The Shimbo Research Pottery

CRYSTALLINE GLAZING OMNIBUS

Fara Shimbo

Master Crystallière

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INTRODUCTION: WELCOME TO UTTER MADNESS

Okay, you've decided to try your hand at crystalline glazes. You poor dear. You've landed smack in the middle of the most esoteric, tedious, infuriating, exhilarating, exhausting and rewarding sub-sub-specialty in all of ceramics. This is not my fault and I take no responsibility for your sanity, but that's okay because you can't have too much left if you've read this far.

Throughout this book you'll see "perfect" crystals that I made and rendered with Blender. I am indebted to one of my favorite websites, Webmineral.com, for providing the paper cut-out forms I needed to see and measure in my hands to get the shapes right. Absolutely invaluable site, WebMineral.com. You should check it out!

There are a number of people whose input has been invaluable in the making of this book. Evan Cornish-Keefe took my Sphene glaze and ran with it, teaching me far more about it than I'd ever have learned on my own. William Schran provided support, encouragement, laughs and more encouragement, all indispensable. Ilene Mahler, my Crystal Sister, provided tchepping, nudging and a good *potch in tuchus* when it was most needed.

I. ABOUT CRYSTALS

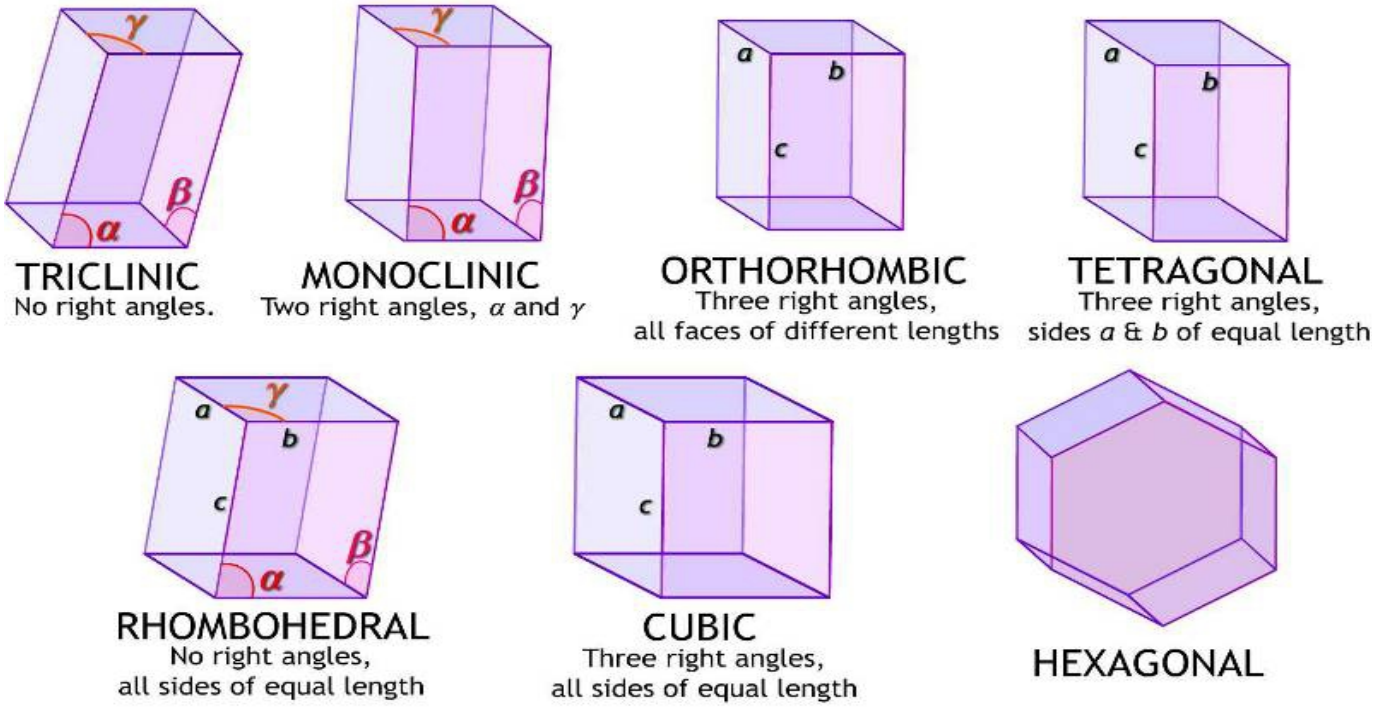
☞WHAT A CRYSTAL IS NOT...

What with all the marketing misheggos that is associated with the word "crystal" these days, it's sometimes hard to remember that this word actually has a very specific meaning. Being transparent does not make something a crystal, even though much expensive glass is called "crystal." Glazes with large chunks of pre-fired glaze of another color are called "crystal" glazes but not only are the chunks not crystals, the results, while often beautiful, are not true crystals. Small things that shine, like the "crystals" in kitty litter, are also not crystals. So, don't expect to be able to grow any of these in a glaze!

☞WHAT A CRYSTAL ACTUALLY IS.

A CRYSTAL is usually planar (having flat faces) solid resulting from the regular and repeated ordering of atoms or molecule in all three dimensions. It is precisely because crystals are what they are that one can grow them in a glaze. The study of crystals is called crystallography, and it is a vast one, full of numbers and measurements and other stuff that makes the heads of people like me explode with delight.

Fortunately for most of my readers, you don't *need* to know all this stuff to become proficient in crystalline glazes. But there are some parts of crystallography that really will help you, and I present them here.



Here are some terms to understand.

