

The Ceramic Spectrum

A Simplified Approach to
Glaze & Color Development

ROBIN HOPPER

PHOTOGRAPHY CREDITS

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The
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To my patient, tolerant, and understanding family

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Robin Hopper

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Introduction

No words can convey the excitement and satisfaction that come from the study of glaze and color development. It is a process of personal understanding, and of the development of a sympathetic relationship with the materials which have been used by our ceramic forefathers for millennia.

This book is not intended to be a recipe book, but to de-mystify an extremely complex subject. It aims to make available to the student of ceramics, whether beginner, advanced, or professional, an approach to the study of ceramic glaze and color development which does *not* rely on the use of published formulae, recipes, or mathematics. It goes back to the empirical methods of glaze making, in use for nearly five thousand years before the understanding of glaze formulation by mathematical equation. As a teacher, I came to the conclusion that the vast majority of potters, ceramists, and

students of ceramics are totally intimidated by the alien chemical/mathematical methods of glaze making, to the point that they give up any meaningful exploration of this fascinating aspect of the potter's art. They turn instead to a bewildering array of other people's recipes, readily available in many books, which seldom offer a totally satisfactory solution to the problem in hand.

Unfortunately, this dependency has the effect of dulling the senses to the almost limitless possibilities of the medium. It also tends to fill the potters' marketplaces with an alarming array of stereotyped pottery, coated with boring and overused glazes. I continually ponder how so many so-called artists or craftsmen can accept such boredom, and ask the following question: "Is there life after temmoku, celadon, and high alumina matt?"

I certainly believe so, and the aim of this book

is to encourage the personal exploration of materials for glaze and color, so that anyone can develop his own glazes, without pain or anguish, and with a very exciting learning experience. Although many recipes are included, they are offered only as suggested examples, or parameters to learn from, not necessarily as solutions in themselves.

The material for this book developed from the teaching of glaze chemistry, and the quick realization that the vast majority of people cannot add, subtract, multiply, or divide with any reliable degree of accuracy more than 50 percent of the time. Thus a study that relies on mathematics is fraught with potential problems. Furthermore, if one adds the complexities of understanding chemical symbolism to that of mathematics, the combination often discourages even the most adventurous from experiment. On a global scale, this is tragic for the continued health of a vigorous and longlived art, which through the centuries has served as an important vehicle for man's creative talents.

First, we trace the historical developments in ceramics, later relating these to the use of materials. We follow a path of increasing complexity to gain a wide knowledge of material reactions under heat. From there we find out what is responsible for the development of color, the assisting factors and the inhibiting factors, and how to create specific colors, rather than the usual unsatisfactory approach of accepting what happens. For most colors, it should be possible to work toward a desired goal, in much the same way as one chooses paint from charts in a paint store.

Any course of glaze development study is only as good as the application which is given to it, the degree of accuracy which is used, and the recording of processes, results, and observations. These will be outlined early on, to make sure of maximum benefit. I cover glaze development and coloration at those temperatures most widely used, cones 04-1, 3-6, and 8-10, which will be called *low-fire*, *mid-fire*, and *high-fire*. There is also coverage of specific temperature areas for colors such as chromium and uranium reds, yellows and oranges, overglaze enamels, and other specialized glazes. The atmospheric variations of oxidation and reduction and their effects, combined with suggestions on how

to relate these to your kiln, are discussed in chapter 3.

Although some might think of this approach as regressive, the material covered in this book is the result of over 25 years of study, much of which dealt with molecular formula, and the resultant commitment that there must be an approach that does not represent an anathema to such an overwhelming number of people. There is a perfectly valid reason for the ceramic industry to use formulae for the development of industrially controlled glazes which can be quickly compared. The studio potter doesn't generally need or want such control in his work; it is too far removed from the actual process and the intimate understanding of ceramic materials. For those who wish to use formulae, and there are many who do, I hope that this book will suggest new approaches, and be of use in determining color development, which formulae cannot do. For those who feel intimidated by mathematical formulae, it is my hope that in the exploration of this book it will be possible for the reader to find a new direction in the search for an individual idiom.

The text can be used as a course outline for either the individual or group, where shared experiences tend to enhance and speed up the learning process. It should also be usable as a research tool for the understanding and development of colors which may have previously seemed beyond reach. The book is a distillation of all that I have read on the subject and a large amount of personal research, in combination with the opportunity, while teaching, of seeing vast numbers of glaze and color tests each year.

Part V is a portfolio of the work of selected potters and ceramists from different parts of the world, who use color in widely differing ways. The captions for these illustrations contain the potters' descriptions of methodology in the creation of the works shown. The portfolio should serve as an inspiration source, and a small view of the incredible wealth of creative potential in the sensitive uses of ceramic materials by experienced artists and craftsmen.

