cosmochemistry), and promoted the development of new cosmogonic theories on the formation of planets, particularly in France where the famous cosmochemist Claude-Jean Allègre (who became Director of the Institut de Physique du Globe de Paris (IPGP) in 1976, and was awarded the Crafoord prize, together with Gerald Wasserburg of the California Institute of technology, in 1986).

Pellas was the first non-American President of the Meteoritical Society (1977–1978) and organized memorable meetings where he energetically discussed science, enjoyed wine and the good French way of living he embodied all his life. Just before his death, he largely participated in the setting out of the scientific content and the organization of the largest meteorite exhibit (1000 m^2) ever achieved in France. He is a co-author of the book on meteorites (Benest *et al.* 1996) that accompanied the exhibit, and which was intended for the general public.

Pellas passed away after a long battle with cancer in 1997. A symposium was organized in Paris in 1998 in his honour (Laboratoire de Minéralogie 1998). Many scientists with whom he had been involved in collaborative studies came to pay him a last tribute. Additional researchers came to discuss results from multidiscplinary studies of meteorites that Pellas had always promoted, athough he had been mainly interested in fission tracks. A paper was also published on his work concerning the onion-shell structure of ordinary chondrite parent bodies (Trieloff *et al.* 2003) and a final posthumous paper on acapulcoite meteorites is in press, projects that he worked on for many years (El Goresy *et al.* 2005).

In the 1970s an ad hoc committee was formed under the responsibility of Fabriès to review the procedures of allocating meteorite samples to requesting scientists. The committee consisted of Mireille Christophe Michel-Lévy, who described the first calcium–aluminium inclusion (CAI) in the Vigarano carbonaceous chondrite, fall, Emilia-Romagna, Italy (Christophe Michel-Lévy 1968); M. Jérome of the Mineralogy and Crystallography Laboratory at the University Pierre et Marie Curie (Paris VI); Michèle Mathilde Bourot-Denise, a student of Christophe Michel-Lévy trained in the study of the mineralogy of meteorites; and Pellas. In 1975 Denise updated an inventory and catalogue of meteorites in alphabetical order (780 meteorites are represented) for the 38th Meteoritical Society meeting held in Tours, France. In 1980 there were 834 distinct meteorites in the collection of the MNHN. Denise was assisted by Marianne Ghelis, a mineralogist from the Université de Pierre et Marie Curie (Paris VI) and the Sorbonne, who (in the 1980s) assisted Pellas with sample preparation and analyses for his research. Ghelis was devoted to the work and person of Pellas until he passed away. She updated the meteorite catalogue with him in 1984 and again in 1995. She also sent data to the world database on meteorites (compiled by the German Jörn Koeblitz).

At the end of the 1970s Claude Perron, an astrophysicist, joined the meteorite research team at the MNHN and assisted Pellas with the national collection of meteorites, particularly with public outreach activities. Perron negotiated numerous exchanges of samples from the MNHN for large slices of meteorites to be used for exhibits. The meteorite team was later strengthened by the recruitment of another astrophysicist, Brigitte Mathilde Zanda, as Assistant Professor. In 1992, Catherine Laurence Valérie Caillet, a cosmomineralogist specializing in the petrology and petrography of chondrites and their white inclusions, was recruited by Jacques Fabriès as Assistant Professor in the Laboratoire de Minéralogie of the MNHN in order to assist with the collection. Sainte-Rose, an unequilibrated ordinary chondrite, the only French meteorite to have been found on a volcano (Piton de la Fournaise, Réunion island, which fell in June 1983), was described and studied by Caillet during her doctoral studies (Caillet 1990). Shortly after, a 342 g specimen of this meteorite was donated to the MNHN.

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The collection of the MNHN from 1998 to 2005

Michel Guiraud, Assistant Professor in the Laboratoire de Minéralogie, later Professor, was nominated in 1998 as Director of the Laboratoire de Minéralogie. In June 1999 he delegated charge of the collection to Michèle Mathilde Bourot-Denise, Engineer in Mineralogy. She efficiently classified all the meteorites found in the Saharan desert and neighbouring countries of northern Africa that were collected and brought to France by many new French meteorite dealers and a few amateur collectors. Unable to classify the resulting very large number of specimens, she opted to classify only the rare types. Hence, the collection was able to expand by the acqusition of some of the choicest new meteorites desired by scientists to undertake new research on the origin of the solar system. However, only small samples (usually 20–30 g) could be obtained in exchange for the official expertise concerning the meteorites brought to the MNHN by the commercial dealers or private owners. Moreover, for every classified meteorite from the desert, a polished section is made and thus archived as well. Some rare types of meteorities were acquired during those years such as a lunar sample, specimens of the martian SNC group, and of a Rumurutiite chondrite (R3) and a carbonaceous chondrite (C3) from Libya.