FACETS. Geological crystals (though not necessarily biological ones) are recognizable by most people because of the angular shape resulting from the fact that their surfaces are flat. These surfaces are called facets, faces or planes. I use facets here because that is the technically correct term and I'm a Geek Girl and proud of it. The facets at the top and bottom of a crystal are called *basal facets,* and those on the sides *prism facets.*

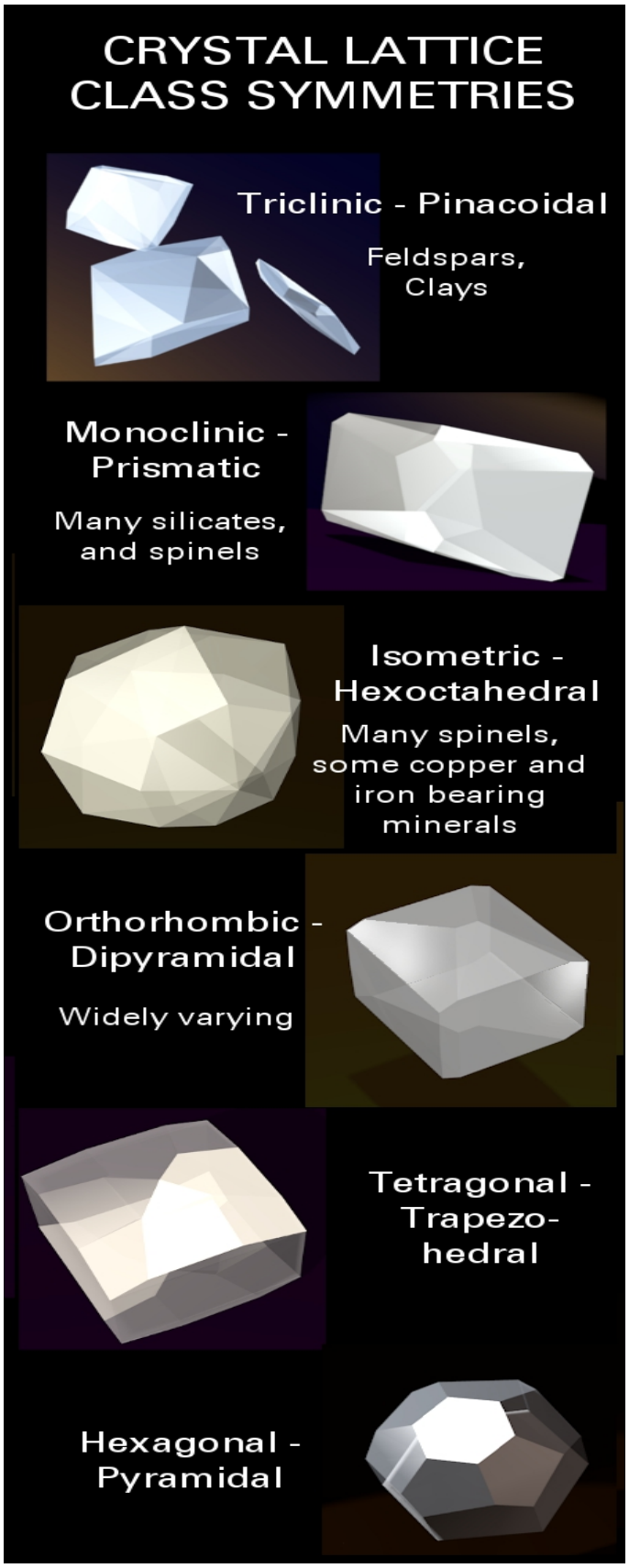
Because the surfaces are flat, the **ANGLES** they meet at are sharp, crisp, straight and... well, always at the same angle. Depending on its overall shape, a crystal can have a few or a great many faces, and all these faces will always be at the same angle relative to the other faces in the crystal.

The relationships of the planes and angles in a crystal makes a **LATTICE SYSTEM.** On the previous page is a diagram of the main ones. There are plenty of subsets of these, but knowing these will give you a good start.

All crystals have **CLEAVAGE.** *(Hey, you in the red shirt! I already warned you to get your mind out of the gutter, in another book!)* Cleavage is the angle at which a crystal will characteristically break.

Very few minerals c[ys]tals crystalize into shapes as simple as the ones pictured above. Not only do the angles and lengths change, but very often, additional faces are added. In each group, there are a number of subdivisions or "lattice symmetries." In the illustration at right, may I present the "generic" forms of some of the crystal shapes we'll be seeing over and over again. These come from Webmineral.com, a truly fabulous and fabulously useful website indeed!

DEFECTS come in quite a variety, and all of them are useful! There are two which are most important to us: *impurities,* (the wrong atom



appearing every now and then, which is how we color crystals), and vacancies (areas where an atom or molecule, or a few of same, are simply not there, which is very often how nature colors crystals).

There's one more crystallographical point I'd like to make here. What defines an individual crystal type is the **angles between each of the facets** in the crystals, not an exact shape. Facets may be large or small, fat or skinny, or sometimes entirely absent. But the angles that exist between them are always the same.

For example, here's a collection of quartz crystals.

Fig. 1.1. Subtle differences in shape, but all quartz.

I'm sure you've all seen quartz crystals before, and have probably recognized the phenomenon I'm talking about here. Notice the different lengths and widths of the crystals vis-a-vis their terminations (non-broken-off, naturally formed ends). Not only do they vary quite a bit, some of these crystals, like the fattest one, have only one face on their termination while others have five or six. Nevertheless, they're all quartz, because the angles between any two faces in a crystal—pick any two, it doesn't matter in this case—are always the same.

