Platinum in the Decoration of Porcelain and Pottery

By L. B. Hunt
Johnson Matthey & Co Limited

The early researches on platinum carried out by a number of distinguished European chemists were virtually contemporary with the first scientific studies of porcelain and its decoration. The author traces the sequence of these investigations leading to the application of platinum to provide a brilliant and permanent metallic lustre to porcelain and later to the less expensive earthenware.

The desire for metallic decoration to supplement the use of enamel colours can be discerned from the earliest days of European porcelain manufacture. By about 1720 Johann Friedrich Böttger, who had successfully produced porcelain at Meissen some ten years earlier, had developed a range of colours and had also established a technique for the firing on of both gold and silver to give a richly decorative effect. But to be suitable for use on porcelain a metal must obviously be able both to withstand the high temperatures of the decorating kiln and thereafter to retain its metallic lustre indefinitely. This was of course impossible to achieve with silver, which rapidly tarnished to a blackish appearance, and the application of a white metallic form of decoration had to wait upon the discovery of platinum and the elucidation of its physical and chemical properties.

It was not until 1750 that anything was known of the first specimens of native platinum, secured from the Spanish Americas and examined by Charles Wood, who reported his findings to his brother-in-law William Brownrigg. The latter passed on the report to William Watson, who in turn presented it to the Royal Society and a few weeks later wrote a short account to Professor G. M. Bose of Wittemberg which was immediately published in Germany. These two communications aroused the greatest interest among the leading chemists in Europe, and a number of them at once set about investigating this exciting new metal. While the Spanish government had prohibited its export to Europe, they were none the less willing to provide interested scientists with modest amounts free of charge, and in this way small quantities reached Stockholm and London, where first Scheffer at the Swedish Mint and a little later, and more comprehensively, Dr. William Lewis carried out a number of experiments. By 1754 Lewis had obtained further supplies from the Spanish ambassador in London, and some portion of this was given to Professor Leonhard Euler in Berlin. The leading French chemists entered the field only a few years later, but it is to the Berlin of Frederick the Great that we have to look for the sequence of events that led to the adoption of platinum in ceramic decoration.

The Berlin Academy of Sciences

Soon after his accession to the throne of Prussia in 1740 Frederick, among many other activities, revived the declining Royal Prussian Academy of Sciences that had been founded in 1700 by his grandfather Frederick I, on the persuasion of Leibnitz, to emulate the Royal Society of London and the French Academy of Sciences. To this end he invited to Berlin both Euler, the Swiss mathematician, and later Pierre Louis Maupertuis from the

Platinum was first used in the decoration of porcelain in the Royal Berlin Porcelain factory owned by Frederick the Great. This statuette of Castor, part of the J. C. Joicey Bequest in the Victoria and Albert Museum in London, and dated by the Museum to about 1785, still shows the brilliant whiteness of burnished platinum in the breastplate and on parts of the helmet

French Academy. One of Euler's assistants was Andreas Siegfried Marggraf, who had studied medicine at Halle and then metallurgy at Freiberg, and who was given charge of the chemical laboratory in the Berlin Academy in 1753, and it was to Marggraf that the sample quantity of platinum was given. Among his findings, reported to the Academy in 1757, he established that platinum could be dissolved in aqua regia, that sal-ammoniac would then yield a precipitate in the form of a red powder (as Lewis had also found earlier) and, for the first time, that this precipitate when heated reverted to metal. Marggraf was thus the first to isolate metallic platinum from its mineral, although unknown to him his product contained small amounts of the other five platinum group metals (1).

Marggraf succeeded Euler as director of the physics and chemistry sections of the Berlin Academy in 1760, but before this Pierre-Joseph Macquer, the eminent French chemist who in addition to his duties as Professor of Chemistry at the Jardin du Roi had succeeded Jean Hellot at the Sèvres porcelain factory in 1757 (and spent ten years of research to perfect their hard paste porcelain as well as working on enamel colours), assisted by Antoine Baume, had also worked on a sample of platinum obtained from Spain and confirmed, before Marggraf's work had been published, both its solubility in aqua regia and its precipitation by sal-ammoniac. Their attempts to melt the metal in one of the furnaces at Sèvres, even after fifty hours, were unsuccessful.