As mentioned above, many exchanges had been made whilst Pellas was curator of the collection. This practice remains to this day the main protocol by which the collection can expand as a result of the almost total impossibility for the MNHN to purchase new meteorites. From 1989 to 2001 more than 100 donations were made (mostly from the oldest current French private collector and dealer, Alain Carion, but also from others). Unfortunately, times have changed and the MNHN has not been endowed by large donations of several hundreds of samples as it was in the past. However, new meteorite casts were commissioned. Over the period from 1989 to 2004 there were 157 exchanges, 1349 loans and 801 specific subsamples sent for destructive research to requesting scientists.

Despite the lack of funds for purchasing new samples, the MNHN collection managed to acquire, in 2001, almost 2 kg of the Bilanga diogenite, which fell in Burkina Faso in 1999. Moreover, the two newest French meteorites acquired by the MNHN are the Alby sur Chéran eucrite achondrite (130 g) that fell on the roof of an industrial plant in February 2002, and the Plaincy l'Abbaye ordinary chondrite that was found in September 2003. This brings the total of meteorite falls from the French territory to 70 (Fig. 1).

In February 2003 the MNHN collection consisted of 1179 meteorites represented by 3192 specimens including nine SNCs, one lunar meteorite, 697 chondrites and 267 irons. In August 2003 there were 1272 meteorites giving 3309 specimens when Denise completed her unpublished digital database (Denise 2003; third written catalogue). In fact, it is necessary to add to this catalogue the 1276 sets of tektite samples, the historical as well as more recent thin sections and polished sections (more than 1000), the historical casts, the samples of rocks from impact craters, and the residues from experiments by Daubrée and Meunier. In addition, there are also numerous unclassified samples, as well as all the samples that are involved in the temporary system of loans, exchanges and scientific donations.

In recent years a profound restructuring of the MNHN led to the creation of scientific departments (3 October 2001) and the nomination of collection curators that depend directly on the Department of Collections. The former Laboratoire de Minéralogie has been separated into two research units: one dealing with petrology and rocks from the deep Earth and Mars directed by Jean-Pierre Lorand (USM 201); and another dealing with the study of extraterrestrial matter under the leadership of François Robert (USM 205). They are both part of the 'Département Histoire de la Terre' of the MNHN, a much larger structure regrouping many distinct units, including the former Laboratoire de Géologie. A scientific committee still exists to oversee the collection. Since 2002 Brigitte Zanda has been in charge of the collection of meteorites of the MNHN. In 2004 Catherine Caillet was nominated, within this committee, to take charge of the scientific expert analysis of all samples brought to the MNHN as potential meteorites (Caillet 2004). However, additional researchers and engineers (i.e. François Robert, Claude Perron, Nicole Guilhaumou, Michèle Denise, Christine Fiéni, Marianne Ghelis and Madeleine Selo and recently Matthieu Gournelle, Anders Meibon and Smail Mostefaoui) of the MNHN's meteorite research team, as well as mineralogists from the former Laboratoire de Minéralogie, are still invited to give their opinion when scientific exchanges are discussed.

In 2005 the MNHN meteorite collection consists of 3385 specimens representing 1343 distinct meteorites and including 512 observed falls, (Fig. 27) to which has been added at least 3000 tektites. Many tens of meteorites are waiting to be classified by Caillet and Denise.