It's extremely important to keep this phenomenon in mind when you're trying to determine what ancillary crystals which grow in glazes from time to time might be. Well, okay, it is if you care about such things. Well, it's my book and I do care about such things, so. Crystals in glazes, especially where the glazes are running as on the sides of vessels, can take a number of what appear to be different forms, but they are still the same mineral species. Other tests will be needed to determine exactly what they are. I guess the take-home message here is, overall shape is not everything! (This applies to people as well as crystals, says the old woman who grew up to be Italian.)

"But wait!" I hear you say. "The crystals I grow in my glazes don't look anything like that." Nope, they don't. And here's why.

☞Macro-Crystals, Polycrystals

What we grow in glazes and call "crystals" are more properly "macro-crystals" (technically, "polycrystals"), large masses of microscopic, typically acicular (needle-shaped) individual crystals lumped together (see illustration 1.2). As far as I understand it, we are taking advantage of the tendency of crystals to "twin." There are many types of twinning, and under a microscope one might see all of them in the same macro-crystal.

The macro-crystal formations we see are generally the result of a phenomenon called cyclic twinning; the crystals all begin to grow from the same central seed and carry on growing

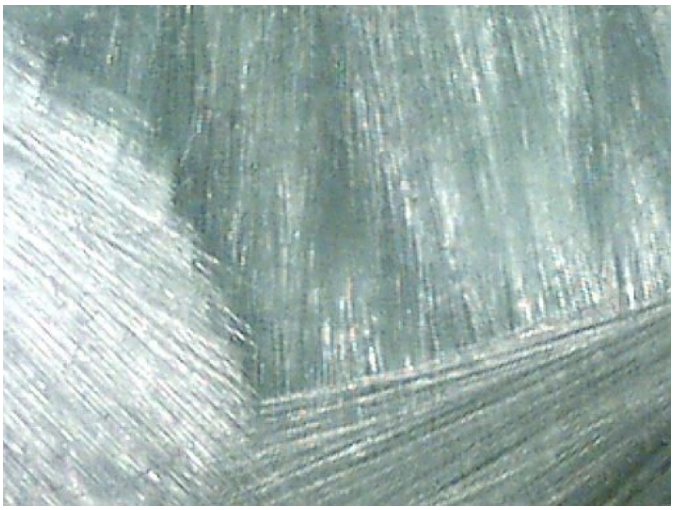


Fig. 1.2. 200x magnification of a willemite polycrystal, showing all the small, acicular (needle-like) individual willemite crystals which make up the large shapes we grow in glazes.

in a what develops into a radiating pattern, as in the photomicrograph below.

Crystallieri grow crystals in glazes and give them shape, texture and color by raising and lowering the temperature of the kiln during growth. Many minerals have different crystal forms which preferentially grow at certain temperatures and are inhibited at others. The change of form due to change of temperature is often a direct cause of twinning (called "annealing twinning") and it is the way we get "halos" or "growth rings" in macro-crystals. The edges where a ring begins and ends are known as "twin boundaries" and are easily seen under the microscope.

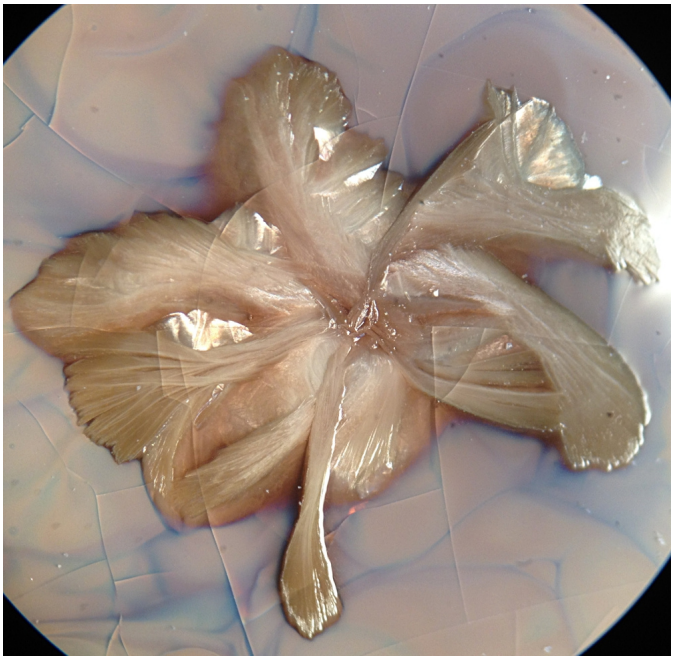


Fig 1.3. As fine an example of cyclic twinning as you're going to see in a glaze. Wollastonite crystals grown by Evan Cornish-Keefe, 10x magnification.

I'll have much more to say on this topic in the section on firing.

At the beginning of the chapters for each type of crystals, I'll have photos of a natural crystal of the same species. The crystals you'll grow in glazes don't necessarily look very much like their natural counterparts, for the most part. There are two reasons for that:

☞ **Glazes are fluid,** and crystal formation often follows the flow of the glaze. In geodes and crystal caves, flow of water is relatively still and crystal formation takes a very, very, *very* long time.

☞ **Glazes are, for all intents and purposes, two-dimensional media** fo~~r crystals to form in~~. At the very bottom of a pot, where glaze pools, you will often be able to see three dimensional crystals, be in a glaze we must of necessity force the crystal to flatten out.

The glazes we make are, pretty much all of them, extremely fluid—so much so that special drip catchers must be made for crystalline-glazed pieces in order to protect kilns and kiln furniture. More on this topic anon, too. In any case, I've often been asked, "Why don't you come up with a crystalline glaze which doesn't run?"

Well, that's answered simply: it wouldn't crystallize—at least, not during our lifetime.

