

RESEÑA BIOGRAFICA

Jean Darcet

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RESUMEN. Jean Darcet (1724-1801) es otro de los científicos Franceses famosos que dedicó su vida a la educación, la ciencia y al desarrollo de la industria nacional en el período crítico de la Revolución. Su muy conocida memoria sobre el comportamiento de los minerales a altas temperaturas condujo a una mejor clasificación de estos y a descubrir el método de fabricar porcelana dura, un evento que hizo a Francia independiente de fuentes externas y transformó a Sévres en un industria de cerámica mundialmente famosa. Darcet descubrió la aleación que lleva su nombre, un material que encontró muchos usos industriales, aun en nuestro tiempo.

ABSTRACT. Jean Darcet (1724-1801) is another of the famous French scientists that devoted his life to teaching, to science, and to the development of the national industry at the critical time of the Revolution. His well-known memoir on the behavior of minerals under high heat led to a better classification of them and to his discovery of the method for making true porcelain from native raw materials, a finding that made France independent of external sources and transformed Sévres into a world-famous ceramic industry. He discovered the alloy that carries his name, a material that found many industrial uses, even in our time.

LIFE AND CAREER¹⁻⁴

Jean Darcet (Fig. 1) was born on September 7, 1724, at Audignon, near Doazit, St. Sever, Landes, France, the son of Marguerite d'Audignon and François Darcet. His father was a well-known judge in Doazit who later became lieutenant general at the Gascogne bailiwick. His mother passed away in 1728 and afterwards his father married Jeanne d'Arbins. At the age of 12 Jean entered the religious school of d'Aire and in 1740, after finishing his studies and having shown a strong interest for sciences, he decided to study medicine at the Faculty of



Fig.1. Jean Darcet (1724-1801).
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Medicine in Bordeaux, against the wishes of his father who wanted him to study law and make a career in the judiciary system. As a result, his father disinherited him, with the acquiescence of his stepmother Jeanne d'Arbins who seemed keen in seeing the fortune go to her children. In order to survive in Bordeaux Jean started giving lessons of Latin and Greek to the children of the middle-class. Eventually, one of his young friends, Augustin Roux (1726-1776), a physician (who would afterwards become professor of chemistry at Faculty of Medicine) introduced him to Charles de Secondat Montesquieu (1689-1755), who took him to Paris in 1742, when he was just 18 years old, to tutor one of sons, Jean-Baptiste Secondat (1797-1871). While working in this position he helped Montesquieu gather the material for his masterpiece *L'Esprit des Lois* (1748).

In 1762 Darcet was awarded his medical degree and although on November 18, 1762 he was appointed docteur-régent (Note 1) at the Faculty of Medicine he never practiced medicine. His strong interest in science led him to attend the courses in chemistry given at the Jardin du Roi by Guillaume François Rouelle (1703-1770), the most famous pharmacist of his time.⁵ Rouelle influenced him in such a manner that not only they started working together

1. In order to be admitted to the Faculty of Medicine it was necessary first to obtain the *Maîtrise ès-Arts* (Master of Arts) of the Université de Paris, then at the Faculty, to obtain successively the degrees of *Bachelier* (bachelor), *Licencié*, *Docteur*, and finally *Docteur Régent* that gave the right to teach at the Faculty. To become a *Bachelier* it was necessary to pass a qualifying exam; followed by two years of study and the approval of four theses to obtain the degree of *Licencié*. Approval of the four theses led to the award of the degree of *Docteur*. The total fees for obtaining all these degrees were about 6 000 livres.

but also he spent the rest of his life studying chemistry. A major factor to his appointment to the Collège de France in 1774 was the fact that among all the physicians being considered, he was the only who had made chemistry his sole occupation.⁶