Major events of a very different kind were taking place in Europe at this time. Frederick the Great, the ambitious and aggressive ally of Pitt in the Seven Years' War against the combined forces of France, Austria and Russia—and the famous "King of Prussia" whose name appears on so many inn signs in England and even on a few in America—had struck at Saxony in 1756 and occupied Dresden and the porcelain factory, that had been established at Meissen by Augustus II, King of Poland and Elector of Saxony, in 1710. (Since his accession to the throne in 1740 he had hoped to become the second royal personage in Europe to have his own porcelain works, and he had prevailed upon the chemist Johann Heidrich Pott who had been a member of the Academy since 1720, to carry out a

lengthy series of high temperature experiments—no less than 30,000 of them—in an unsuccessful attempt to match Meissen porcelain, but when Marggraf was appointed over his head in 1754, Pott abandoned his researches and resigned from the Academy.)

Frederick suffered severe defeats in the following two years and was forced to retire from Dresden until his military genius enabled him to regain the lost territory in 1762. But when peace came later that year he removed from Meissen the moulds and models, together with some of the leading workers, to the Berlin Porcelain Works. This had been established, with Frederick's encouragement, in 1751, had closed in 1757, but had been re-established in 1761. On his return to Berlin, Frederick purchased the enterprise, which then became known as the Royal Porcelain Factory. Frederick had a great love of French art and literature—he habitually spoke and wrote French and he had Voltaire as a guest at his court for three years—and it is easy to imagine his keenness to acquire and expand the factory as a snub to two of his defeated enemies, Louis XV whom he hated, and Madame Pompadour whom he despised, the two patrons of the Sèvres factory—set up originally at Vincennes in 1738—who for many years had themselves envied, and endeavoured to emulate, the products of Meissen. Frederick could at last boast of his own source of high-class porcelain.

To return to the chemistry and metallurgy of platinum, a curious lull of nearly twenty years followed upon the rather intense activity of the 1750's, partly because supplies were difficult to obtain, and partly because of the great difficulties encountered in the attempts to render the metal malleable. One of the earliest successes in this latter direction again centred upon the Berlin Academy. Marggraf had died in 1782 and had been succeeded as director of the physics section and the chemical laboratory by his pupil and friend Franz Karl Achard. A little before this Achard, acting upon an earlier suggestion of the Swedish chemist Scheffer, had shown that the addition of arsenic to platinum caused it to melt at a low temperature and that the arsenic could subsequently be removed by volatilisation. A malleable ingot could then be produced and worked into sheet or wire, and by 1784 Achard reported the possibility of making

> "all kinds of vessels and especially fusion crucible which can be useful in certain operations"

This development was followed up in Paris by the King's goldsmith Marc Etienne Janety, who by 1786 was successful in producing both crucibles and articles of jewellery, but it was only a little later that the first application of platinum in the decoration of porcelain was achieved, again in Berlin.

Klaproth's Experiments with Platinum Decoration

In the winter of 1788–89 a paper "On the Use of Platina in the Decoration of Porcelain" was read to the Berlin Academy by Martin Heinrich Klaproth (2), the most distinguished German chemist and the leading analyst and mineralogist of his time. Beginning as a poor apothecary, he had later studied under Marggraf and in 1780 had married his wealthy niece, so being able to buy himself a laboratory, and from here there poured out analyses of hundreds of minerals as well as many papers to the Academy. His analytical skill and accuracy led him to the discovery of uranium and to the establishment of the identity of zirconium, tellurium and strontium, although he was not the first to isolate these metals. His activities did not end here, however, and for some years he was retained as a consultant to the Royal Berlin Porcelain Factory. No records of his work here survive, but in 1786 he is known to have tried unsuccessfully to melt a sample of Cornish tungsten mineral in the porcelain furnace (3), while Alexander von Humboldt records working with him in the factory in 1792 (4).