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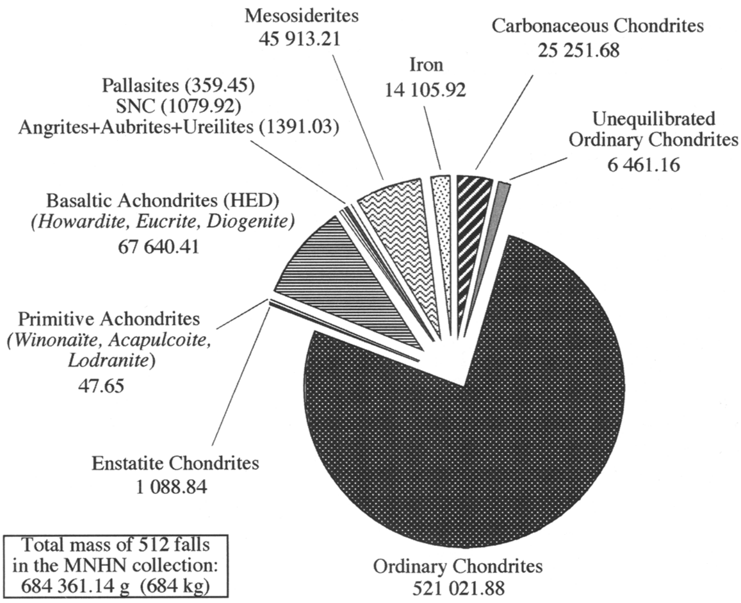

Fig. 27. Sector diagram showing the total mass of samples (in grams) of meteorite falls in the MNHN collection as a function of each main meteorite class. SNC, Shergotty–Nakhla–Chassigny (martian) meteorites.

The collection is currently housed in a secured building with a controlled dry environment. The most fragile samples are kept in a neutral and dry atmosphere buffered by nitrogen. At present the MNHN's role has been limited to curating the collection. Exchanges with commercial meteorite dealers have been forbidden and there are only extremely limited funds to purchase new meteorites (the prices of which have soared). Consequently, only very small amounts or a few samples can be purchased. Meteorites provide invaluable clues to the origin and evolution of our solar system, and today scientists are almost completely dependent on a small number of major meteorites for research material. As in the past, the curation of the meteorite collection at the MNHN lacks human and financial resources, as well as a modern and expanded storage facility and a permanent exhibit. These new and needed facilities will also have to handle the preservation of samples that the MNHN is keen to acquire when they are brought back from space surveys on other planets or celestial bodies during the ensuing century. We are hopeful that the creation at the MNHN, in 2003, of the new multidisciplinary research and analytical group – the Laboratoire d'Etude de la Matière Extraterrestre (Laboratory for the Study of Extraterrestrial Matter; L.E.M.E. or UMS-2679 CNRS) – that is being equiped with France's newest Cameca nanosims ion probe will have a positive impact on the meteorite collection and will promote a new impulse for research in France on meteorites, extraterrestrial processes and the origins of life.

I am particularly grateful to J.-P. Lorand for his spontaneous loan of many original and rare documents and photographs from the archives of the Laboratoire de Minéralogie, and for interesting discussions. P.-J. Chiappero is sincerely thanked for allowing me access to old catalogues of the Laboratoire de Minéralogie and loan of photographs. I am grateful to many other people from the 'Département Histoire de la Terre' of MNHN and in particular to M. Serrano for his kind assistance with web searches and the scanning of old documents, and to A. Cornée for providing the photographs of Cordier and Meunier. I thank the Service du Personnel and the Service du Patrimoine of the Bibliothèque Centrale of MNHN for their help. I thank the staff of the L.E.M.E. and, in particular, M. Bourot Denise for providing unpublished data on the collection, C. Fiéni for assistance with the iconography, and M. Ghelis for assembling a variety of old diverse and unpublished notes on the collection and particularly regarding Paul Pellas. A special mention of G. Carlier who helped me in my tasks of informing the public who brought me numerous potential but false meteorites to assess while I was particularly busy. Finally, I thank F. Robert for his permanent support and J.-C. Komorowski who agreed to read this work and make valuable suggestions. I am also grateful to the reviewers R.J. Howarth and G.J.H. McCall, and especially to the editor A.J. Bowden, for all their useful comments that have improved this work.

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Appendix 1. *List of meteorite falls in the collection of the French Muséum National d'Histoire Naturelle classified chronologically by date*