Darcet, little by little, specialized in the theoretical study of chemistry, looking for the application of theory to practice. His opportunity came with the count Louis de Lauraguais (1733-1824), a nobleman interested in chemistry and industrial entrepreneur. At that time all objects made of quality porcelain were imported from China and Japan; all French efforts to manufacture true porcelain (*porcelaine dure*) with local materials had failed completely. After the death of the duc d'Orleans, Montamy, his maître d'hôtel, approached Lauraguais with the claim that his laboratory had found a method for making true porcelain from raw materials found in France. Lauraguais became extremely interested in this possibility; he purchased the remaining material from Montamy together with several finished pieces and secured the help of Leguay, the artisan responsible. He then approached Rouelle to assist him engage a chemist to help in this project. Rouelle recommended Darcet. Darcet, together with his patron, Roux, and Leguay, studied more than 200 earths, minerals, and metallic oxides, until eventually he discovered the procedure for manufacturing true porcelain. The kaolin of St.-Yrieix was discovered in 1768 and Limoges surged ahead in 1772. At about the same time Darcet, who was already a consultant with authority in the chemical aspects and traveled to Sèvres several times a week, signed together with Macquer and Hilaire-Marin M. Rouelle (1718-1779), the brother of Guillaume, a certificate reporting that various pieces of pottery submitted for a privilege by a certain Brolliet were just a low-grade faïence.⁶

A year after Rouelle's death his widow carried out the wishes of her husband and as a testimony of their confidence in him in 1771 she offered to Darcet, then 41, to marry her

daughter Françoise Amélie. The bride was then 18 years and died in 1791 at the age of 38. They had four children, two boys (one of them died in infancy) and two girls. When Madame Rouelle also died, her aunt, a young sister of Madame Rouelle kept house for him and the three children.⁶

On December 1774 Darcet was appointed to the first chair of experimental chemistry at the Collège de France. His inaugural speech was symbolized by some drastic changes in the traditions of the Collège not only because he was allowed to give it in French instead of Latin but also without wearing the traditional robe. The authorization for lecturing in French was more one of public relations than factual, it was said that Latin did not have enough technical terms to express appropriately Darcet's scientific terms. In fact, Darcet's concepts were not that different from previous scientific lectures given at the Collège; in addition, he was very well versed in Latin and Greek, as seen by his early occupation as a tutor in both languages.

The creation of the chair of experimental chemistry at the Collège was accompanied by promises from the ministers Anne Robert Jacques Turgot (1727-1781) and Chrétien Guillaume de Malesherbes (1721-1794) to provide the space and equipment for a research laboratory. This turned out not to be the case, space for a laboratory was provided but not funds for the equipment and ancillaries. Darcet had to supply his own equipment, reagents, and fuel, which he paid from his salary (at that time 1 200 francs) and his own private resources. He did not have much difficulty in doing so because his wife brought him a substantial dowry, together with Rouelle's stock and apparatus. He was a hard working chemist, and it was a matter of pride to be teaching his science on the most advanced level at the Collège. In 1778 he assured the ministry that his demonstrations and experiments were as full as if he had been giving private lectures for subscribers.⁶

Darcet's chemistry course at the Collège followed more or less the

structure of the one given by Rouelle, in which the knowledge of chemistry was explained along the lines of the mineral, animal, and vegetable kingdoms. His auditorium was always full. In 1784 he took on an assistant, Jérôme Dizet (1764-1852), a nineteen-year-old pharmacist apprentice from his native region in Les Landes. Dizé prepared the demonstrations and experiments and performed the same service for the course in experimental physics, which Louis Lefèvre de Gineau (1751-1829) had begun teaching in 1786. Dizé was an extremely meticulous worker that relieved Darcet of most of the experimental duties related to the course. Darcet taught for 27 years at the Collège de France; he became known as a remarkable teacher, by the content of the courses he taught, the clarity of exposition, and the logic of his reasoning.

Recognition by the Académie de Sciences came late to Darcet. On April 4, 1784, at the age of fifty-nine, he was appointed *associé chimiste supernuméraire* to the Académie de Sciences in replacement of Pierre-Joseph Macquer (1718-1784), and remained a member until its suppression in 1784. The supernumeraries were scientists of prestige, nominated by the King without previous presentation to the Académie and destined to become *titulaires* (Note 2). In 1785 the government created the Institute de France and Darcet was among the first members of the institution.