Klaproth had not been among the numerous chemists who had worked on platinum, but he was obviously thoroughly familiar with the

progress that had so far been made. After a summary of what was then known and a reference to the work of "my worthy colleague M. Achard" Klaproth wrote

> "How far platina may be employed in porcelain painting has never yet, as far as I know, been examined: I therefore thought it of considerable importance to make some experiments on this subject, which did not deceive my expectation; but on the contrary, convinced me that this object, in the hands of an ingenious artist, may be brought to perfection"

Klaproth exhibited to the meeting a number of samples of porcelain made in the Berlin factory and ornamented with platinum. He described his "simple and easy" process as follows:

> "I dissolve crude platina in aqua regia, and precipitate it by a saturated solution of sal ammoniac in water. The red crystalline precipitate thence produced is dried, and being reduced to a very fine powder is slowly brought to a red heat in a glass retort. As the volatile neutral salt, combined with the platina in this precipitate, becomes sublimated, the metallic part remains behind in the form of a gray soft powder. This powder is then subjected to the same process as gold; that is to say, it is mixed with a small quantity of the same flux as that used for gold, and being ground with oil of spike is applied with a brush to the porcelain; after which it is burnt-in under the muffle of an enameller's furnace, and then polished with a burnishing tool.
>
> The colour of platina burnt into porcelain in this manner is a silver white, inclining a little to a steel gray. If the platina be mixed in different proportions with gold, different shades of colour may be obtained; the gradations of which may be numbered from the white colour of unmixed platina to the yellow colour of gold. Platina is capable of receiving a considerable addition of gold before the transition from the white colour to yellow is perceptible."

In addition to this method of application, which would have given a reasonably thick deposit of platinum suitable for burnishing, Klaproth described a further technique:

> "Besides this method of burning-in platina in substance on porcelain, it may be employed also in its dissolved state; in which case it gives a different result both in its colour and splendour. The solution of it in aqua regia is evaporated, and the thickened residuum is then applied several times in succession to the porcelain. The metallic matter thus penetrates into the substance of the porcelain itself, and forms a metallic mirror of the colour and splendour of polished steel."

By modern standards this latter process is of course quite ineffective, but it must be remembered that the platinum available to Klaproth was highly impure, containing all the other platinum group metals—palladium, rhodium, iridium, osmium and ruthenium—as well as some gold and appreciable proportions of base metals such as iron and copper, and that the presence of these impurities would undoubtedly have been beneficial in securing adhesion to the ware and, after

Martin Heinrich Klaproth
1743–1817

The greatest German chemist of his time, Klaproth also took an active interest in technology and served for some years as a consultant to the Berlin Porcelain factory. In 1788 he presented a paper to the Berlin Academy of Sciences describing his experiments on the use of platinum for the decoration of porcelain and displaying a number of specimens. His reputation as a chemist was so great that when the University of Berlin was founded in 1810 (Napoleon having closed down the much older university at Halle) Klaproth was appointed Professor of Chemistry although he was 67 years old

From a copper plate engraving by E. S. Henne in the German National Museum in Nürnberg

several applications, the formation of a continuous film. At all events the Berlin figurine of Castor illustrated on page 139 clearly shows that in Klaproth's hands a highly successful result was obtained, probably after a great deal of experimentation.