Crystals grow because their component parts, be they individual atoms or molecules, just fit. The best way to understand how this happens is to grow some crystals in your kitchen sink!

Get yourself some blocks. I have a huge collection of 1950's Block City (pre- (and *way* better than) Legos), and occasionally, something will happen which requires me to have to wash them. They go into the sink, dropped in one at a time in this case, and like this:

=====[PHOTO]=====

INDIVIDUAL BLOCKS IN SINK

Then I begin to wash the blocks by swirling the water around. After ten seconds (yes, I kid you not, ten seconds!) the blocks look like this:

=====[PHOTO]=====

BLOCK MOLECULES IN SINK

What's happened here? As the water is agitated, the blocks are carried along. Inevitably, tops and bottoms bump into each other, and they bond.

This is exactly what happens in our glazes. Like atoms or molecules just plain fit together, and while in the blocks it's a friction fit, on the micro-scale the fit is due to other things that you'll get mad at me if I get too far into here. As soon as two like atoms/molecules meet and bond, a **seed crystal** is formed.

The whole point is that if the water/glaze doesn't move, neither do the molecules.[1] We need a liquid medium for the crystals to grow, so we hold or "soak" the glaze at crystal-growing temperatures. Then gravity takes over, pulling the glaze inevitably down the pot, and the glaze runs. Oh well. Into each life some glaze must drip.

But this is why crystalline glazes, with some very few exceptions, do what they do. Me, I think it's pretty dang cool!

One thing which has puzzled me for several years is, why is it that the crystals in these glazes almost universally, regardless of species, grow on the surface of the glaze? Someone once told me that that was because they require oxygen from the kiln atmosphere in order to form. Well... I don't buy it. By the time the glaze reaches about Δ6, it's all oxides already; no more would appear to be needed. But, the argument ran, crystals won't grow in a reduction kiln, which would seem to indicate atmospheric oxygen is needed, no? Well, no, not necessarily. What it may mean is that the oxides necessary to crystal growth are not present in the first place in a reduction kiln.

So, I tried the following experiment. You might find this dry reading; well, this is how I was trained to write a scientific paper. I encourage you to try it as well!

Experiment 1. Materials and Methods:

I made a ring of test tiles out of the porcelain everyone seems to love, Babu. These were bisqued to ^04 to ensure clay outgassing and to make the tiles easier to write on with an underglaze pencil.

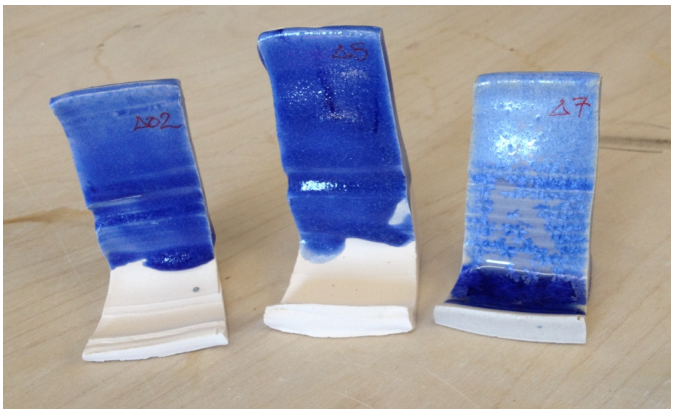
I then made a batch of Bory 1 glaze, my most bulletproof mix. I added .5% Cobalt Oxide for photographic contrast.

Using an AIM 88 test kiln, I fired them to a variety of cones, beginning with Δ022 and ending with Δ10. I fired them directly to cone and

1 Well, this is not a *precise* analogy. Brownian Motion, all that stuff, will cause crystal formation in a pool that looks absolutely still. But it will take a few thousand years.

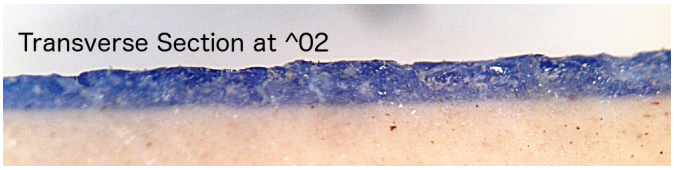
allowed them to cool without a hold.

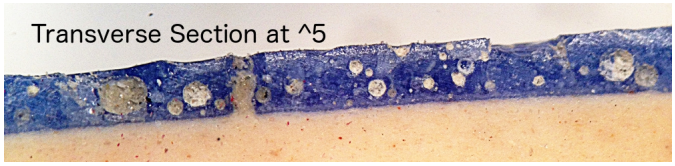
Experiment 1 Results: The glaze began to melt at Δ010. By Δ06, the glaze had become a frosty, matte blue and had already begun to run. Running halted between cones 04 and 02. At Δ02, the glaze was losing its frosted character and becoming glossy, though still granular in appearance.



At Δ6, the glaze suddenly became transparent, and recommenced to run. Small crystals formed on the surface of the glaze on cooling, even without a hold, although some slight graininess remained. At Δ7, the character of the glaze was completely as in previous firings. There was no obvious change between cones 7 and 10.

Three test tiles were chosen from the cones at which there was the most discernible and abrupt change in the character of the glaze: cones 02, 5 and 7. These were cut into slices with a diamond saw and polished with a lapidary wheel to enhance detail, and then examined at 30x magnification. Photomicrographs were taken. These photos were imported into the GIMP (GNU Image Manipulation Program, GIMP.org) and enhanced with the Unsharp Mask filter to bring out details.





Experiment 1 Discussion: I was very surprised to find that the glaze ran at as low a temperature as it did, and even more surprised with the unexpected result that at one point it not only stopped running, but later began to run once again. What could account for this?