After the occupation of Hanover during the Seven Year war (1756-1763), Darcet had the opportunity of studying the local copper and iron mines, as well as the local metallurgical industry. Darcet first major work was a long series of experiments on the action of strong heat on minerals. The most significant memories he published on the subject were two *Mémoires Sur l'Action de Feu Dans un Grand Nombre de Terres*, published in 1766 and 1771.^{7,8} His results, read to the Academy in 1766 and 1768, represented an extension and improvement of the work of Johann Heinrich Pott (1692-1777), who In 1746 had found that clay earths and stones, although not fusing when heated alone, did so when

2. In 1785 the Académie was reorganized, the adjoint category was eliminated, and eight classes were created: geometry, astronomy, general physics, anatomy, chemistry and metallurgy, botany and agriculture, natural history, and mineralogy. Each class had six members, and three pensionnaires; in addition, twelve free associates and eight foreign associates. The *surméraires* were eliminated and the adjoint geographer became the associate geographer.

heated under the proper proportions with calcareous earths and stones.⁹ Darcet's findings helped to clarify the ideas about the classification of minerals and eventually they also led to the improved production of true or hard porcelain in France. These memoirs were followed by reports on the action of heat on the diamond and other precious stones⁸, in which he demonstrated the complete destructibility of the diamond when it was heated in air and distinguished it from other precious stones, such as rubies and emeralds (see below). He occupied himself with metallurgy and coins; discovered the fusible alloy (*alliage fusible*, a mixture of tin and bismuth, Darcet's alloy) (see below), melting at the temperature of boiling water and in 1775 found a use for it in the production of stereotype plates; by 1860 Darcet's alloy was also employed in the valves of steam engines.

In 1783 he read a memoir on the action of heat on calcareous earth (calcium carbonate) where he proved that the ability of this material to scavenge other earths and minerals during the fusion of glass was due to its alkaline nature.¹⁰

Darcet's work on the geology of the Pyrenees and his researches on the action of strong heat on calcareous earth indicate that his interest in mineral and their analysis dominated his work throughout his career. Nevertheless, he did work and contributed in several other fields, as illustrated by the application of nascent electricity to the cure of nervous ailments¹¹, the possibility of preparing gelatine from the nutritive matter in bones, translating into French of the work on viper venom by Felix Fontana (1730-1805), as well as annotating Joseph-Louis Lagrange's (1736-1813) translation of Seneca's *Questions Naturelles*. Darcet was also called by the Duc d'Orleans as a referee of Nicolas Le Blanc's (1742-1806) proposal for converting common salt into soda, or mineral alkali. Darcet was extremely busy at that time and turned the matter over to Dizé. When Dizé's first attempts to reproduce Le Blanc's results failed, the latter requested that the initial report be delayed and that Dizé continue working with him in order to find and overcome the source of the difficulty. Dizé agreed, with the concurrence of Darcet, and thus did the development of the Leblanc process begin in the laboratory of the Collège de France.¹²

His wide experience in industrial activities led to his being picked by the government to participate in the direction of several manufacturing activities of the state. For example, Darcet occupied several important positions at the Manufacture Royale de Sèvres. First he became inspector of colors, then one of the representatives (*commissaire*) of the Académie in the directing body, replacing Étienne Mignot de Montigny (1714-1782) who had recently died; and in 1784 he became Directeur of the factory, replacing Macquer. According to Gillespie⁶ there is no evidence on the reasons why the comte Charles Claude d'Angiviller (1730-1809) selected Darcet instead of Fourcroy to succeed Macquer. During his tenure at Sèvres Darcet perfected the different manufacturing procedures and demonstrated the identity between the scarlet dye obtained from the wild cochineal of Santo Domingo with the one obtained from the Mexican variety. After the death of Mathieu (1714-1791), general inspector of coin assay, Darcet was promoted from adjoint to Director of the Mint.

His many academic and industrial activities made Darcet very rich; he devoted part of his patrimony to different philanthropic activities, particularly for hospitals.

In 1789, at a time when only the esteem determined the right to vote, he was selected as Elector for the city of Paris. After Maximilien Robespierre (1758-1794) took the government, he wanted Darcet be put in the list of suspects because of his close relation with the Duke of Orleans (the Duke was tried and beheaded on November 6, 1793), who had financed part of his researches. Darcet was put in the list of those to be guillotined, but was saved by the intervention of Antoine-François Fourcroy (1750-1809) who explained to Robespierre the true nature of his relation to the Duke, indicating not only that it antedated the Revolution, but also the importance of Darcet's scientific discoveries to France and science. Darcet, after this incident, hid for some time with his family at Prouilh.