One of the Earliest Applications of Platinum

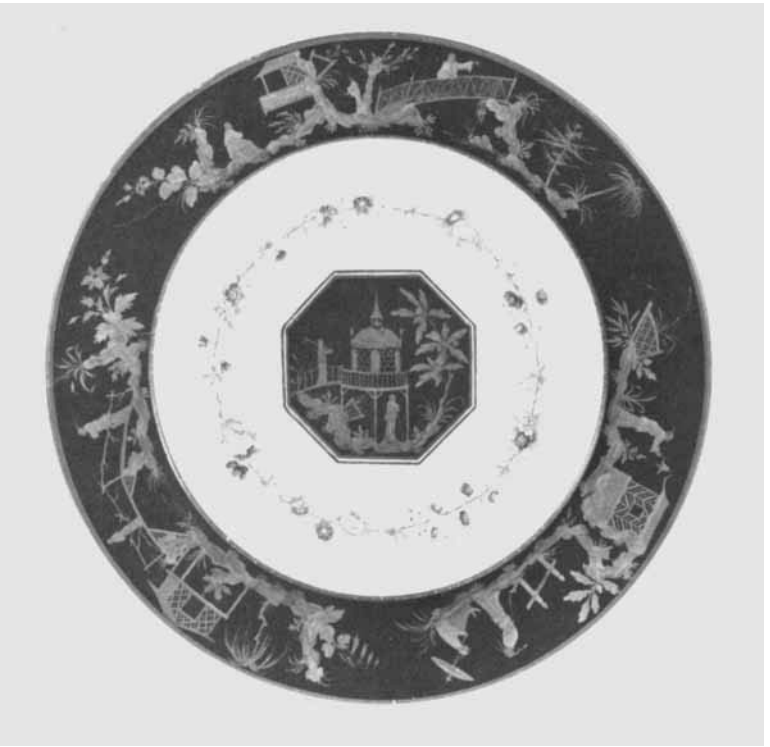
Thus by as early as 1788 the advantages of platinum as a decorative medium had been established, and at least a few samples had been prepared in the Berlin factory. This application therefore ranks as one of the very earliest in the long history of the uses of platinum in manufacturing industry.

There is, however, a curious gap in the further disemmination of this technique in the literature. The reference to Klaproth's work commonly quoted is to a reproduction in 1802 in the *Allgemeine Journal der Chemie* (5), founded and edited by Alexander Nicholas Scherer in Leipzig in 1798. The bound collection of papers, including Klaproth's, read before the Berlin Academy in 1788–89 appeared in 1793, and was certainly a rather exclusive publication. The question remains why so many years passed before Scherer decided to reproduce it for a wider readership. His journal carried a minimum of original papers with a more substantial number of reproductions and translations from the *Philosophical Magazine*, *Nicholson's Journal*, *Annales de Chimie* and *Journal de Physique*, with reviews of other published papers by the editor, and—for the first time in a chemical journal—correspondence from distinguished chemists in France, England, Russia, Holland, Italy and Spain. In 1799 he re-published almost immediately the well-known report by Fourcroy, D'Arcet and Guyton in *Annales de Chimie* (6) on the palette of enamel colours for porcelain developed by Christophe Dihl at the porcelain works he had established in Paris in 1780 under the patronage of the Duc d'Angoulême, while he also reproduced later papers by Klaproth presented to the Berlin Academy.

Certainly by 1801 Scherer was having difficulties in editing and producing his journal, partly because he was appointed Professor of Physics at the University of Halle in 1800, and also because of strong competition from the older *Chemische Annalen* published by Lorenz von Crell, who made matters even more confusing for Scherer by adhering to the old phlogiston concept and firmly rejecting the new chemical nomenclature put forward by Lavoisier, Guyton, Berthollet and Fourcroy in 1797 and now becoming generally accepted. A further possible reason for Scherer's interest in Klaproth's paper was his appointment, also in 1800, as consulting chemist to the faience factory that the Baron von Eckarstein had just purchased from Constantin Sartory in Potsdam (7). At all events, re-published it was after a lapse of ten years or so, and only a year before Scherer's journal ceased publication and Scherer left for his native Russia, the journal being carried on as the *Neues Allgemeine Journal der Chemie* by A. F. Gehlen. Almost immediately afterwards, Klaproth's paper appeared again in an English translation in the *Philosophical Magazine* (8) (which had begun publication in 1798) while an abridged version also appeared in April 1804 in *Nicholson's Journal* (9), and this wider publicity led naturally enough to an interest being taken by British pottery manufacturers, although before Scherer's republication action had already been taken at Sèvres.