Crystalline glaze formations are extremely alkaline in character, and crystallieri have observed for at least the last century that these glazes will actively leach materials from the clay bodies onto which they are put. In recent years, this has become a problem for crystallieri in that some clay bodies said to be "white stoneware" or "faux porcelain" are made white by the addition of titanium dioxide, resulting in extreme over-nucleation in most glazes and ugly khakis when used with nickel. Additionally, some stonewares which are particularly high in alumina will not work with crystalline glazes (that is, the glaze will mature but no crystals will grow).

With all this in mind, my thinking about what is happening here is this:

At about Δ08, the frit (Ferro Frit 3110 in this case) melts, and Gerstley will be melted by Δ06. This probably accounts for the initial running of the glaze. Other materials begin to decompose afterwards; after discussion with my Science Buddy, Jon Singer, it appears that the bubbles seen in the section at Δ5 may be other materials in the glaze, possibly those in the Gerstley, decomposing from carbonates to oxides and expelling carbon dioxide. Note also that there is a spot on the Δ5 tile where the glaze appears to have crawled. I noticed this phenomenon when I used to fire my gas kiln; crystalline glazes uniformly crawl something frightful at about this temperature. This process appears to be

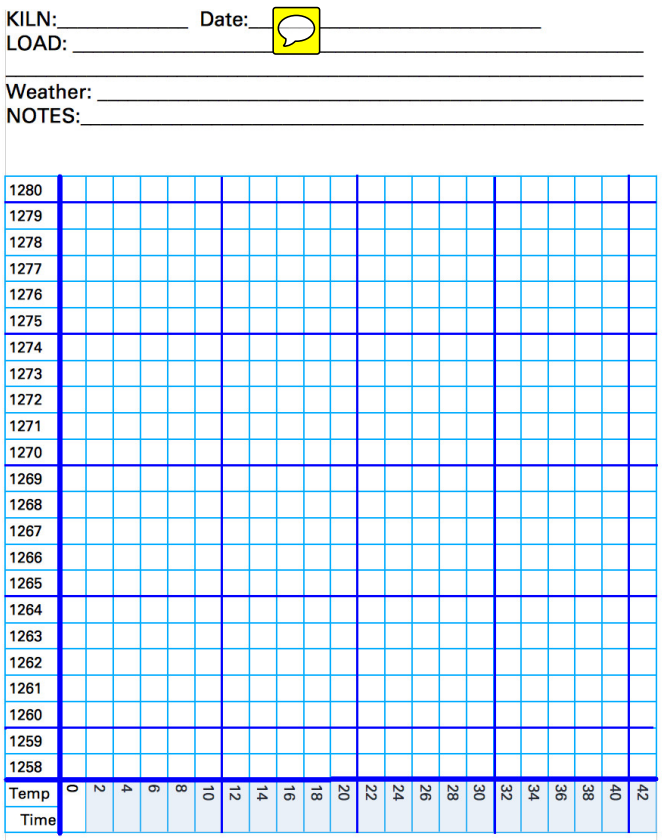
complete at ∆7 and once again, the glaze begins to run, and this time it runs with such force that the thickness of the glaze layer is halved. It may be that the runny layer of glaze drags part of the under-layer with it.

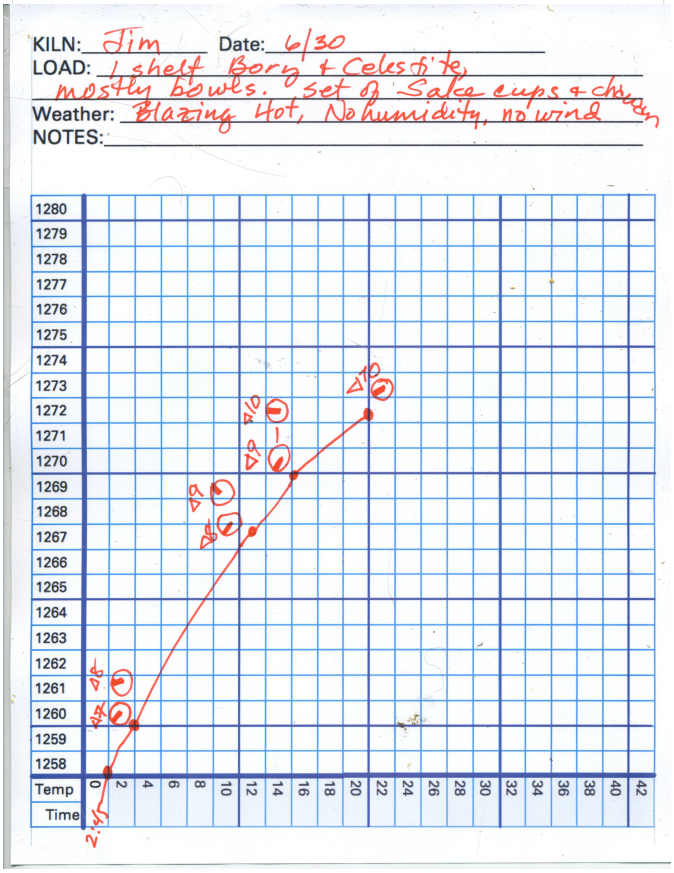
When the crystals begin growing, the top of the piece often has far fewer of them. It's often been said that this is because the glaze is thin, but since crystal-growth is a surface phenomenon, I wonder now if it's because the more liquid area of the glaze, where molecules can find each other with relative ease, is being effected by the more viscous layer underneath. As one goes down the tile, the "liquid" layer becomes thicker, more molecules run into each other and are caught up in the crystal, and larger crystals can form.

