tenmoku to tomato red

by Ryan Coppage, PhD and Jenn Wicks

Do you ever wonder what the surface of a glaze really looks like? Or how a glaze can completely change color with the adjustment of one ingredient? Explore some of the causes using the transition from tenmoku to tomato red glazes.

Define the Terms

Crystallization: A highly ordered, crystalline deposition of material that exists in large or small sizes, dependent on the amount of material provided for it to grow and the length of time it is allowed to grow.

Nucleation Sites: The sites in which crystals grow as a result from (after?) their formation when atoms/molecules/ ions are arranged in a particular way that produces a crystal solid. (Do these sites have particular characteristics? Specific elements?)

Precipitation: The change of a phase or nature of a material that occurs to remove it from suspension in a solution of another material.

Saturation: When a maximum amount of a substance is homogeneously distributed throughout a medium or substrate, such that an excess would result in a phase change or deviation from predicted behavior.

Tenmoku: An iron-saturated type of Japanese glaze that is traditionally fired to cone 10. It can appear black to red depending on iron levels and the applied thickness of the glaze.

Tomato Red: An iron-saturated glaze that is traditionally fired to cone 10, in which the iron precipitates out of the glaze base and manifests as red crystals on the fired glaze surface.

Iron-Saturate Glazes

As the name implies, these types of glazes are saturated with iron—including both tenmoku sand tomato reds. Iron-saturate glazes have been traditionally used in cone-10 reduction and wood-fired kilns; however, they have recently made their way into the cone-6 oxidation world. While tenmoku glazes are notorious for yielding blushes and shades of red—where thin or when breaking forces thinner layers of the glaze—it is not their primary color. They mostly exist as solubilized iron oxide in a silicate matrix, and the bulky metal absorbs across most of the spectrum, reflecting back a deep brown-black color. This is often described as a “potter’s color” or “potter’s glaze.” We love them. We covet beautiful tenmokus and the depth and purity that they offer, but also manage the constant disappointment that they do not sell quite like bright copper-red or deep-cobalt blue glazes. Similarly, tomato reds can range from the desirable deep tomato color to a burgundy red brown that we reason might sell someday if a patron is partially color-blind and likes the color of the high clay-content mud in Virginia or Kentucky. And so, we fight. We struggle for those deep reds that are still bright enough to catch the public’s eye. Figure 1 is an example of a cone 6 tomato red on red clay.

What is not often taught, however, is that tomato red and tenmoku glaze recipes are mostly the same. They possess similar base glazes; they are both saturated with iron; and noticeably, tenmoku breaks in tomato colors and tomato red will break in tenmoku colors. These recipes are much the same except for a few ingredients—crystallizers, which will shift a tenmoku to a tomato-red glaze, seen in the glaze tile progression in figure 2.

Crystallization

Crystallization exists when a material falls out of or precipitates from a solution. This is much the same as the process of rock candy forming around a stick (you’ve probably seen in Ye Olde Candy Shoppe.) Precipitation happens when too much of a material is dissolved in a solution (in the case of a tomato -red glaze, iron oxide) and the very first amounts of material nucleate from the glaze melt. As more and more of the saturated material precipitates from the glaze, it attaches to the solid chunks of nucleated iron oxide and grows into what we see as crystals. If they exist as a single crystalline form, you would see singular, round crystals growing (as you see in 25% zinc oxide glazes.) Otherwise you would see a shiny, unordered crystalline surface growing—as we see in tomato reds (Is the iron oxide also a single crystalline form? Or because it is unordered, is this not the case?) This comes down to crystallizer additives. If the nature of a glaze base is changed to make iron oxide less soluble in it, the iron will precipitate from the glaze during firing, forming iron crystals on the surface. This happens in two ways: you can either build a base that is not soluble for the amount of iron it contained to start with, or add crystallizers to the base that would force

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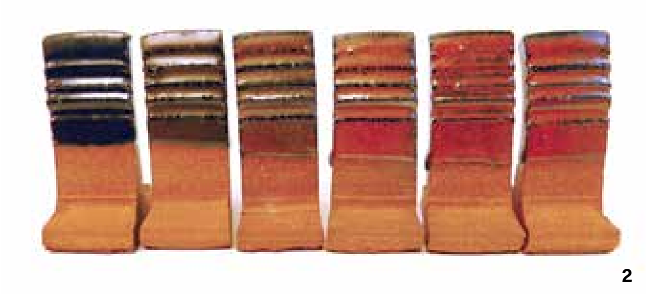
1 An espresso mug with a modified Bill Van Gilder Crocus Martis Red glaze on Brooklyn Red Clay (Standard 308) fired to cone 6 in oxidation.



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some of the iron to crystallize out. Common glaze base crystallizers are calcium, magnesium, and titanium. Tomato reds employ the first of these two, calcium and magnesium, sourcing them from dolomite ($CaMg(CO_3)_2$) and bone ash ($Ca_3(PO_4)_2$). Crystal formation has been studied as a function of heating and cooling cycles,[1] but not as a function of recipe modifications under constant firing conditions.

From a modified Bill Van Gilder Crocus Martis Red base, both dolomite and bone ash are used to crystallize iron oxide.