Name of meteorite fall	Class	Mass (g)	Year
Elbogen	IID	109.61	1400
Ensisheim	LL6	8342.77	1492
Vago	H6	7.50	1688
Ogi	H6	35.10	1741
Hraschina	IID	2.90	1751
Luponnas	H3-5	56.20	1753
Tabor	H5	143.70	1753
Albareto	LL4	3.40	1766
Luce	L6	0.58	1768
Mauerkirchen	L6	197.00	1768
Sena	H4	113.34	1773
Eichstadt	H5	12.77	1785
Kharkov	L6	1.79	1787
Barbotan	H5	429.26	1790
Siena	LL5	122.99	1794
Mulletiwu	L	25.50	1795
Wold Cottage	L6	114.51	1795
Bjelaja Zerkov	H6	72.39	1796
Salles	H6	1545.03	1798
Benares (A)	LL4	25.40	1798
Apt	L6	1937.62	1803
L'Aigle	L6	9895.74	1803
Darmstadt	H5	24.00	1804
Bocas	L6	7.20	1804
High Possil	L6	1.40	1804
Doroninsk	H5-7	1.69	1805
Alais	CI1	39.30	1806
Weston	H4	272.03	1807
Timochin	H5	35.08	1807
Stannern	AEUC-M	1269.73	1808
Lissa	L6	178.90	1808
Borgo San Donino	LL6	406.79	1808
Kikino	H6	5.50	1809
Mooresfort	H5	137.23	1810
Charsonville	H6	4043.62	1810
Berlanguillas	L6	1005.12	1811
Kuleschovka	L6	8.86	1811
Borodino	H5	2.37	1812
Erxleben	H6	6.55	1812
Toulouse	H6	145.70	1812
Chantonnay	L6	2039.34	1812
Luotolax	AHOW	10.00	1813
Limerick	H5	145.19	1813
Agen	H5	8723.87	1814
Bachmut	L6	63.44	1814
Durala	L6	34.20	1815
Chassigny	SNC	318.47	1815
Seres	H4	4.50	1818
Slobodka (1818)	L4	35.00	1818
Zaborzika	L6	104.20	1818
Jonzac	AEUC-M	483.89	1819
Pohlitz	L5	6.30	1819
Lixna	H4	78.00	1820
Juvinas	AEUC-M	36 031.76	1821
Epinal	H5	202.53	1822
Kadonah	H6	1.20	1822
Clohars	L4	4.66	1822

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
Angers	L6	105.94	1822
Futtehpur	L6	284.41	1822
Renazzo	CR2	75.25	1824
Zebrak	H5	2.36	1824
Nanjemoy	H6	28.10	1825
Honolulu	L5	13.52	1825
Galapian	H6	33.90	1826
Pavlograd	L6	133.20	1826
Bialystok	AEUC-P	1.00	1827
Drake Creek	L6	180.97	1827
Mhow	L6	6.00	1827
Richmond	LL5	9.76	1828
Deal	L6	0.46	1829
Forsyth	L6	8.74	1829
Wessely	H5	0.72	1831
Vouille	L6	10 954.31	1831
Blansko	H6	3.35	1833
Okniny	LL6	0.60	1834
Aldsworth	LL5	9.40	1835
Aubres	AAUB	11.44	1836
Macau	H5	283.92	1836
Gross Divina	H5	213.83	1837
Esnandes	H6	4.08	1837
Cold Bokkeveld	CM2	352.20	1838
Akbarpur	H4	16.80	1838
Kaee	H5	1.30	1838
Chandakapur	L5	3.96	1838
Montlivault	L6	437.00	1838
Little Piney	L5	14.41	1839
Cereseto	H5	8.14	1840
Karakol	LL6	0.20	1840
Uden	LL7	1.14	1840
Gruneberg	H4	40.57	1841
Chateau Renard	L6	1559.35	1841
Saint Christophe la Chartreuse	L6	261.56	1841
Aumieres	L6	1430.85	1842
Milena	L6	10.20	1842
Barea	MES-A1	87.70	1842
Bishopville	AAUB	47.04	1843
Manegaon	ADIO	2.69	1843
Verkhne Tschirskaia	H5	15.18	1843
Klein Wenden	H6	4.82	1843
Utrecht	L6	28.76	1843
Cosina	H5	127.91	1844
Favars	H5	356.98	1844
Killeter	H6	0.39	1844
Le Teilleul	AHOW	356.91	1845
Le Pressoir	L6	189.32	1845
Cape Girardeau	H6	120.40	1846
Monte Milone	L5	163.89	1846
Braunau	IIA	424.17	1847
Marion (Iowa)	L6	175.30	1847
Marmande	L5	1.25	1848
Castine	L6	0.07	1848
Ski	L6	1.63	1848
Monroe	H4	59.30	1849
Shalka	ADIO	35.42	1850
Kesen	H4	356.40	1850
Gutersloh	H4	3.02	1851

(Continued)