I have often cut catchers in half and observed a "boundary layer" in the glaze. You can see boundary layers clearly in both the clay and the glaze in the photomicrographs of catchers in the chapter on Zinc Silicate glazes. Because these test tiles were vertical, I was not able to observe this in this case, so:

Experiment 2 Materials and Methods: A new set of test tiles was made, with extended feet on both sides, which can be dipped into a glaze and glaze allowed to run down both sides. These tiles were made wide enough so that they could easily be cut vertically through their entire length. The tiles were all glazed at the same time with the same glaze as in the previous experiment. They were glazed by dipping, with three coats applied, each successive coat applied after the previous coat had dried.

These tiles were fired in various crystalline fires at different cones. After the entire set was fired, the tiles were cut lengthwise with a diamond saw, ground flat and polished on a lapidary unit, and examined microscopically to





see if a boundary layer could be detected.

Experiment 2 Results:

2. RECORD-KEEPING

MythBuster Adam Savage said one of the wisest things I've ever heard said. I repeat it as often as I can, and it is this:

"Remember, kids, the only difference between Science and screwing around is ***writing it down!"***

There is probably no field of ceramics in which WRITING STUFF DOWN is more important than in crystalline glazing!

What should you write down?

Everything.

No, I mean it. *Everything.*

Day and date, certainly.

Weather conditions. I don't know why, but even my electric kilns fire better on rainy days. Also, if you're firing an electric kiln on a day when everyone in the neighborhood is using their air conditioning, and your power grid was built in 1939 and hasn't been updated since (like mine), your kiln will lag something dreadful and your results will vary.

How full the kiln is. How fast a kiln fires is directly proportional to how full it is, more and more so as the elements age. Rate of firing is everything when doing crystalline glazes, no matter which type of crystal you're trying to grow.

Time. Time in all its wonders. Particularly relevant to you are how long it takes your kiln to get those lost 10° to maturing temperature has an enormous impact on both the growth of the crystals and the number of them you will get, and is the best indication of how well your kiln elements are holding up.

How the witness cones looked when you finished. Now....

(Taps foot ominously.) There are some people out there who do not use witness cones. SHAME ON YOU.

"Oh, but I have a chart and it says when you get to temperature X you're at cone Y."

That is true *only* for a very limitted set of ideal conditions. Depending on the day, date, weather, time of year, how full the kiln is and just about everything else, on one day Δ8 will be at 1260° and on another 1265°. Five degrees—and even five degrees ~~Fakenheit~~ I mean Fahrenheit—can make a big difference in the growth of crystals! You should have four witness cones PER SHELF in your kiln; two below the cone you want, one at the proper cone, and one above. I generally fire to Δ9, so I use a pack of cones 7, 8, 9 and 10. One on each shelf.

Yes, you in the back (throws a chalk-loaded eraser at head if the miscreant and is pleased to see her aim is still true after all these years away from academia). I know many of you think cones are meant to fall at a certain temperature. Uhm. No. Take that Bluetooth thingy out of your ear and pay attention. Like Yogi Berra once said, "You can observe a lot by watching!"

What a cone actually measures is heat work, which is how much change heat effects over time, just as happens when you cook in an oven. And the results of the combination of temperature and time are not quite the same—just like in an oven. But, just as with a nice pie, you can get it done both in a really hot oven and a cooler oven. With the latter, it will just take longer. Cones are not measuring temperature,

and they're not measuring time. They're measuring *done.* It's that simple.

The problem is, if you're only tracking temperature, you can't measure "done" unless you have witness cones to tell you.

This is one reason **it's vitally important for you to get to know your kiln,** about which I'll have more to say in the chapter on kilns. You can fire your crystalline glazes in a manual kiln (well, I can, and do, all the time), but you need to know your kiln. Electronically controlled electric (and fuel) kilns can also be a problem. Mine allows you to program only by temperature; I can tell it, "go up to 150° at *x* speed and up to 500° at *y* speed," but I have to tell it, "stop when you reach 1280°" when what I really need to tell it is, "stop when you reach Δ9." I'm told newer controllers than mine can do this, but alas, I missed out.

Since I've fired this kiln a zillion times, I know (pretty much) how much I have to program an offset to get to the cone I want. And the reason I know this is that ***I write stuff down***.

There is a lot about any single fire to remember. So to help with that, I've updated my firing log pages, and here's a copy for you. One blank, one filled in. Full-sized blank in the Appendices, or you can download/print it out via the link there.

I use a sort of analog clock method of marking my cone positions. I use re-usable cone setters and I mark the angle between the bottom of the cone and the tip. So, 9:00 is "done."

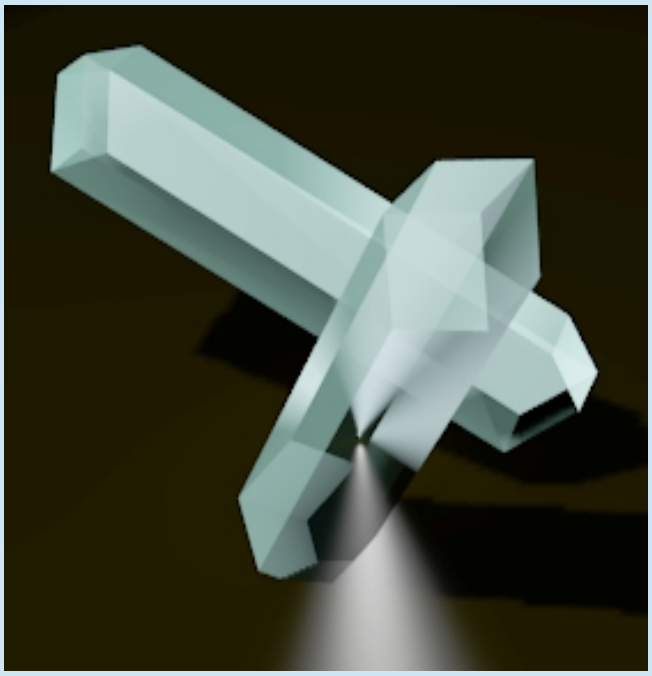
I don't keep track of the entire firing time; my big kiln does that for me. What I'm really interested in is how fast the kiln goes up the last few degrees. After a while, you'll notice that the curves are getting flatter and flatter. If you are doing only crystalline glazing, this will be your sign that it's time to change your elements. If you do other things as well, you may want to save a little money and switch for a while. Moly (molybdenum carbonate) crystals will still grow well in a slower kiln as while the crystals are finicky, the glaze itself isn't. Oil-spot glazes will also be quite happy.