At the end of 1800, the Constitution of the year VIII, through its four assemblies, created the Senate, to which Bonaparte incorporated all the illustrious of France. Darcet was one of the first Senators and put his intelligence and talent to the service of the country. He was part of the Committee that examined and condemned Louis XVI, as well as Franz

Anton Mesmer (1734-1815) and his magnetic fluid (the cures achieved were explained by reasons different from animal magnetism). During the last few years of his life Darcet did little original work, but he served on a number of government commissions and contributed several reports for the Academy.

The many intrigues going on at that time in France led the Convention to charge Darcet with the macabre accusation of manufacturing cups of gelatine using the bones of Jean-Baptiste Molière (1622-1673), Blaise Pascal (1623-1662), Hélioise (1101-1164) and Abélard (1079-1142), etc. Another rumour said that he had used the bones for preparing the calcium phosphate required for manufacturing a porcelain cup at Sèvres, on which he and friends had drank patriotically to the Republic. He was again condemned to the guillotine but managed to escape the night before he was to be decapitated.

Darcet died on February 12, 1801, at the age of seventy-five, during violent intestinal spasms, probably caused by a gout metastasis. Georges Cuvier (1769-1832) pronounced the *Éloge Funèbre*.¹

HONORS AND POSITIONS

Darcet received many honors for his contributions to science, industry, and the Nation. He was a member of the Lycée des Arts and one of its founders, Professor of chemistry at the Collège de France, member of the Académie des Sciences, honorary member of the Collège de Pharmacie, member of the senate; member of the Société Royale d'Agriculture, Inspector General of Assays of Coins, and Inspector of the Manufactures Nationales de Sèvres et des Gobelins.

Scientific contribution

Some of the most important contributions of Darcet will now be described with more detail.

1. Hard porcelain^{7,8,13}

Darcet and his patron, the count of Lauranguais, studied more than two hundred soils, minerals, and metal oxides and eventually were able to determine the constituents and proportions of the materials needed for the manufacture of true porcelain (*porcelaine dure*). Under the direction of Darcet the manufacture of porcelain at Sèvres achieved numerous improvements. The changes he made in the composition of the paste allowed the manufacture

and burning of large vases made of one piece, which could not be burned before but only divided into five or six related pieces. The delicate coating of porcelain was changed and made more beautiful; he conceived a fumigation process that was afterwards applied in the muffles of the painting ovens in order to give the colors on porcelain an iridescent appearance, as well as having more variegated shades; he also developed some important improvements on the porcelain ovens themselves. He participated in the detection and exploitation of the St. Yrieix kaolin deposits in 1768 and thus the manufacturing enterprise at Limoges came up in 1772.

Darcet's results at Sèvres were so significant that it was said that "*les Saxons avoient bien le secret de leur belle porcelaine, mais qu'ils ne connoissoient pas l'art de faire la porcelaine*" (the Saxons have the secret of their beautiful porcelain, but do not know the art of making porcelain).¹

2. Geology of the Pyrenees

Darcet was very fond of hiking in the Pyrenees alone and with his colleagues, and inspecting the different geological features. Interestingly enough, the result of his observations was the subject of his inaugural address when appointed to the chair of experimental chemistry at the Collège de France (*Discours en Forme de Dissertation sur l'État Actuel des Montagnes des Pyrénées et les Causes de leur Dégradation*).¹⁴ In the opening statements he referred in general to the modifications caused by erosion to the surface of the globe, and then its application to the Pyrenean chain, particularly the valleys on the French side. He described in general terms the great catastrophes and destructions that had afflicted the Pyrenees in the past and examined in detail their present state and composition. In his opinion these valleys had been created by water, as could be seen from the lateral layers that built its slopes. He described the geology of the Barèges valley with its rising soil, the original rock born at its summit, and the possibility that the Iray Peak at Saint-Jean-Pied-de-Port was made of eroded stones by the simple action of rock disintegration by the climate. In the same terms he described the geological features of the summit of Pic du Midi. The rolling rocks located all over the Aquitain basin originated from the

degradation of the Pyrenean, and the agents of the phenomenon were first water, then avalanches, the melting of snow, and infiltrations. Of course there were usual possibilities such as earthquakes, alternation of dry and wet years, gel, and vegetation. Darcet then posed a series of questions: The summits, where the rocks are nude, where they covered with slime before erosion took place? Was the Aquitain basin a sea sometime, as indicated by the presence of sedimentary layers? Had the Pyrenean in ancient times be a uniform bank, which afterwards slit all around? Finally, the fact that this mountain chain did not have a volcano, like the Andes Mountains, seemed to indicate a very old existence.

