The Ceramic Spectrum
A Simplified Approach to Glaze & Color Development
ROBIN HOPPER
Second Edition
The

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To appreciate the gradual development and understanding of ceramic materials that has occurred over at least the last 8,000 years of man’s history, it is helpful to know a little of the background that has given birth to the overwhelmingly rich and diverse art form we have in ceramics. I choose not to follow these developments in any specific chronological order, but more in the order of technological progress - the transition from pit fire to porcelain. This transition has led from the earliest accidents of pottery making to the astounding scientific advances in the use of ceramics in the space programs of the late 20th century. These advances in ceramic technology are already having a profound effect on the potter through the development of high temperature refractories such as spun kaolin insulation now used greatly in kiln construction. Further inventions will certainly create new and exciting movements for the future. The illustrations also follow the same zigzag path as ceramic history, where one culture has learned from the developments of another.

Archaeologists generally agree that like most of mankind’s major discoveries, the earliest pottery probably developed by accident. This may have occurred from observations of the way the earth became baked around fire pits, with the subsequent experiment of firing clay pots. It could have also come from the accidental burning of clay-lined baskets. Baskets woven from reeds, roots, or soft tree branches were the original storage containers. At this time, man was primarily a seed-eating creature who stored his food supplies in baskets. Baskets, of course, are anything but impervious to the loss of small seeds, which easily find their way through the mesh of basket weave. After a while, inner coatings of clay were probably smeared onto the basket to prevent loss. The next development was likely the accidental setting on fire of one of these mud-lined baskets, resulting in the first major step in our technology - that of fired clay and thus pottery.

The same sort of accident most likely occurred all over the world at different times, creating what is generally referred to as primitive pottery. Probably, because of the early associations with baskets, much of the world’s earliest pottery is decorated with simulated basket weave patterns. Over very long periods of time man developed his use for fired clay materials to encompass a wide range of functions, from seed container to sculpture, from votive doll to space capsule. In this book I am not concerned with the most recent developments of space age technology, except where pertinent to some other aspect of the potter’s art. I am concerned only with those ceramic developments which fall into the area of impervious coatings of clay, glaze, and color.

When fired in a pit or bonfire, clay doesn’t get hot enough to shrink and fuse into a tight waterproof solid. Although in many cultures porous clay vessels were (and still are) used for the storage of water, where loss by evaporation caused the water to be kept cool, it soon became evident that some method for making the surface of clay impervious to water loss would be beneficial. The earliest waterproofing
was most likely done by the rubbing of pots, hot from the fire, with some form of resinous material from the leaves of trees, or by smearing the pots with animal fats to seal the pores of the clay. Burnishing the clay with a pebble also helped to develop a very smooth and fairly waterproof surface by compacting the surface. These techniques are still very much in use in societies where pottery is made in primitive ways. In fact, a significant amount of the world’s pottery is made this way, although it is falling victim to the insidious encroachment of plastics. Unfortunately, the resin- and fat-coated surfaces were not very resistant to wear with continual use, and other methods of making vessels waterproof were soon sought.

The next step in the development of an imperious surface came through the use of a refined liquid clay coating, or thin colloidal slip with ultrafine particle size, which formed a glaze-like skin. These slips are mostly reddish brown, dark brown, or black in color, and are generally known by the Latin name of *terra sigillata*, meaning sealed earth. They are made by allowing surface clays, usually red clays, to soak in a suspension of water until the heavier particles sink to the bottom. The water and thin slip are then siphoned off and the process repeated until the resultant slip is of a very fine particle size. The slip is sometimes made to liquefy and settle more readily by using an alkaline deflocculant such as lye or sodium hydroxide, sodium silicate, sodium carbonate, or even urine.