Kiln logs are not the only records you should keep. I have a few spiral notebooks in which I write down any changes I've made to glaze formulations, what was on each piece that goes into the kiln, any special application techniques and so on. These are incredibly important.

I guess I should say at this point that kilns, clays, raw ingredients and everything else being what it is, just because you keep meticulous notes doesn't necessarily mean you will be able to repeat an outstanding result. I got true opalescence from a silver glaze once, and it took me almost 15 years to get it again! I had all kinds of notes and records of that firing. What I didn't have was a giant wad of dog hair that fell into the kiln and I was just plain too lazy to unpack the kiln to get it out. Did that have anything to do with it? I doubt it. But Dog Hair happens.

But do keep records and do go over them from time to time. Look to see what kinds of patterns are emerging. You can observe a lot by looking!

WILLEMITE



a.k.a.	Zinc silicate
Formula:	Zn_2SiO_4
Mol. Weight:	222.86
Color:	green to white
Fluorescence:	LW: none to weak green SW: bright green
Hardness:	5.5
Streak:	white
Lattice:	Trigonal - Rhombohedral
Habit:	in nature, massive granular, prismatic; in glaze acicular, spreading
Density:	4.0 on average
Fracture:	uneven
Cleavage:	poor

3. WILLEMITE (ZINC SILICATE) CRYSTALS

Ah, the Willemite crystal. This is where just about all crystallieri start. While still fairly touchy, Willemite (zinc silicate, Zn_2SiO_4) crystals are the easiest and most reliable to grow, and there are even a couple of commercial willemite glazes. You can always start out with them, but their patterns and effects are limitted, and soon you will be drawn to the Dark Side and want to formulate your own glazes. Come to the Dark Side. We have chocolate.

I could write a book on Willemite glazes. Well, actually, I have, and it's in its third edition. I'll just go over them quickly here, and give some tips and tricks that apply equally to all crystalline glazes.

Willemite crystals, in nature, look like this:

3.1. 10x magnification of a willemite specimen. Actual crystals, even tiny ones like these, are extremely rare. Most willemite is "massive."

This is a mineral specimen I bought many, many years ago. I swear it is smaller than it was when I bought it. Willemite is expensive; it's a fluorescent mineral and as such highly collectible. This sample glows green and magenta under short wave UV light and is shown here under 10x magnification.

I mentioned twinning ~~in the~~ previous ~~chapter~~, and here you can see a very good example of it. This sample is nothing but a huge cluster of twins, and they formed so easily that the mineral sample, when being held in the hand, appears to have no crystals at all, just little aquamarine mounds.

This is typical. I have seen very, *very* few photos of actual single crystals of Willemite and they have invariably been 1cm to microscopic in size. Of course, having said this, someone will find me a picture of a nice big one, and if you do, I'd be happy to see it!

Below are a couple of photomicrographs of a slice through a zinc-silicate macro-crystal. These are photos of the same slice, but with the light shining on them at different angles and therefore showing different things. Figs. 3.2 and 3.3 show a section through a glaze catcher; it was broken, rather than sawn, in order to preserve the characteristic cleavage. In Fig. 3.2, light is shining onto the glaze perpendicularly to the lay of the crystals (from above); in Fig. 3.3, light was shone parallel to the crystals (from the left).

...and the same slice but with the light shining parallel to the crystals.

In the top photo, you can clearly see the acicular nature of the individual zinc-silicate crystals, as they grow outward from a nucleation point. In the bottom, you can see larger crystals, which had grown through the glaze earlier at a higher temperature, sliced crosswise. Notice the hexagonal cross-sections of the crystals. The whole trick to developing and firing crystalline glazes is to control where, how, and how long these individual crystals develop.

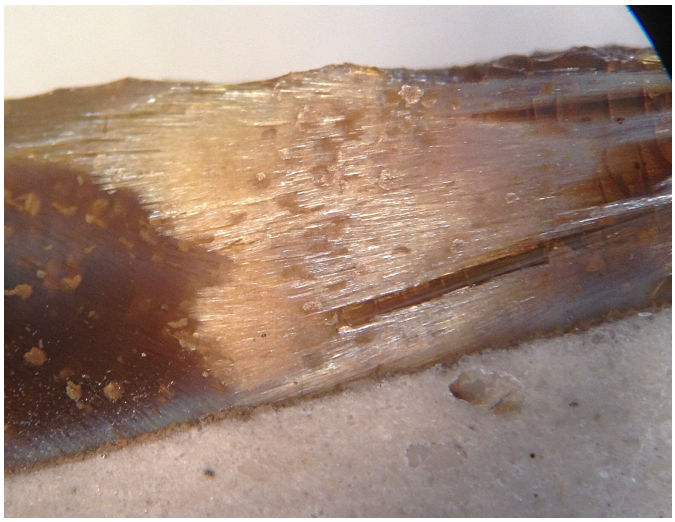


Fig. 3.2. Cross-section through a poly-crystal which grew in a glaze drip catcher, with light shone from above. The individual zinc-silicate needles are clear.