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
Nulles	H6	109.70	1851
Quincay	L6	9.60	1851
Bustee	AAUB	19.40	1852
Yatoor	H5	82.19	1852
Mezö-Madaras	L3.7	380.35	1852
Borkut	L5	16.60	1852
Girgenti	L6	411.80	1853
Segowlie	L6	13.12	1853
Linum	L6	0.77	1854
Petersburg	AEUC-P	9.60	1855
Bremervorde	H/L3.9	34.95	1855
Oesel	L6	7.60	1855
Saint Denis Westrem	L6	30.19	1855
Trenzano	H3/4	145.82	1856
Oviedo	H5	7.40	1856
Kaba	CV3	2.40	1857
Quenggouk	H4	122.12	1857
Heredia	H5	53.60	1857
Ohaba	H5	240.10	1857
Les ormes	L6	72.98	1857
Stavropol	L6	17.00	1857
Parnallee	LL3.6	468.76	1857
Molina	H5	456.09	1858
Ausson	L5	2532.56	1858
Kakowa	L6	1.40	1858
Beuste	L5	399.20	1859
Pampanga	L5	89.33	1859
Harrisson County	L6	12.70	1859
Alessandria	H5	49.30	1860
Sologne	H5	2.59	1860
New Concord	L6	1632.84	1860
Dhurmsala	LL6	272.35	1860
Grosnaja	CV3	63.50	1861
Canellas	H4	212.43	1861
Butsura	H6	148.90	1861
Menow	H4	95.11	1862
Sevilla	LL4	2.40	1862
Buschhof	L6	52.44	1863
Shytal	L6	4.30	1863
Tourinnes La Grosse	L6	1224.99	1863
Manbhoom	LL6	77.97	1863
Orgueil	CI1	11 312.31	1864
Dolgovoli	L6	59.90	1864
Nerft	L6	657.40	1864
Gopalpur	H6	45.60	1865
Supuhee	H6	143.54	1865
Vernon County	H6	65.31	1865
Muddoor	L5	61.96	1865
Aumale	L6	8125.00	1865
Shergotty	SNC	100.44	1865
Cangas De Onis	H5	1837.30	1866
Pokhra	H5	13.00	1866
Udipi	H5	48.22	1866
Knyahinya	L/LL5	7673.42	1866
Saint Mesmin	LL6	5555.05	1866
Khetri	H6	5.20	1867
Tadjera	L5	6501.06	1867
Frankfort	AHOW	13.61	1868
Lodran	ALOD	30.25	1868

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
Ornans	CO3.3	2633.22	1868
Daniel's Kuil	EL6	16.00	1868
Pillistfer	EL6	59.26	1868
Motta Di Conti	H4	17.80	1868
Pultusk	H5	19 974.49	1868
Slavetic	H5	30.68	1868
Moti-Ka-Nagla	H6	138.00	1868
Danville	L6	9.90	1868
Pnompehn	L6	64.56	1868
Sauguis	L6	140.33	1868
Mount Vernon	PAL	142.75	1868
Angra Dos Reis	ANGR	14.80	1869
Hessle	H5	646.61	1869
Kernouve	H6	13 960.12	1869
Tjabe	H6	109.99	1869
Krahenberg	LL5	3.30	1869
Ibbenburen	ADIO	2.30	1870
Nedagolla	IR-ANOM	6.20	1870
Cabezo de mayo	L/LL6	373.77	1870
Roda	ADIO	56.61	1871
Laborel	H5	1823.22	1871
Searsmont	H5	33.53	1871
Bandong	LL6	2318.44	1871
Dyalpur	AURE	1.10	1872
Lance	CO3.4	1112.56	1872
Orvinio	H6	110.00	1872
Tennasilm	L4	151.92	1872
Khairpur	EL6	15.00	1873
Santa Barbara	L4	1.34	1873
Jhung	L5	120.10	1873
Aleppo	L6	157.93	1873
Virba	L6	75.67	1873
Castalia	H5	36.55	1874
Kerilis	H5	3358.49	1874
Sevrukovo	L5	292.52	1874
Nagaria	AEUC-C	0.57	1875
Feid Chair	H4	21.90	1875
Mornans	H5	36.58	1875
Sitathali	H5	35.87	1875
Zsadany	H5	13.96	1875
Homestead	L5	6997.82	1875
Stalldalen	H5	1170.90	1876
Judesegeri	H6	30.10	1876
Rochester	H6	4.77	1876
Rowton	IIIA	2.30	1876
Vavilovka	LL6	6.10	1876
Jodzie	AHOW	1.47	1877
Warrenton	CO3.6	120.47	1877
Cronstad	H5	11.30	1877
Hungen	H6	2.00	1877
Cynthiana	L/LL4	699.50	1877
Soko Banja	LL4	1655.73	1877
Tieschitz	H/L3.6	187.51	1878
Dandapur	L6	285.60	1878
Mern	L6	98.12	1878
Rakovka	L6	98.54	1878
Nogoya	CM2	276.38	1879
Gnadenfrei	H5	2.72	1879
Tomaltan	H6	12.58	1879