The waterproof *terra sigillata* surface was employed by many cultures, some in very colorful ways. Despite its Latin name, its use was particularly developed by the Greeks. It formed the basic decorating medium on classical Greek pottery from very early times, and became the basis for the familiar black and red decorated ware. The black developed from the reduced slip surface (see reduction, Chapter 3) and provided the artists in the Greek society with an excellent medium in which to record their myths and customs. This pottery was fired in kilns of a more sophisticated nature than the pit-fired wares, with significant control over the firing. The subtle reduction of the surface slip was achieved without reduction of the underlying clay body. If over-reduced, both would turn black. The fact that there is still so much of this pottery around today points to a very successful methodology of firing, usually done not by the potters themselves, but by a fireman responsible for only that part of the total process. In fact, the Greeks were the first to develop a factory system of working, where specific jobs were done by designated people. The pot was made by a potter, decorated by a painter, mainly the court painters of the time, and fired by the fireman. The degree of control each exerted in his particular field allowed interesting ceramics to develop. The forms were established along mathematically controlled lines according to the principles of the Golden Mean. The potter did not have much opportunity for self-expression; the vessel was just the ground for the more important painting on the surface. Although we often find that the pot and surface tend to detract from each other, in the hands of sensitive painters, the integration of form and surface is delightful. Scenes of mythological heroics and histrionics abound on the vast majority of these pots, done with a combination of brush painting, *sgraffito* (scratching through the painted surface with a pointed metal implement of some sort), and sometimes post-firing additions of white details. This seemingly small palette of color was entirely sufficient to depict the subject matter for these wares.

*Terra sigillata* was also used to a very large degree by the Romans for the pottery made especially for the patricians, and was known as Samian or Arretine ware. Instead of being painted, however, this ware was generally made in molds where a decoration was cut into the mold surface. Clay was then pressed into the mold, forming a raised relief pattern. These wares emulated the raised repoussé decoration of silver and gold vessels that possibly originated in China. Decoration was also made by painting with a fairly stiff slip, sometimes referred to as paté sur paté or barbotine, to leave a similar raised surface. The piece was subsequently dipped into a thin sigillata slip and fired in a kiln with no reduction, leaving a reddish satin surface. Roman pottery decoration rarely has the same vigor as that of the earlier Greek wares, and far less is seen in the museums of the world. Many other cultures used *terrasigillata* techniques for sealing and beautifying the surfaces of their wares, particularly pre-Colombian cultures of Central and South America. *Terra sigillata* slips have been in use for thousands of years.

The first actual glazed surface most likely occurred, again probably accidentally, in the area...
of Egypt or Syria approximately 5,000 years ago. The usual theory of the first glaze development comes from the probable use of sandstone containing considerable sodium and potassium, called natron, as the material with which to build a fireplace. Natron has a very low melting point and the surface of the rock facing the fire would easily develop to a fused glaze. A fairly logical step from this point might have been to make small statues from this sandstone and heat them, and this is what most likely led to the first glaze on pottery. Natron, sand, and clay were mixed, and figurines were made by pressing the mixture into molds. When the material dried, the soluble sodium materials migrated to the surface, forming a powdery scum. When heated to a low red heat, this scum melted, and combined with the clay to form a glaze. This is, in fact, a self-glazing clay, which we now call Egyptian paste. It was often colored by the introduction, natural or fabricated, of metallic compounds of copper, manganese, iron, and cobalt.

Although it may have taken several hundred years to happen, technically it is a comparatively small jump from this material to a glaze made from the same materials, put into a solution with water, and subsequently used to coat the pottery form. So we have the first glazes developed for use on pottery. This discovery seems to have had little practical use in functional pottery for quite some time. Egyptian patricians generally used either gold or alabaster for their functional needs, and the humble peasant potter made use of simple unglazed dishes and storage containers for his daily life, blissfully unaware of the fact that he could have had impermeable glazed surfaces to eat from and store liquids in. Alkaline glazes such as these had certain drawbacks, such as some solubility after firing, particularly when used in cooking. There were also difficulties in application, as well as a strong tendency to craze and chip easily. However, even with their drawbacks, they were a great deal more serviceable than the earlier unglazed wares.

Further developments were needed, and the next important advance in the understanding of materials came with the introduction of lead compounds into materials for use by potters. Lead compounds were fairly common, and it was found that lead sulfide, or galena, when ground up and applied to the surface of the clay, would easily melt and fuse to a shiny smooth glaze. This advance probably occurred in either Babylonia or Syria between 3000 and 2500 B.C. Both lead and alkaline materials were used together in the production of colored glazes.