Platinum Decoration at Sèvres

Another curious feature here was that although at least two distinguished chemists associated with porcelain, Macquer and the Comte de Milly, had carried out investigations on platinum and were well aware of its remarkable resistance to high temperatures and to corrosive attack, it apparently occurred neither to them nor to other French scientists of the time to turn these properties to advantage in the decoration of porcelain. Macquer's researches on both the body and the colours have already been mentioned; the



By 1791 platinum decoration had come into use in the Sèvres factory. This is one of a set of Sèvres hard paste porcelain plates dated 1792 on which the chinoiseries have been carried out in gold and platinum. All the faces and many of the architectural details are in platinum on a black ground. The gift of Lewis Einstein in 1962, this is now in the Metropolitan Museum of Art in New York

Comte de Milly, a soldier turned chemist, on the conclusion of the Seven Years' War spent several years in the service of the Duke of Wurttemberg, who had started a porcelain works in his castle at Ludwigsburg near Stuttgart as a step "necessary to the splendour and dignity of my realm". Here Milly secretly studied both the preparation of the porcelain body and of the enamel colours, as well as the gilding process, and on his return to Paris in 1771 he gave a report thereon to the Academy of Sciences (10). A few years later he secured some platinum from the Spanish government (11) and also produced specimens of ductile metal from the sal-ammoniac precipitate and used them successfully to make a few articles of jewellery. Both Macquer and Milly died in 1784, however, and it was Jean D'Arcet, Professor of Chemistry at the College de France and Macquer's successor as technical director at Sèvres, where he improved the enamel colours to give greater brilliance, who requested a supply of platinum from Spain in 1780 (11). By 1791 he had introduced platinum decoration—soon after Klaproth's paper had been read but before it had been published—and towards the end of the long period, over forty years, in which Jean-Jacques Bachelier, Madame Pompadour's protègè, was artistic director, and in the very midst of the French Revolution! (12). One piece illustrated here dates from 1792; it is decorated in gold, with all the faces and some of the architectural details in platinum. Unfortunately no trace of the platinum formula can be found in the archives at Sèvres.

The earliest use of platinum on porcelain among the Staffordshire manufacturers dates from 1805 when John Hancock, working with Henry Daniel as independent decorators in the Spode factory, devised a process for the so-called "silver lustre". This tea-set, in the Spode Museum in Stoke-on-Trent, is decorated with deep bands of platinum and with gold borders. The pattern was introduced in the following year, 1806

Platinum was also introduced at the Vienna factory, which had been established as early as 1717 with the aid of two runaway workers from Meissen, but not of course until much later in its history. It came into the possession of the Empress Maria Theresa in 1744 and remained as a state-controlled enterprise; in 1784 Baron Konrad von Sorgenthal was appointed as director and encouraged the colour chemist Joseph Leithner to develop a range of rich enamel colours, and in the years 1803 to 1805 Leithner successfully applied platinum decoration (13) although no account of his work appeared until 1813 when a description of the technique was published by Gehlen (14), together with details of his own experiments in the same direction. Leithner mixed platinum in the form of very fine powder with oil of turpentine and applied the paste in several layers, each coating being carefully dried before the next was added, and then fired the ware "in a heat of 14–18° Wedgwood". (This would have been equivalent to about 800°C.)

English Lustre Ware

The date of introduction of bright platinum decoration into the Staffordshire potteries in England has been the subject of great debate and of many claims that cannot be upheld.

Had Josiah Wedgwood still been alive and active when Klaproth's paper appeared in English the story would have been different; he was of course a Fellow of the Royal Society and a keen reader of the scientific journals, but he had retired by 1790 and he died in 1795, leaving his great enterprise in the hands of his son Josiah II and his nephew Thomas Byerley. Many writers on ceramics have maintained that silver lustre ware was produced by the Wedgwood factory in the 1790's or early 1800's, but in fact it was not until 1806 that any real evidence can be presented for their use of platinum, and then they were following the practice of a rival pottery.