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
Kalumbi	L6	377.70	1879
La Becasse	L6	2150.00	1879
Tenham	L6	155.07	1879
Estherville	MES-A3/4	45 434.09	1879
Veramin	MES-B2	128.60	1880
Grossliebenthal	L6	74.50	1881
Middlesbrough	L6	0.80	1881
Pacula	L6	69.10	1881
Pavlovka	AHOW	108.62	1882
Mocs	L5-6	3302.84	1882
Alfianello	L6	1207.98	1883
Saint Caprais De Quinsac	L6	129.43	1883
Ngawi	LL3.6	111.01	1883
Tysnes Island	H4	143.05	1884
Djati Pengilon	H6	778.34	1884
Pirthalla	H6	3.97	1884
Chandpur	L6	67.85	1885
Novo-UREI	AURE	37.75	1886
Assisi	H5	219.90	1886
Nammianthal	H5	815.80	1886
Kyushu	L6	146.83	1886
Bielokrynitschie	H4	257.35	1887
Ochansk	H4	2407.59	1887
Phu Hong	H4	450.87	1887
Lalitpur	L6	21.30	1887
Mighei	CM2	72.22	1889
Ergheo	L5	158.04	1889
Lundsgard	L6	85.30	1889
Jelica	LL6	672.90	1889
Kakangari	CH-KAK	3.66	1890
Nawapali	CM2	10.71	1890
Collescipoli	H5	76.17	1890
Forest City	H5	1668.89	1890
Misshof	H5	34.58	1890
Saint Germain Du Pinel	H6	417.80	1890
Hassi Jekna	IIICD	1162.37	1890
Farmington	L5	243.70	1890
Indarch	EH4	84.00	1891
Bath	H4	72.10	1892
Cross Roads	H5	2.60	1892
Guarena	H6	103.55	1892
Beaver Creek	H5	502.25	1893
Pricetown	L6	48.50	1893
Zabrodje	L6	4.61	1893
Bori	L6	714.98	1894
Fisher	L6	470.04	1894
Savtschenskoje	LL4	5.31	1894
Ambapur Nagla	H5	257.20	1895
Bishunpur	LL3.1	45.14	1895
Lesves	L6	28.82	1896
Madrid	L6	2.74	1896
Ottawa	LL6	36.16	1896
Lancon	H6	4822.34	1897
Gambat	L6	423.80	1897
Zavid	L6	364.24	1897
Allegan	H5	454.86	1899
Magnesia	IIICD	4614.70	1899
Bjurbole	L/LL4	1914.71	1899
Felix	CO3	203.50	1900

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
N'Goureyma	IR-ANOM	1599.70	1900
Hvittis	EL6	71.97	1901
Sindhri	H5	923.13	1901
Chervettaz	L5	0.71	1901
Mount Browne	H6	40.25	1902
Crumlin	L5	247.50	1902
Bath Furnace	L6	86.94	1902
Marjalahti	PAL	216.70	1902
Saint Mark's	EH5	54.90	1903
Dokachi	H5	108.30	1903
Uberaba	H5	1166.43	1903
Jackalfontein	L6	70.90	1903
Valdinizza	L6	2.41	1903
Gumoschnik	H5	48.20	1904
Shelburne	L5	254.68	1904
Bholgati	AHOW	4.53	1905
Karkh	L6	129.40	1905
Modoc (1905)	L6	680.87	1905
Bali	CV3	29.40	1907
Leighton	H5	3.58	1907
Domanitch	L5	431.40	1907
Chainpur	LL3.4	65.46	1907
Mokoia	CV3	30.33	1908
Gifu	L6	14.80	1909
Lakangaon	AEUC-M	3.45	1910
Vigarano	CV3	213.97	1910
Grzempach	H5	22.30	1910
Paitan	H6	23.10	1910
Khohar	L3.6	224.00	1910
Hedjaz	L3.7-6	5017.03	1910
Saint Michel	L6	611.24	1910
Nakhla	SNC	430.46	1911
Holbrook	L6	473.56	1912
Moore County	AEUC-C	8.83	1913
Saint Sauveur	EH5	262.37	1914
Ryechki	L5	16.10	1914
Kuttippuram	L6	402.25	1914
Sinai	L6	132.40	1916
Boguslavka	IIA	2892	1916
Colby (Wisconsin)	L6	247.66	1917
Nan Yang Pao	L6	9.40	1917
Richardton	H5	949.71	1918
Saratov	L4	387.28	1918
Cumberland Falls	AAUB	300.11	1919
Bur-Gheluai	H5	955.70	1919
Merua	H5	25.20	1920
Sharps	H3.4	24.60	1921
Navajo	IIB	17.70	1921
Beyrouth	L4	50.42	1921
Tuan tuc	L6	2939.75	1921
Tjerebon	L5	37.64	1922
Serra De Mage	AEUC-C	299.14	1923
Birni N'koni	H4	458.70	1923
Johnstown	ADIO	89.50	1924
Bereba	AEUC-M	13 474.10	1924
Fenghsien-Ku	H5	8.80	1924
La Colina	H5	50.30	1924
Santa Isabel	L6	33.37	1924
Olivenza	LL5	3386.87	1924