At this point I should make it clear that neither alkalis nor lead are glazes in themselves, but become so because of the immediate availability of silica and alumina in clay when combined.

A period of ceramic history where the simplest use of lead is apparent is in the pottery of medieval England. Damp pots were dusted with powdered galena, which, when the pots dried and were fired, fused with the clay to form a glazed surface.

We now know that these wares were potentially hazardous, but for several centuries simple lead glazes were used for the production of amber, colored, and clear glazes for domestic pottery. Today, in many parts of the world and in many countries, the use of lead is either banned outright or severely restricted. Although the use is diminishing, simple lead glazes are still used in many areas, presumably because of availability and ease of fusion.

The Assyrians learned to make colored glazes by the addition of metallic oxides to the lead glaze, and with these glazes decorated huge architectural edifices with multicolored low relief bricks and tiles. This represented a high development in the process of glaze making.

Knowledge of the use of lead in glazes spread eventually to China, and much of the pottery of the Han dynasty (25-220 A.D.) used lead for its surface. In many cultures, clay was used as a material to provide an acceptable copy of other more precious materials, and both the form and surface of much Han dynasty pottery emulated bronze. The addition of copper to lead glazes produced colors that closely resembled bronze. Lead glazes later developed into regular use for pottery, and eventually to a wide range of colored glazes.

Low-temperature earthenware glazes fulfilled the needs of mankind for many centuries before the next major step in glaze technology occurred. This step depended on the development of a kiln that could fire at considerably higher temperatures than previously possible. With the discovery of more heat-resistant clay materials that could be used for kiln building, the production of a dense, hard form of pottery, which we call stoneware, became possible. Stoneware clays had very great advantages over the red-burning low-temperature clays in use at the time; when
fired, they were considerably harder, and thus more durable.

These new developments in ceramic technology occurred in China as long ago as 1500 B.C., and represented a great technical leap forward. With higher temperatures, new forms of glaze were needed. The earliest to appear were those that came from the natural melting of wood ash, as it moved through the kiln from the stoking of the fireboxes, and of the red-burning clays which fused to brown or black glass.

Wood ash is a material which, at high temperatures, fuses with the clay and forms glazed surfaces with no other materials needed. Another common material that formed the basis of high-temperature glazes with no other additions was the red earthenware clay which had until this point been the basic material for the production of the pots themselves. These clays contained the basic requirements of flux, alumina, and glass-former, to form a glaze. When liquefied to slip and applied over the stoneware clay, they turned readily into a gloss surface when exposed to a sufficiently hot fire. Combinations of wood ash and clay in varying ratios were used to make a wide variety of glazes.

With the further understanding of their raw materials, the potters toiled for more refinement, and through the use of rocks ground to powder learned to produce a wide range of glazes at high temperatures. The powdering of a certain igneous rock called petuntze, and the subsequent intermixing with a light firing clay called kaolin brought about the development of what was to become the most sought after pottery compound ever produced - porcelain.

Although quite refined, white-firing clays for pottery making date back to about 1500 B.C., the Chinese first produced porcelain during the Tang dynasty (618-906 A.D.) from the refinements of hard-firing light-colored stoneware clays used in the Han dynasty. These gradual refinements produced a paste material which, when fired properly, had a quality of translucency never seen before. The refinements reached their peak during the Song dynasty (960-1220 A.D.), although further developments were made in later dynasties. The new material was more or less half clay and half glass, and retained some of the qualities of both materials. Not only was it translucent, it also rang like a bell when tapped. It was so close to glass in its makeup that when glazes were developed for its surface, the materials fused together so completely that the body and its skin were integrated as never before. The resultant material was so pure and fine that the Venetian merchant explorer Marco Polo dubbed it “porcellana” after the quality of the smooth glossy seashell.

