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Wedgwood Jasper Vase with cover; Shape No 1, black dip with white relief of Muses, c. 1875. Photography M. Coupe.

The science and society of WEDGWOOD

Art, science and a quest for perfection are unmistakeable in the refined and classical ceramics of Wedgwood.

BY **DAVE SAMMUT**

England, 1759. An ailing King George II sits upon a throne in torment. British troops are at war in Canada, and have just captured Quebec. The restive American colonies are just a few years from open revolution. Railway lines are rolling out across the green fields of England with the speed and power of the steam engines they will carry. An entirely new class of 'industrialists' is growing wealthy from great endeavours of earth, fire and steel.

Josiah Wedgwood (1730–95) has just leased his first factory, the Ivy House Works, in Burslem, Staffordshire. Already the fourth generation in a family of potters, he has been working since he was just nine, when his father died. He has only a basic education, yet he has a keen intellect and a spirit for problem-solving.

Wedgwood throws himself at the task of refining and industrialising the manufacture of ceramics, developing techniques for their mass production. Within just three years, he releases the first of three signature styles of earthenware. Queen's Ware, released in 1762, was a cream-coloured, lead-glazed product, a durable mixture of flint and white clay and the first example of coloured ceramics.

The new Queen Charlotte (wife of King George III) was so pleased with Wedgwood's tea set that Wedgwood was granted permission to style

himself 'Potter to Her Majesty', and his fame spread quickly across Europe. Just a few years later, Catherine the Great ordered the famous Frog Service of 982 individually painted English views and the green frog emblem of her country estate *La Grenouillère*.

Two key challenges for any scientist of that era were measurement and control. For Wedgwood, the uniformity and quality of his materials, and the temperature control of his furnaces, were crucial. Daniel Gabriel Fahrenheit's mercury thermometer was at that time a relatively recent invention, and not suitable for the high temperatures at which kilns fire clay – around 1200–1300°C.

With the growing international success of his products, Wedgwood rapidly gained a reputation for his tireless experimentation. Wedgwood received clay and mineral samples from all over the world. He sought constantly to refine the purity and uniformity of his starting materials and to refine production processes. His innovations helped the Wedgwood factory to gain a reputation for product quality and consistency.

The chemistry of ceramics is too diverse and complex to cover here. The elements can be metal, non-metal or alkaloid, with ionic or covalent bonding. Generally, ceramics are characterised by key attributes – hardness, toughness, poor conductivity and chemical resistance.

Wedgwood's experimentation with materials allowed him to create consistently coloured ceramics that did not rely on glazes for colour, where coloured glazes were unreliable. However, he continued to experiment with these ideas for other production purposes, and to create the unique products for which he is famous.

An early idea for gauging temperature that Wedgwood trialled was to place discs of clay doped with iron oxide in the kilns. On firing, the oxide would darken from beige through to brown and black,

Photo ©Wedgwood Museum/WWRD.

Tray of Jasper trials, 1773. Each trial piece is marked with a number that corresponds to an entry in Wedgwood's 'Experiment Book'. Many pieces are impressed with the firing instructions, for example 'TTBO' for 'tip-top of biscuit oven'.

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The Sydney Cove Medallion

Following the establishment of the New South Wales colony in 1788, Governor Arthur Phillip sent a sample of clay from Sydney Cove to Sir Joseph Banks, who in turn gave it to Josiah Wedgwood. Using this sample, Wedgwood created a commemorative medallion titled 'Hope encouraging Art and Labour, under the influence of Peace, to pursue the employments necessary to give security and happiness to an infant settlement'. The Sydney Cove Medallion illustrated dates from the 1920s and is from the collection of a member of the Wedgwood Society of NSW. The year 1789 on the medallions is the year the originals were made and sent back to Governor Phillip.

depending on the temperature reached. However, he was concerned that the 'phlogistic vapours' (see July 2014 issue, p. 22) in the kiln would contaminate the discs, leading to false results. He also trialled the use of metal rods, but measuring the expansion at high temperatures was impractical.

Instead, he pursued experiments based on the shrinkage properties of clay itself. Using the purest Cornish clay, he created moulded cylinders that he placed in the kiln with each firing. After cooling, the plug was pushed into a brass gauge with a tapering, graduated groove of his own scale, 'degrees Wedgwood'. Using precise measurements of the degree of contraction of the plug, Wedgwood could determine the temperature of the kiln.

Wedgwood's 1782 paper 'An attempt to make a thermometer for measuring the higher degrees of heat, from a red heat up to the strongest that vessels made of clay can support', in the *Philosophical Transactions of the Royal Society of London*, saw him elected a Fellow of the Society the following year.

The way that Wedgwood marketed his products – particularly via advance order from catalogues and travelling salesmen – allowed him to plan his production and minimise waste. He developed multiple innovations in the production processes, such as simplifying shapes for higher volume production. Wedgwood is also credited with perfecting the revolutionary use of transfer printing to achieve interchangeable patterns for pre-ordered plates, replacing the laborious and inconsistent practice of hand-painting designs.

Various fortunes and misfortunes in Wedgwood's life meant that his influence extended well beyond his work in ceramics.