Darcet and his friend, Gaspar Monge (1746-1818), a professor of physics at Mézieres, used their vacations to make barometric and temperature measurements in the Pyrenean. Darcet raised afterwards the question that if it was certain that the air became rarified with height, or was the reason simply the changes in air density caused by the oscillations of the barometer? Since Darcet felt that at the top of the mountain he could breath easily, he could not square this fact with the claim that at higher heights air became rarified. He believed that those who had reached higher heights had become dizzy and bleedy simply because they had become very tired. Darcet thought air was a fluid like water, having essentially a constant density.

3. The burning of diamond controversy^{15,16}

It was generally believed that diamond was indestructible under the action of high heat, Robert Boyle (1627-1691) was the first to study with some precision the action of fire on diamond and Isaac Newton (1642-1727) had predicted that diamond could be burned and had thus classified it in the class of combustible substances. In his book *Opticks*¹⁷ Newton, after presenting a table of the values of the ratio between the refractive power and the density for twenty-two substances (diamond had the largest value, 14,556) wrote: "*all Bodies seem to have their refractive Power proportional to their Densities...it seems rational to attribute the refractive Power of all bodies chiefly, if not wholly, to the Sulphureous Part with which they abound. And as Light congregated by a Burning glass acts upon Sulfure-*

ous Bodies to turn them into Fire and Flame..." Hence, according to Newton, diamond was highly combustible.

Between 1694 and 1695 Jean-Gaston de Médicis, Grand Duc of Tuscany (Cosmo III), had seen in Florence diamonds destroyed by a burning mirror during an investigation he had commissioned from Giuseppe Averani (1662-1738) and Giovanni Targioni (1712-1783) to pursue further Boyle's experiments. Similarly, François Etienne de Lorraine (who afterwards became Grand Duc of Tuscany and then the emperor François I) had spent a fortune commissioning different examinations trying to burn diamonds and rubies.¹⁶ Up to Darcet's time it was believed that the actual result was just a simple evaporation, without the intervention of air. Many scientists found these results difficult to believe until Darcet published the results of his work on the action of strong heat on materials.^{7,8} Darcet showed that diamond was combustible when heated in the presence of air in a simple muffle and at a temperature inferior that needed to melt gold; diamonds did not withstand long heating in a furnace, even when surrounded by a thick porcelain paste. Darcet memoir convinced most chemists that diamonds could be destroyed by heat, but many jewellers and diamond merchants were unable to accept these results, for, from very early times, they have been accustomed to remove or diminish flaws from diamonds by exposing them to a strong heat for some time. As told by Macquer¹⁶ Le Blanc, a well-known Parisian jeweller, offered to provide a diamond, to prepare it in its usual manner, and to submit it to Darcet and Rouelle's tests. They surrounded the stone with a paste of chalk and charcoal and placed it in a crucible surrounded by sand (this was the procedure used by diamond jewellers to treat the stone). After three hours heating the diamond was found to have vanished completely. This fact suggested (again) that its destruction was due to the volatilization rather than to combustion or burning or decrepitating into fragments too small to be observed.¹⁸

In July 1771, Godefroide Villethaneuse and Macquer heated a diamond (to a temperature not higher than to turn copper red) in a crucible in Macquer's furnace, in the presence of Darcet, Rouelle, and others. After 20 min heating the crucible was opened and the observers no-

ticed that the diamond appeared to be enveloped in a small pale phosphorescent flame. They repeated the procedure for another half hour with the same stone and on opening the furnace found that the diamond had been completely destroyed.¹⁶ An account to the experiments was read to the Academy the following day. Further experiments were made later by Rouelle and Darcet.¹⁹

Stanislas Marie Maillard, despite the failure of Le Blanc's experiment, offered three diamonds for experiment, which he surrounded very carefully with charcoal and sand, and this time, after two hours of heating, the diamond was found to be unchanged. This result was quite unexpected by Macquer, who concluded from it, and from the flame that he had seen before on the surface of a red-hot diamond, that diamonds were combustible and, like other bodies, required air for their combustion. Subsequently Maillard allowed Macquer to repeat the experiment in the furnace of the factory at Sèvres, with a diamond he had packed as before, to prevent contact with air. Again, the stone was unharmed by the fire.¹⁶