The development of this wonderful new material represented the ultimate achievement of the potter’s art. The subsequent export of wares made from porcelain across the Asian trade routes, and later in large volume by ship, brought about great changes in pottery styles in the areas it touched.

The world of Islam was the first to experience this change. Pottery production in the Islamic cities on the trade routes was at this time limited to earthenware. The new imports from China were highly prized and sought after. The net effect of this trade was to put the livelihood of the local potter in jeopardy, who had neither the raw material resources nor the expertise to produce porcelain. In reaction he produced copies of the refined Chinese wares, using the materials he was familiar with. The addition of tin oxide to the lead and alkaline glazes created an opaque white base for added decoration. He also often used a white slip under the glaze to further whiten the ware, in the hope of competing with the imports. To the untrained eye, the copy and the original are very easily confused.

The same development of copies occurred in the port cities such as Delft in Holland, Bristol and Lowestoft in England, and many other European ports, as well as others in various parts of the world at a considerably later date. However, the hunt was on for the secret of the wondrous material in centers of pottery making all over Europe, and this in itself led to other technical developments. The secret was eventually found in Germany in the 18th century, but the search had already led to the invention of both soft-paste porcelain and bone china. Since glaze chemistry at this time was purely an empirical affair, the developments were slow in coming. This is not surprising, particularly when you remember that the secrets were passed through generations of families, and little change might occur in a single lifetime.

Islam saw the growth of many different styles of pottery within its borders, particularly of surface embellishment using the wide range of color available with low-temperature glazes. Two processes of decorating on top of an already
fired glaze were used. The first, smoked luster, was made by fusing a thin layer of metal to the slightly softened glaze surface by heavy reduction of metallic salts, creating an iridescent sheen. The second, using a highly colored, very low-temperature glaze led to what we call overglaze enamel. Wares from Islam traveled across the trade routes to China and soon the decorative use of enamels was seen in great abundance, although they may well have been independently developed there. The new Chinese wares were exported in great volume to the Middle East, to Europe, and to Japan in the 17th and 18th centuries. This led to the production on a massive scale of wares of an oriental flavor in factories throughout Europe, and was itself responsible for the great surge of growth of industrially produced wares of the 18th and 19th centuries. The cycles of growth, alteration, refinement, and further growth continue to the present day.

One particular development that seems to have no associations with other cultures was that of salt glaze, which occurred in Germany during the 15th and 16th centuries. This seemingly autonomous discovery of the reaction that takes place when salt is thrown into the very hot kiln brought an interesting new surface to pottery. The salt volatilizes in the kiln, and fills the interior with fumes. The sodium gases react with the silica of the clay to form a glassy, often textured surface. Its use was initially restricted to the Germanic countries, and its often dull grey or brown color did little to increase its universal appeal. Except for small isolated areas in England and France, its use remained very much a localized tradition until the emigration of German potters who brought the technique to the east of North America in the early 19th century, where it saw renewed growth.

By the end of the 17th century, the growth and development of all the major technical advances in pottery had occurred, and in many cases, their rise and subsequent demise as fashion dictated. The only real developments left were those attempts to place our long empirical history into a scientific context. The German chemist Dr. Hermann Seger developed the scientific approach to glaze calculation with the invention of the Seger Formula in the late 19th century. This comparative system, generally used by industry, facilitates easy comparison between various formulae of glazes for ceramics. Seger was also responsible for the invention of ceramic cones to enable more accurate control of the firing process. The rise of industrialization, and with it, standardization, has had the unfortunate side effect of eliminating much of the personality of most of the world’s pottery in the process.

The ceramic industry continues to improve its products, and the 20th century has seen great advances in many sectors. The development of new and more stable colorants and the invention of various materials to solve the problems of space travel have given the 20th century ceramist new materials and directions to explore. It is an exciting time.


1.5. Black Figure Hydria (water jug), Greek, Attic, c. active about 525-500 B.C. Dionysus and Two Satyrs, pottery, incised and painted decoration, unknown artist close to the Nikoxenes Painter, 1939.Cb.1. Courtesy of the Montreal Museum of Fine Arts, Gift of Harry A. Norton.