Having survived smallpox as a child, Wedgwood had a permanently weakened knee. After a bad fall in 1762, around the time of his initial fame, his doctor introduced him to a rich and educated businessman, Thomas Bentley, who opened up the classical world to Wedgwood and redefined his taste. Classical themes came to be a signature of Wedgwood's ceramics.

Wedgwood became fascinated with classical ceramics, and he continued to research these thoroughly. His second signature line, Black Basalt (1768), was in the Etruscan style, the basis for the name of his newly constructed Etruria Works in Staffordshire, in 1766. This facility continued production for 180 years, across another five generations of Wedgwoods.

Wedgwood became friends with Joseph Priestly through the Lunar Society and corresponded with many of the great scientists of the day.

Through his new connections, Wedgwood later came into contact with Erasmus Darwin (see 'Curious connections'). Together, they were among the founders of the Lunar Society, which in part reflected the changing relationship between technology and science, moving from an artisanal craft practice to one with a more scientific basis, even as the scientific method was first coming to be developed and codified.

Wedgwood became friends with Joseph Priestly through the Lunar Society and corresponded with many of the great scientists of the day. He came to supply scientific instruments to Priestly, Lavoisier and others – pyrometers, retorts, crucibles and tubing. Another of Wedgwood's papers to the Royal Society concerns his experiments with Lavoisier's idea that heat could be measured by determining the quantity of ice that a warm body could melt.

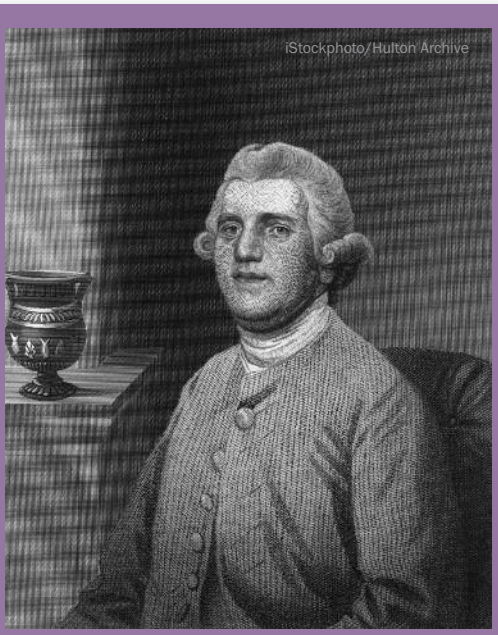
The Etruria factory included a laboratory where Wedgwood pursued his investigations. His favourite phrase was 'Everything yields to its

Curious connections

Because of the friendship between Wedgwood and Erasmus Darwin, their children had plenty of opportunity to become acquainted. Robert Darwin married Wedgwood's eldest daughter, Susannah, in 1796. Among their children was Charles Darwin, who in 1839 married Emma Wedgwood, daughter of another of Josiah Wedgwood's children, Josiah Wedgwood II (himself a member of parliament and a patron of the arts – he donated a life annuity of £150 to Samuel Taylor Coleridge to free him from financial worry and allow him to pursue his literary and philosophical interests). Yes, Emma was Charles' first cousin, if you're counting.

Charles Darwin's dual access to the Wedgwood fortune (via his mother and wife) substantially contributed to the opportunities he had in life, first to join the voyage of the *Beagle*, and later to pursue his interests in natural history.

Wedgwood was also known as the 'Father of Potters'. In a curious loop, about a century later Beatrix Potter was to write *The tale of Peter Rabbit*, and there would be few English children in the century that followed that didn't have an item of Wedgwood pottery decorated with Potter's illustrations.



Josiah Wedgwood (1730–95).

experiment'. After three years of experimentation, including more than 5000 recorded experiments, Wedgwood went on to develop his third and possibly most famous product: Jasper Ware (1774), a coloured stoneware with applied relief decoration.

In general terms, decoration applied directly to the pottery (which can be raw, 'green' or 'biscuit-fired') can include colourants (such as iron oxides, $CuCO_3$ and $CoCO_3$) or opacifiers (such as SnO and ZrO). A wet, usually transparent glaze (primarily of silica as the main glass former, with metal oxides (often Na, K or Ca) to act as flux, and often with alumina for stiffening to prevent it running off the piece) is applied over the decoration. The pigment fuses with the glaze, and appears to be underneath a clear layer. This is the basis of Jasper Ware, with the striking colour of the blue pieces coming from cobalt as CoO or $CoCO_3$.

There remains disagreement about how scientific Wedgwood was in his experimentation. It seems that he was less interested in the intellectual science of his day than in empirical application. According to the Wedgwood Museum's website, 'Josiah was using materials which were full of unidentified impurities and which consequently produced infuriatingly, unpredictable variations in behaviour. His success was purely the result of trial and error.'

From my perspective, the differentiation is unnecessary. There is no doubt that Wedgwood saw the value of science in his work. At his Etruria factory he engaged a chemist (whose name I have unfortunately been unable to find. Readers are encouraged to write in if they know). He actively participated in the learned societies of his day, corresponding with and assisting some of the names we hold great, and he ensured that his own children were educated in chemistry.

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