Antoine-Laurent Lavoisier (1743-1794), who had witnessed some of the preceding experiments and found them quite relevant to the work he was doing on the causes and agents of combustion, invited Louis-Claude Cadet de Gassicourt (1731-1799) and Macquer to assist him in performing more experimental work. Their experimental set up was now provided with the necessary ancillaries to permit collection of the possible gases released, either by distillation or by sublimation in the cooler parts of the apparatus. They were, however, unable to detect any product.²⁰ When the diamond was burnt in a closed vessel by means of the glass in the apparatus designed by Lavoisier, it was found that a part of the air in the vessel was used up as was the case with other combustible bodies, and when lime was subsequently added it turned milky and deposited a precipitate.²¹ When a dia-

mond was subjected to the heat from the Academy's large burning-glass,²² it decrepitated and split into tiny fragments, but this did not happen if the heat was applied gradually, when the diamond slowly disappeared without giving off any smell or visible fumes.

Sometime later Louis-Bernard Guyton de Morveau (1737-1816) accomplished the combustion of diamond in the presence of oxygen and suggested that it was made of pure carbon. Additional experiences with strong heat led Darcet to prove that rubies, sapphire, emerald, topaz, although having similar properties to diamond had a completely different nature.²³

4. Soap manufacture

Darcet tried to obtain soda from marine salt, and manufactured soap from all types of oils and fats. By the end of the eighteenth century, the only comprehensive account of soap making then extant was the almost 100 page long "Rapport sur la Fabrication des Savons" published in 1797 by Jean Darcet (1725-1801), Claude-Hugo Lelièvre (1752-1835), and Bertrand Pelletier (1761-1797).²⁴ The Committee of Public Safety of the National Convention charged the three with "de faire des expériences sur l'union de différentes espèces d'huiles et de graisses avec la soude, de faire connoître au comité les savons qui résultent de ces combinaisons, leur nature, leur qualité, etc." (charged with the task of performing experiments on the union of different kinds of oils and fats with soda in order make known to the committee the soaps that resulted from the combinations, their nature, their quality, etc.). The first part of the report described the sources, methods of preparation, and characteristics of the raw materials required (sodium hydroxide, potassium hydroxide, calcium hydroxide, and oils), as well as the equipment necessary for the different operations. This was followed by procedures for the preparation of soda and causticized lye, the appa-

ratus for preparing the lye and for soap boiling operation; the characteristics of the resulting soaps, and the instruments used for measuring the strength of the lye. They also made a comparison of the soaps obtained from different oils and classified the oils in the following order of decreasing fitness for soap: (1) olive and sweet almond oils; (2) tallow, lard, rancid butter, and horse oil, (3) rapeseed oil, (4) beechnut and poppyseed oils, (5) walnut and linseed oils, (6) hempseed oil, and (7) fish oils.

Darcet, Lelièvre, and Pelletier also studied the methods for making hard soaps from potash soaps by the addition of salt solution to the soft soap and boiling the mixture for several hours. They also considered the methods for making fraudulent soaps, particularly by the addition of water, salt, alum, starch, chalk, and lard. According to them, the only way of identifying the adulterants was by analysis.

The final part of the report was a set of instructions for those who wanted to make soap by themselves.

5. Alloys^{25,26}

During his work on fusible alloys Darcet developed (1775) an alloy made of three part of tin, eight of bismuth, and five of lead that was liquid at the temperature of boiling water and latter found use in the production of stereotype plates (Note 3).²⁵ Further work on alloys, some in collaboration with Bertrand Pelletier (1761-1797), his assistant and *demonstrateur* at the Collège de France, enabled Darcet to develop a method of separating the copper from church bells and show how these could be melted down to cast cannon. In order to try to solve the monetary deficit, the Assemblée Nationale Constituante decreed in 1789 that all the ecclesiastical property should be put at the disposition of the Nation; as a consequence many churches fell in disuse and a large number of bells came into the market and with them the interest in the large quantity of copper available in the form of bell metal, an al-