Since the whole concept of this book is to simplify a mystifyingly complex subject, and I have

found from personal experience, both as teacher and potter, that one tends to become overanxious and intimidated by both equation and symbol, I have decided to eliminate these from the text. Except for chapters 5, 14, and 17, which include lists of ceramic materials, colorants, and opacifiers, with their chemical symbolism, and any places where chemical symbolism is unavoidable, all reference to materials will be made in the commonly used form. For example, kaolin will be called kaolin, and not china clay or hydrous silicate of alumina, and its formula will only be found in chapter 5; similarly dolomite will be called dolomite, and not calcium-magnesium carbonate; and iron will be red iron, unless stated differently, instead of ferric oxide. Particular types or brand names of various materials, such as feldspar, kaolin, ball clay and so on will be omitted, and only these generic terms will be used. Mathematics will be limited to the addition and subtraction of 1 to 100. All temperatures will be recorded either by Orton cones or degrees Celsius (centigrade). Appendix 1 is a reference chart on cones and temperatures (including a conversion for Celsius to Fahrenheit) for comparison purposes.

This means that anyone, anywhere in the world, can use the information as guidelines, setting out knowing nothing, and in this ignorance or innocence achieve exciting results. This doesn't mean that we should turn our backs on chemistry, since the whole process of glaze and color development is one of chemical reaction. What it does mean, however, is that by eliminating the dogma of chemistry and mathematics, we can concentrate on the actual and observable reaction, and leave the other to the chemists and mathematicians. Glazemaking can and should be an exciting and enjoyable learning experience, as well as an extremely important part of a ceramist's personal development, and the growth of an individual approach to working in clay.

As one learns to develop glazes and colors, it will soon become obvious that one cannot be dogmatic about a great deal of the technical side of things. The nature of the materials and process will suggest a variety of ways to achieve a given result. Explore them all and make decisions accordingly. Don't accept dogma as gospel; there is almost always more than one way to do things and get the required result.

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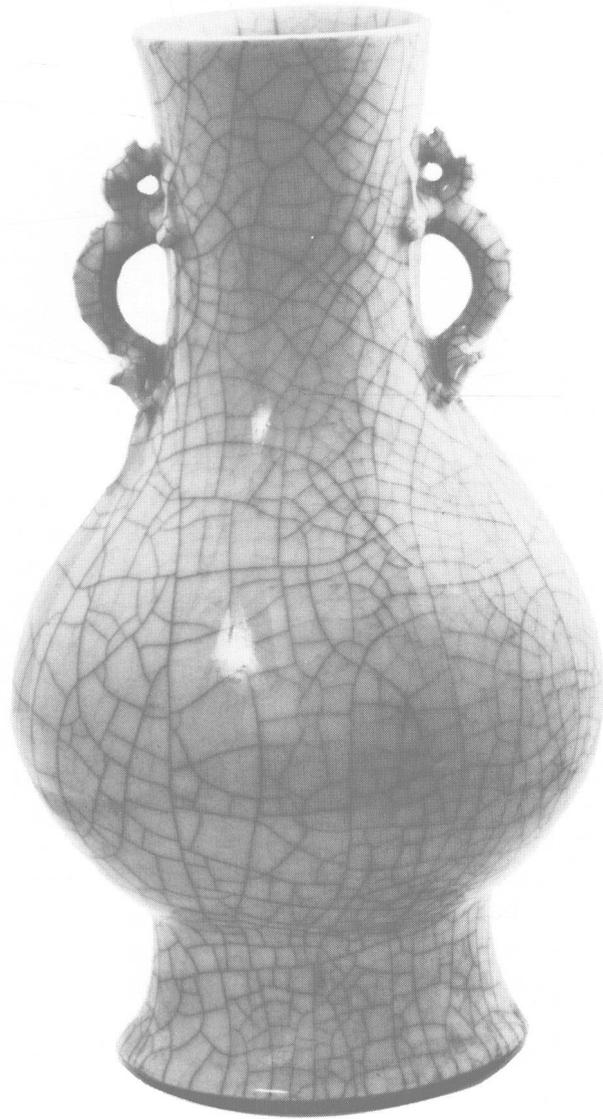
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PART ONE

The Basics



I

Glaze: A Brief Technical History

To appreciate the gradual development and understanding of ceramic materials which has occurred over the last 8000 years of man's history, it is helpful to know a little of the background which has given birth to the overwhelmingly rich and diverse art form that 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 twentieth century. These advances in ceramic technology are already having a profound effect on the potter, and will certainly create new and exciting movements for the future. The illustrations also follow the same zig-zag 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



1-1. Round bottomed urn. Red earthenware pottery; moulded criss-cross decoration in relief around base, cross-hatched string impressions on body. China, late Zhou, 6th-3rd century B.C. Courtesy of the Royal Ontario Museum, Toronto, Canada: 924.26.32. George Crofts Collection.

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. Because of the early associations with baskets, much of the world's earliest pottery is decorated with simulated basketweave 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.

Clay, when fired in a pit or bonfire, doesn't get hot enough to shrink and fuse into a waterproof

solid. Although in many cultures porous clay vessels were and still are used for the storage of water, where loss by evaporation causes 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. Bur-nishing the clay with a pebble would also help to develop a very smooth and fairly waterproof 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 are not very resistant to continual use, and other methods of making vessels waterproof were soon looked for.

The next step in the development of an impervious surface came through the use of a refined liquid clay coating, or thin colloidal slip having 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 liquify 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 glaze 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 develops from the reduced slip surface (see reduction, chapter 3), and provided the artists in the Greek society 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-