It is to one John Hancock, employed by Henry Daniel as an enameller in the Spode factory, that credit must be given for a process that made metallic decoration with

platinum a commercially successful technique. Hancock had been apprenticed to the Derby Porcelain Factory under William Duesbury where he acquired his knowledge of the preparation of colours. He was taken on by Daniel in 1805 under a curious arrangement by which undecorated ware was passed on to Daniel, working inside the Spode factory as an independent decorator. Hancock must have read, or had his attention drawn to, one of the English translations of Klaproth's paper, for by the closing months of 1805 he had successfully developed metallic lustre decoration. The details of this sequence of events have been established by Leonard Whiter in his massive study of the Spode family and factory (15). Under the arrangement just mentioned Daniel had to pay Spode a rental for the equipment used in the preparation of colours, and he had no intention of revealing Hancock's invention to his employer. Whiter continues:

> "This presented him with the problem of how to enter in the record the grinding of platinum, the very mention of which would tell too much. No such secrecy was necessary for 'pale gold' (which Daniel made in the proportion of half an ounce of prepared gold to 12 grammes of prepared silver) and in his colour book he noted November 11th 1805 half pound platina entered by the name pail gold in Mr. S.—book"

The earliest surviving pieces of Spode ware with lustre decoration—and these are very few—show the rather dull leaden variety, but the details of Hancock's adaptation of Klaproth's formula have not been and may never be established. It is likely that several years of experimentation and failure by Hancock and by others were necessary to bring the process to full success.

The secret could not be kept however—Hancock is said to have sold the recipe for a small sum of money to anyone who wanted it (16)—and very soon Wedgwood, among others, was employing platinum decoration. By December 1806 John Wedgwood had sent jugs decorated all over with platinum and gold respectively to their friend John Leslie, the Professor of Mathematics in Edinburgh University, who had once been employed as tutor for his children by the first Josiah. Leslie, afterwards Sir John, and the great authority on heat radiation, sent a characteristic reply to Josiah II:

> "26 Decr. 1806
> I have to thank your brother John for the handsome present of the Jugs. They are very much

During the first half of the nineteenth century the so-called silver lustre was used extensively on earthenware. Applied all over the ware, the platinum coating was designed to simulate the appearance of silver and great quantities of pottery tea-pots, sugar basins and cream jugs were produced in rigid imitation of the shapes of the much more expensive silverware. This Staffordshire coffee pot, now in the Victoria and Albert Museum, is a typical example

Shortly after the introduction of platinum decoration in the Spode factory the process was adopted by Wedgwoods. This pillar candlestick, made in 1811 and now in the Victoria and Albert Museum, has "steel resist lustre" ornamentation

admired. I wish you could inform me how the metallic coating is applied. While the Common Jug cools down in 60 minutes the platina one required 80 and the gold one 70 to come to the same point. The platina coating is therefore much thicker. I would strongly recommend it for coffee pots" (17)

According to Simeon Shaw, (16)

"The first maker of the Silver Lustre properly so-called, was Mr John Gardner (now employed by J. Spode, Esq.) when employed by the late Mr Wolfe, of Stoke"

The date of Gardner's discovery is not known, but a letter in the Wedgwood archives strongly suggests that it was not earlier than about 1812 or so. Writing to Josiah Wedgwood II on September 13, 1814, Josiah Byerley, the son of Wedgwood's nephew Thomas Byerley who had followed his father as London Manager, refers to the demand for silver lustre ware for export and goes on:

"Let the Silver lustre be as like Silver as possible—Mr. Hamilton of Stoke showed me some that he makes much whiter and resembling Silver much more than ours does. Perhaps a little Silver is mixed with it, or a thicker coating of the platina to increase the opacity." (18)

The Robert Hamilton referred to was the son-in-law and partner of Thomas Wolfe, Gardner's employer.