3. The name fusible metals is now applied to a variety of alloys, usually composed of bismuth, lead, and tin, which possess the property of melting at comparatively low temperatures, (between 91 to 95 °C). Variation of the proportion of the components can also lead to melting temperatures above that of boiling water. The addition of cadmium or mercury reduces the melting point further. Fusible metals have the additional property of expanding as they cool, for this reason they may be used for taking casts of anatomical specimens or making clichés from wood blocks. High melting fusible metals are used for making the fusible plugs inserted in the crown of steam boilers, as a safeguard in the event of the water level falling too low. In automatic fire sprinklers the orifices of the pipes are closed with fusible metal, which melts and liberates the water when the temperature in the room rises about a predetermined limit.

loy containing 20 to 25 % of tin. Several possibilities were considered for their use: to sell them as such, to separate the components, or to alloy them with a certain amount of copper in order to make them ductile enough so that they could be used to manufacture cannons, coins, or statues. Darcet in collaboration with Pelletier, and Fourcroy made the most important contributions to the subject.²⁶ Darcet and Pelletier's method was based on the oxidation of the bell alloy with manganese oxide, which attacked the tin before the copper and gave a good yield. Fourcroy's approach²⁷ was in two different directions, based on the variable affinity that oxygen has for metals. In one of them, the bell metal was heated in a crucible in the presence of air until the increase in weight showed that sufficient oxygen had been absorbed to convert all the tin into oxide, followed by heating the molten metal in a closed crucible, avoiding the possibility of further absorption of oxygen. During this second heating stage the copper oxide was reduced by the unreacted tin and at the end of the reaction all the tin was oxidized and could be separated from the molten copper. Fourcroy's second approach was based on the oxidation of the tin by heating the alloy with certain metallic oxides; he achieved good separation with black oxide of manganese but litharge and oxide of arsenic were found to be unsatisfactory.

As a result, in 1793, when large quantities of copper were urgently needed for manufacturing cannon, the Committee of Public Safety decreed the destruction of all church bells. Instructions describing both Pelletier's and Fourcroy's methods were published in detail and both were recommended. Fourcroy's procedure proved to be cheaper, although both helped provide copper to the revolutionary government during the many wars it held during its existence.

6. Miscellaneous

The logical reform of the chemical language proposed by Lavoisier, Fourcroy, Berthollet, and Guyton de Morveau, did not gain a complete approval of the referees appointed by the Académie des Sciences in 1787, Antoine Baumé (1728-1804), Louis-Claude Cadet de Gassicourt (1731-1799), Darcet, and Balthazar-Georges Sage (1740-1824). The three were supporters of the phlogiston theory and hence they

recommended: "Nous pensons qu'il faut soumettre cette théorie nouvelle (la chimie pneumatique) ainsi que sa nomenclature, à l'épreuve du temps, au dire des expériences, au balancement des opinions qui en est la suivre; enfin au jugement du public comme au seul tribunal d'où elles doivent et puissent ressortir. Alors ce ne sera plus une théorie, cela deviendra un enchaînement de vérités, ou une erreur. Dans le premier cas, elle donnera une base solide de plus aux connaissances humaines, dans le second, elle rentrera dans l'oubli avec toutes les théories et les systèmes de physique qui l'ont précédé" (We believe necessary to subject this new theory, as well as its nomenclature, to the test of time, to the experiments, to the doubts it has raised, in short, to the judgment of the public as the only tribunal. Then it will not be a theory; it will become a chain of facts or an error. In the first case it will provide a solid base for solid human knowledge; in the second case, it will go into oblivion with all other theories and systems that have preceded it).