As a result of the crystallizers being added back to the glaze, varying shades of a red, orange, and brown color appear in the glaze alongside crystal formation. With the use of a couple different microscopes (Depstech Wifi MW9002 50x and AxioCam MRc Zeiss with 12-150x), these crystals become visible and allow for a better understanding of the crystallization process and formation of red color.

Tiles 1 and 2 are brown-black in nature, but crystals are visible at the surface; they just aren't red. When observing each tile and comparing it to its microscopic image, they seem like completely different glazes. Believe it or not, they are subtle ariations of the same base. (What about added iron oxide? (5% and 2%) Not the same base glaze then...are those two glazes considered tenmokus?) Tiles 4–6 all appear to possess different amounts of the same type of red, with crystalline prevalence increasing with added crystallizers. Their microscopic images reveal increasing amounts of red-iron crystallization that results in increased visible red color. And finally, the addition of Crocus Martis introduces a new crystalline form to the surface, which could contribute a larger range of reds and more perceived color depth.

the authors *Ryan Coppage is currently chemistry faculty at the University of Richmond. He teaches a Japanese Ceramics and Glaze Design class at the Visual Arts Center of Richmond and is starting to make a reasonable number of pots. To see more, visit www.ryancoppage.com.*

Jenn Wicks is an art major/chemistry minor at the University of Richmond.

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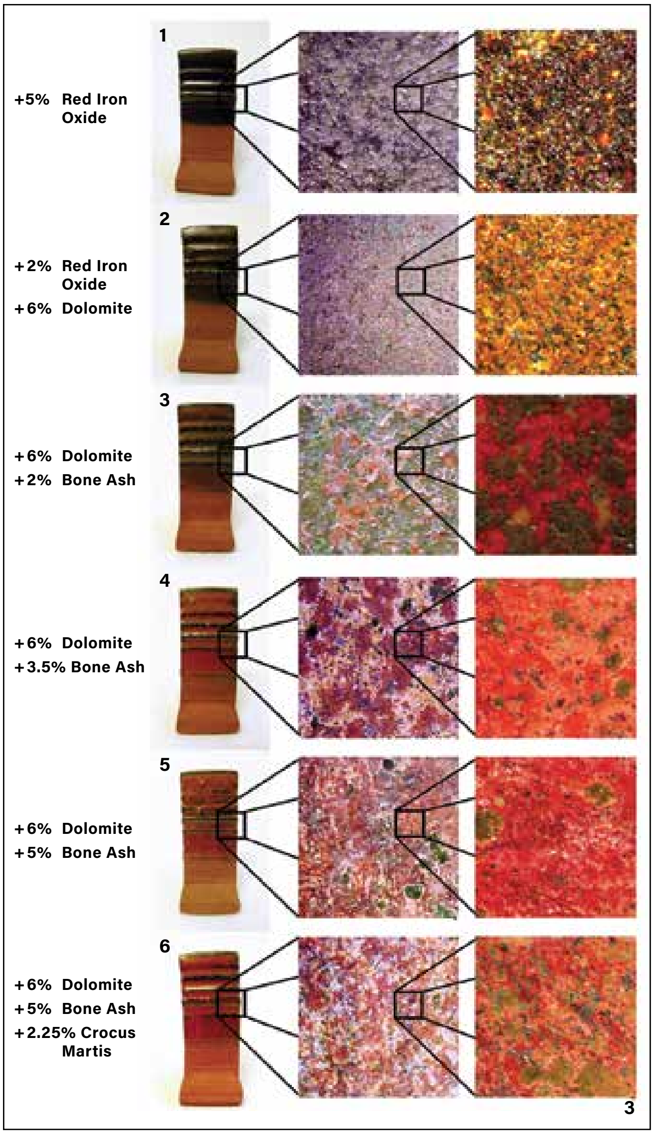
1. Lewter, George. Iron Glazes and Achieving Red Color in Oxidation. Glazes – Development and Adjustment. 2012. https://cone6pots.ning.com/forum/topics/iron-glazes-and-achieving-red-color-in-oxidation

(Is there any colorant in tiles 3–5? (Do they also have iron oxide? Is the last tile the only one with 2.25% crocus martis? Or do they all have it? The written recipe suggests that all do but the chart suggests that only #6 does?)



2 A transition from tenmoku to tomato red as crystallizers are added to the glaze base (cone 6 oxidation on Standard 308). **3** Imaging of various magnifications of the tile surface as crystallizers are added back to the glaze recipe.

TOMATO RED BASE (TILE 6)

Cone xx Oxidation/Reduction

Bone Ash	5.0 %
Dolomite	6.0
Gerstley Borate	18.6
Red Iron Oxide	13.0
Talc	10.1
F-4 Feldspar	32.7
EPK Kaolin	3.4
Silica	11.2
	100.0 %
Add: Crocus Martis	2.25%

To test this, both dolomite and bone ash were totally removed from the recipe and then added back in, seen in figure 3, with observed crystallization. (Did you use a sub F-4?) (Should this say that iron% changed in testing for 1, 2, and 6?)