A few years later an entry in the Wedgwood Pottery Memo Book, undated but from internal evidence about 1817 or 1818, gives the following details of both procedures:

"To make Steel lustre, mix solution of platina with oil of tar and brush it over the ware—then fire in the enamel kiln—to silver this grind up the precipitate of platina by sal-ammoniac with water and apply it over the steel and then expose it to a heat barely red"

The first printed recipes for pottery decoration were those compiled by Thomas Lakin—for some time a partner in Lakin and Poole in Burslem but later the manager of the Leeds pottery—and published in 1824, shortly after his death, by his impoverished widow, to the intense annoyance of the Staffordshire potters (19). Lakin describes first the gradual mixing of one part of a solution of platinum in aqua regia with three parts of spirits of tar ("all other spirits would be destructive"). The recipe continues:

"First procure brown earthenware of a full soft glaze, and with a broad camel hair pencil lay on all over the piece of ware the platina in solution, and fire it at a strong enamelling heat, by which it will acquire a shining steel colour lustre; then take the oxide of platina mixed up with water to a thickish consistence, and lay it

A typical "silver resist" jug, made in Staffordshire late in the first quarter of the nineteenth century and now in the Victoria and Albert Museum. It is decorated in underglaze blue with reserves left for the later application of the platinum and shows the improvement achieved during the years following Hancock's original discovery, particularly by comparison with the dull "steel lustre" of the Wedgwood candlestick shown on the facing page

> on the steel lustre, as it is commonly called, and fire it again in a kiln or muffle but not to exceed a blood red heat; it is then called silver lustre, being less resplendent, having more solidity and whiteness, and a very similar appearance to silver. On all white earthenware the platina in solution is perfectly sufficient to produce a silver lustre"

To the modern potter or ceramic chemist the latter part of this recipe would seem to be quite ineffective, but it must again be remembered that the platinum available at the time was highly impure by comparison with the refined metal now produced and that some proportion of the impurities would be absorbed or occluded in the precipitate and—as with Klaproth's original procedure—would help significantly in securing adhesion to the glaze and the achievement of a continuous film of metal. To confirm the successful results that could, with some considerable care, be obtained by the Wedgwood and Lakin recipes some experimental work was undertaken in the Johnson Matthey Research Centre. Using platinum deliberately adulterated with small percentages of the other platinum group metals and of copper and iron dissolved in aqua regia, the ammonium chloride precipitate was dried, mixed with water, and applied directly on to the glaze and also over an initial layer of burnish platinum (to simulate the "steel lustre") on white earthenware. After firing at around 650°C the specimens emerged from the furnace with an extremely thin but brilliant and continuous film of platinum—the "silver lustre" effect.

Unquestionably "silver lustre", an essentially English development, became commercially successful and was exploited throughout Staffordshire and also by the potteries in Leeds, Swansea, Newcastle, Sunderland and elsewhere. When applied all over the ware it was seen as a cheap substitute for the silver and Sheffield plate tea pots, cream jugs, sugar basins and so on, and for many years, until the introduction of electroplating in the 1840's, there was a great production of such articles in rigid imitation of the shapes of the silverware. The all-over usage then declined, but the use of platinum decoration in a more artistic form had arisen in which either a pattern or its background was painted on to white ware with an aqueous

solution of a viscous substance such as gum or honey before the platinum was applied. After drying, the "resist" was dissolved off in water, leaving the decorative platinum effect on firing. Some most attractive designs were achieved in this way by a number of pottery manufacturers.

Modern Formulations

By the 1860's the formulation of suitable platinum preparations began to be taken over by the leading companies engaged in noble metal refining and fabrication, and their specialised knowledge enabled them to produce much more stable solutions and pastes—the old recipes gave preparations that were quite unstable and had to be used immediately—while the controlled addition of small amounts of base metals such as bismuth, chromium and cobalt ensured greatly improved adhesion to the ware. Improvement has been progressive, not only in relation to the original shortcomings but also in response to the much more exacting requirements imposed by mechanised processes of application, developments in the composition of glazes and enamels and more severe firing cycles.