BIBLIOGRAPHY

1. Cuvier G., Notice Historique Sur Jean Darcet, *Mémoires de l'Institut*, 4, 74-88, 1801.
2. Cuvier G., Éloge Historique de Jean Darcet, *Recueil des Éloges Historiques*, I, 165-185, 1819.
3. Coleby L.J.M. *The Chemical Studies of P. J. Macquer*, George Allen & Unwin, London, 1938.
4. Cuzacq R. *Le Chimiste Jean Darcet et sa Famille*, Editions Jean-Lacoste, Mont-de-Marsan, 1955.
5. Wisniak J. Guillaume-François Rouelle, *Educ. Quim.*, submitted (2004).
6. Gillispie C.C. *Science and Polity in France at the End of the Old Regime*, Princeton University Press: Princeton, 1980.
7. Darcet J. Mémoire sur la Action d'un Feu Égal, Violent et Continué Pendant Plusieurs Jours, sur un Grand Nombre de Terres, de Pierres et de Chaux Métalliques, *Hist. Acad. Royale de Sciences*, 75, 1766; also published as a book (P. G. Cavelier, Paris, 1766).
8. Darcet J. Second Mémoire sur la Action d'un Feu Égal, Violent et Continué Pendant Plusieurs Jours, sur un Grand Nombre de Terres, de Pierres et de Chaux Métalliques, *Hist. Acad. Royale de Sciences*, 1771.
9. Pott J.H. *Fortsetzung Derer Chymischen Untersuchungen Welche von der Lithogegnosie, Oder Erkenntniss und Bearbeitung derer Steine und Erden Specieller Handeln*, Christian Friedrich Voss, Potsdam, 1746.
10. Darcet J. Mémoire sur la Calcination de la Pierre Calcaire et sur sa Vitrification, Paris, 1783.
11. Darcet J. *Rapport sur l'Électricité Dans les Maladies Nerveuses*, Paris, 1785.
12. Lelièvre C.H., Darcet J., Giroud A. *Rapport sur les Divers Moyens d'Extraire Avec Avantage le Sel de Soude du Sel Marin*, De l'Imprimerie du Comité de Salut Public, Paris, 1795. Published also in *Ann. Chim.*, 19 (1797) 58-156.
13. Fourcroy A., Darcet J., Guyton de Morveau L.B. *Rapport Sur les Couleurs Pour la Porcelaine*, De l'Imprimerie du Comité de Salut Public, Paris, 1779.
14. Darcet J. L'État Actuel des Montagnes des Pyrénées et les Causes de leur Dégradation, *J. Phys.*, 8, 403-425, 1776.
15. Darcet J. Mémoire sur le Diamant et Quelques Autres Pierres Précieuses, *Hist. Acad. Royale de Sciences*, 1771.
16. Macquer P.J. *Dictionnaire de Chymie*, Lacombe, Paris; Vol. 1, 499-524, 1766.
17. Newton I. *Opticks*, London, 1730. Republished by Dover Publications, New York, 1952; Book II, Proposition X.
18. Rouelle G.F., Darcet J. Procès-verbal des Expériences Faites Dans le Laboratoire de M. Rouelle, Sur Plusieurs Diamans & Pierres, Paris, 1772.
19. Rouelle G.F., Darcet J. Expériences Nouvelles sur la Destruction du Diamant, *Hist. Acad. Royale de Sciences*, 1773.
20. Lavoisier A.L. Premier Mémoire Sur la Destruction du Diamant Par le Feu, *Mém. Acad. Royale Sci.*, Part II, 564-591, 1772.
21. Lavoisier, A. L., Second Mémoire Sur la Destruction du Diamant Par le Feu, *Mém. Acad. Royale Sci.*, Part II, 591-616, 1772.
22. De Montigny T., Macquer P.J., Cadet L.C., Lavoisier A.J. Premier Essai du Grand Verre Ardent de Mr. Trudaine Établi au Jardin de l'Infante au Commencement du Mois d'Octobre de l'Année 1774, *Mém. Acad. Royale Sci.*, 62-72, 1774.
23. Dizé M. J.J. *Précis Historique Sur la Vie et les Travaux de Jean Darcet*, Gillé, Paris, 1801.
24. Darcet J., Lelièvre C.H., Pelletier B. Rapport sur la Fabrication des Savons, sur leurs Différentes Espèces, Suivant la Nature des Huiles et des Alkalis qu'on Employe Pour les Fabriquer; et sur les Moyens d'en Préparer Par-Tout, Avec les Diverses Matières Huileuses et Alkalines, *Ann. Chim.*, 19, 253-354, 1797.
25. Darcet J. Expériences sur l'Alliage Fusible de Plomb, de Bismuth et d'Étain, *Hist. Acad. Royale de Sciences*, 1775.
26. Pelletier B., Darcet J. *Instruction sur l'Art de Séparer le Cuivre du Métal des Cloches*. Publié par Ordre du Comité de Salut Public, De l'Imprimerie du Comité de Salut Public, Paris, 1794.
27. Fourcroy A.F. Recherches Sur le Métal des Cloches, et Sur les Moyens d'en Séparer le Cuivre, *Ann. Chim.*, 9, 305-352, 1791.