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
Ellemeet	ADIO	20.72	1925
Chaves	AHOW	64.71	1925
Queen's Mercy	H6	1.20	1925
Lanzenkirchen	L4	127.70	1925
Renca	L5	4.60	1925
Air	L6	21 706.56	1925
Lua	L5	3.92	1926
Ojuelos Altos	L6	65.17	1926
Udei Station	IA	288.70	1927
Isthilart	H5	28.70	1928
Naoki	H6	253.10	1928
Padvarninkai	AEUC-M	28.16	1929
Beardsley	H5	49.10	1929
Olmedilla De Alarcon	H5	444.60	1929
Bencubbin	CH-BEN	148.20	1930
Karoonda	CK4	67.99	1930
Boriskino	CM2	0.50	1930
Miller	H5	0.15	1930
Tatahouine	ADIO	11 944.24	1931
Pontlyfni	AWIN	2.20	1931
Malotas	H5	230.57	1931
Khor Temiki	AAUB	7.20	1932
Khanpur	LL5	5.70	1932
Douar Mghila	LL6	640.85	1932
Pesyanoe	AAUB	5.97	1933
Sioux County	AEUC-M	36.55	1933
Malvern	AEUC-P	2.40	1933
Pasamonte	AEUC-P	85.43	1933
Banten	CM2	4.60	1933
Phum Sambo	H4	6729.27	1933
Harrissonville	L6	238.20	1933
Pervomaisky	L6	461.50	1933
Zemaitkiemis	L6	69.37	1933
Hainaut	H3-6	687.06	1934
Fayetteville	H4	1.33	1934
Charlotte	IVA	71.80	1935
Perpeti	L6	407.00	1935
Patwar	MES-A1	179.82	1935
Lowitz	MES-A3	83.00	1935
Macibini	AEUC-P	5.20	1936
Yurtuk	AHOW	3.08	1936
Nassirah	H4	311.19	1936
Mascombes	L6	447.92	1936
Kainsaz	CO3.1	178.60	1937
Putinga	L6	19.90	1937
Tauti	L6	11.80	1937
Ivuna	CI1	13.80	1938
Pantar	H5	8.65	1938
Zhovtnevyi	H6	240.00	1938
Kukschin	L6	35.02	1938
Washougal	AHOW	0.63	1939
Santa Cruz	CM2	2.22	1939
Ekeby	H4	0.70	1939
Glanggang	H5-6	9.30	1939
Andura	H6	1.42	1939
Kendleton	L4	368.70	1939
Semarkona	LL3.0	6.47	1940
Bununu	AHOW	3.09	1942
Kapoeta	AHOW	47.94	1942

(Continued)