Today of course an extensive range of liquid bright platinums and liquid burnish platinums is available, based upon oil soluble sulphur-linked platinum complexes, and benefiting from the production of platinum powders of specificable degrees of fineness, and with the tar oils of the last century replaced by stable media of reproducible properties. These are designed to suit different types of glazes and the numerous methods of mechanical application employed in modern potteries—including the use of silk screen transfers—while carefully designed firing cycles are followed by the user. The remarkable results obtained by porcelain and pottery decorators in the early days, with no adequate means of temperature measurement and with but little knowledge of the chemistry of the complex reactions involved, must excite profound respect and admiration for their achievements.

Acknowledgements

The writer wishes to express his gratitude to Mrs. Una des Fontaines for advice on many aspects of porcelain and pottery decoration; to Mrs. Clare Le Corbeiller of the Metropolitan Museum of Art, New York, for drawing his attention to the Sèvres plate and for providing the photograph; to Mr. John Mallet and Miss Gay Blake-Roberts of the Victoria and Albert Museum, London, for making possible the colour photographs; to Mr. Robert Copeland for the photograph of the Spode tea service; to his colleagues Mr. O. N. Collier, Mr. F. E. Kerridge and Mr M. H. Summerhayes for valuable discussions and Dr. P. M. Willis for carrying out the experimental work on the old formulae for "silver lustre".

References

1 Donald McDonald, "A History of Platinum", Johnson Matthey, London, 1960. This comprehensive study gives a detailed account of all the early researches on platinum

2 M. H. Klaproth, Sammlung der deutschen Abhandlungen König. Akad. der Wissenschaft zu Berlin in Jahren 1788 u. 1789, Berlin, 1793, p. 12–15

3 M. H. Klaproth, *Crell's Chemische Annalen*, 1786, **1**, (5), 502–507

4 K. Bruhns, "Life of Alexander von Humboldt", London, 1873, Vol. I, p. 123

5 M. H. Klaproth, *Scherer's Allg. J. der Chemie*, 1802, **9**, 413–422

6 A. F. Fourcroy, J. Darcet and L. B. Guyton, "Rapport sur les couleurs pour la porcelaine du Cit. Dihl", *Ann. Chim.*, 1798, **25**, 83–101

7 Allg. Deutsche Biog.; O. Riesebieter, "Die deutschen Fayancen des 17 und 18 Jahrhunderts", Leipzig, 1921, p. 182

8 M. H. Klaproth, *Phil. Mag.*, 1803–4, **17**, 135–138

9 M. H. Klaproth, *Nicholson's J.*, 1804, **7**, 286–287

10 Comte de Milly, "L'Art de la Porcelain", Acad. des Sciences, Descriptions des Arts et Metiers, Paris, 1771

11 Ramon de Manjarres, *Rev. Arch. Bibl. Mus. Madrid*, 1913, **28**, 58–74

12 P. Verlet et S. Grandjean, "Sèvres", Paris, 1954, p. 23

13 E. W. Braun and J. Folnesics, "Geschichte der k.k. Wiener Porzellanmanufaktur", Vienna, 1907, p. 101

14 A. N. Gehlen, *Schweigger's J. für Chemie und Physik*, 1813, 7, 309–316

15 Leonard Whiter, "Spode; A History of the Family, Factory and Wares from 1733 to 1833", London, 1970, p. 43

16 Simeon Shaw, "History of the Staffordshire Potteries", Hanley, 1829, p. 227

17 Wedgwood Archives, Etruria 1, 315. I am greatly indebted to Mrs. Una des Fontaines for this and the other Wedgwood references

18 Wedgwood Archives, 12119–13

19 Thomas Lakin, "The Valuable Receipts of the Late Mr. Thomas Lakin", Leeds, 1824, p. 59–61