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
Pollen	CM2	1.60	1942
Ankober	H4	79.82	1942
Forest Vale	H4	412.04	1942
Benoni	H6	20.46	1943
Leedey	L6	17.30	1943
Hallingeberg	L3	11.77	1944
Oubari	LL6	5605.96	1944
Isoulane-n-Amahar	L6	72 708.90	1945
Pena Blanca Spring	AAUB	830.73	1946
Schonenberg	L6	124.83	1946
Krymka	LL3.1	117.58	1946
Seldebourak	H5	104.34	1947
Sikhote Alin	IIB	2913.77	1947
Rupota	L4-6	110.10	1949
Akaba	L6	21.70	1949
Kunashak	L6	145.50	1949
Mezel	L6	764.34	1949
Adzhi-Bogdo	LL3-6	6.50	1949
Guidder	LL5	754.75	1949
Garland	ADIO	8.10	1950
Murray	CM2	74.70	1950
Monte Das Fortes	L5	182.76	1950
Dubrovnik	L3-6	5.60	1951
Elenovka	L5	145.08	1951
Manych	LL3.4	1.50	1951
Galim B	EH3/4	13.90	1952
Abee	EH4	498.44	1952
Avanhandava	H4	3.47	1952
Galim A	LL6	15.07	1952
Molteno	AHOW	0.07	1953
Zvonkov	H6	128.60	1955
Breitscheid	H5	1.90	1956
Nadiabondi	H5	2568.65	1956
Trifir	L6	815.20	1956
Ibitira	AEUC-M	20.44	1957
Massenya	H5	528.13	1958
Pribram	H5	0.60	1959
Saint Chinian	L6	56.28	1959
Hamlet	LL4	10.50	1959
Millbillillie	AEUC-M	1066.94	1960
Gao-Guenie	H4-5	4617.69	1960
Al-Ghanim (Pierre)	L6	22.60	1960
Bruderheim	L6	142.30	1960
Djermaia	H	625.07	1961
Ehole	H5	0.70	1961
Koutiaran		104.30	1962
Sainte Marguerite En Comines	H4	3029.97	1962
Sao Jose Do Rio Preto	H4	4.30	1962
Dosso	L6	870.80	1962
Kiel	L6	0.20	1962
Zagami	SNC	230.56	1962
Granes	L6	4917.92	1964
Conquista	H4	18.60	1965
Barwell	L5	85.36	1965
Chitado	H6	76.00	1966
Saint Severin	LL6	182489.24	1966
Wiluna	H5	52.86	1967
Tugalin-Bulen	H6	7.00	1967

(Continued)

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Appendix 1. Continued

Name of meteorite fall	Class	Mass (g)	Year
Niger II	L6	6.06	1967
Tathlith	L6	10.80	1967
Parambu	LL5	4.70	1967
Niger III	LL6	11.50	1967
Murchison	CM2	495.01	1969
Allende	CV3	7433.29	1969
Bou Hadid	L	366.98	1969
Kiffa	H5	155.10	1970
Ucera	H5	3.70	1970
Tillaberi	L6	112.74	1970
Havero	AURE	0.43	1971
Marilia	H4	3.10	1971
Ipiranga	H6	3.69	1972
Mayo BeLWA	AAUB	115.05	1974
Aioun El Atrouss	ADIO-P	10.10	1974
Naragh	H6	9.34	1974
Tuxtuac	LL5	4503.32	1975
Acapulco	ACAP	15.20	1976
Qingzhen	EH3	0.50	1976
Dhajala	H3.8	49.48	1976
Jilin	H5	54.00	1976
Alta'Ameen	LL5	5.22	1977
Nuevo Mercurio	H5	210.31	1978
Chitenay	L6	232.72	1978
Itapicuru-Mirim	H5	6.20	1979
Chiang Khan	H6	39.34	1981
Dahmani	LL6	106.46	1981
Ningqiang	C3-UNGR	22.13	1983
Gujba	CH-BEN	237.64	1984
La Criolla	L6	83.00	1985
Ceniceros	H3.7	115.70	1988
Pe	L6	10.60	1989
Itqiy	E-UNGR	12.50	1990
Mount Tazerzait	L5	1236.50	1991
Galkiv	H4	6.00	1995
Petelkole	H5	16.10	1995
Zag	H3-6	1635.49	1998
Portales Valley	H6	570.10	1998
Bilanga	ADIO	1898.88	1999
Gasseltepaoua	H5	15.80	2000
Beni M'hira	L6	468.30	2001
Alby Sur Cheran	AEUC-M	130.00	2002
Oum Dreya	H3-5	20.00	2003

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Note: information in this chapter was also largely taken from the archives of the Mineralogy and Geology laboratories of the MNHN that consist of numerous unclassified, unpublished, sometimes anonymous letters, transcripts of oral speeches, loose notes, photographs, yearly progress reports and handwritten manuscripts that are referenced collectively in this note.

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