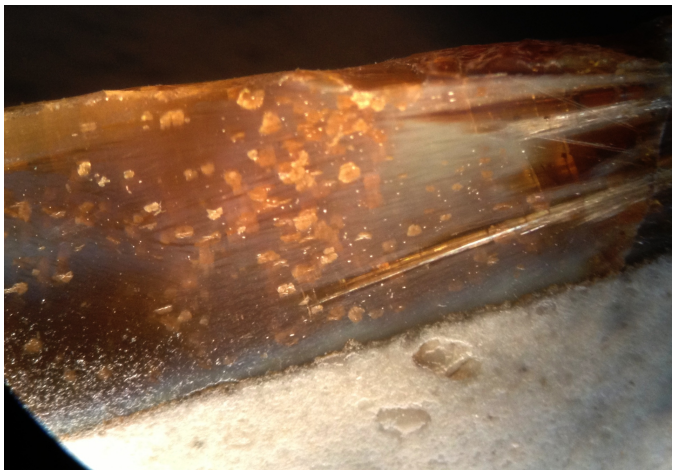


Fig. 3.3. The same glaze sample as above, but with light being shone parallel to the lay of the crystals, from the left. I am, alas, not entirely certain what the large hexagonal shapes are.

The actual shape of the macro-crystal is determined somewhat by the glaze recipe used but principally by the temperature at which it is grown. Very high "soak" or "hold" temperatures

encourage (but by no means guarantee) straight, spiky crystals. Lower soak temperatures encourage crystals to fan out. How is it, then, that you get these gorgeous twirls and swirls from what are needle-shaped crystals?

I've seen several different hypotheses about this, and some of these involve maths that make me happy but make most people scream.

If you look at the willemite crystals on the previous page, you can see that they have plenty of angles. New/twinning crystals can begin growing with any face touching any other face, and which might be the preferred way is, in our case, largely temperature dependent. Because of this, you can see how curving is achieved.

☞ENCOURAGING GROWTH

I would love to give you a means to be absolutely sure you will grow crystals, but alas, that's not possible. Crystals of all kinds are finicky (although willemite crystals are perhaps the least so), and their growth depends upon a great many factors.

☞ **Glaze Recipes.** There are a veritable zillion recipes out there for zinc-silicate glazes. You'll find a fair few of them in the Appendices. Nevertheless, you'll want to come up with your own, sooner or later.

Yup, you will.

Trust me on this.

The most successful recipes produce glazes which non-crystalline potters would probably want to use for wares fired several cones below the temperature for which crystallieri intend to reach. This fluidity is absolutely necessary for crystal growth, as I touched on in a previous chapter.

There is a good reason for this. One of the reasons we fire willemite glazes so high is not, as many people believe, to generate nucleation points, but to cull them down to only a few hundred.

☞ **Temperature to which the glaze is fired.** According to Kingery *et alii's Introduction to Ceramics,* willemite crystal "seeds" grow in their wild abandon between 830° and 880°, or about Δ012. As the temperature is raised, more and more of these nuclei are dissolved and the glaze goes from matte to glossy. This is discussed in detail in a previous chapter.

☞ **Kiln Atmosphere.** It's long been said that crystals will not grow in a reducing atmosphere, and that saying is right. Crystals grow because like atoms line up regularly with reference to each other to give a characteristic shape. When a glaze is reduced, many of the ZnO and SiO_2 molecules floating around in a glaze are reduced to Zn (metallic zinc) and SiO. Metallic zinc is extremely reactive and will immediately hook up with anything else from whom it can beg, borrow or steal an electron. SiO is the same way. Because of this electronical dalliance, there just aren't enough ZnO and SiO_2 molecules banging into each other for crystals to form.

In the Recipes chapter you'll find tons of different recipes for various crystalline glazes, but as I've said before, you're going to want to come up with your own. So, where do you start?

Start without about 25% of the batch being zinc oxide.

There has been, over the years, a lot of discussion over whether or not you should calcine your zinc. Zinc oxide is hydrophilic, and over time it does tend to absorb atmospheric humidity (unless, like me, you live in Colorado,

where we don't believe in humidity). If your zinc oxide does absorb a lot of humidity, it will tend to clump, and will actually weigh more because now you are measuring the captured water as well. It won't be a very large amount, but it will be enough to mess up the results of a small or test batch of glaze.

So, if you find yourself having this problem, go ahead and calcine your zinc. Put a pile on a large bisque plate or a clean kiln shelf and fire to about ∆020. If your zinc was very wet, you may notice that when you put a sample of calcined zinc next to a sample of uncalcined, you'll see a difference in color, generally with the calcined zinc a little yellower. If the zinc was already calcined and you just didn't know, don't worry, you didn't hurt it.

Fig. X.X Some of my favorite crystals, these colored mainly with manganese. The lighter-colored "growth rings" were made during a cooling cycle, and the darker ones during a heating cycle. This is typical—but not guaranteed—of efforts to grow such rings.

☞ Feldspar or Frit?

That's entirely up to you. Raw glazes (those made without the use of a frit) do tend to be more variable in their results since raw materials themselves are variable from one part of the mine to another. On the other hand, certain frits are notorious for varying from batch to batch, and sometimes the best ones go out of production, or are sold to another firm which makes them slightly differently.

The main problem I've found in making up raw crystalline glazes is that if you use a lot of feldspar, the amount of alumina in the glaze becomes high and the rate of crystal growth slows. Forty parts by weight of the 100-part batch, but not more, is enough. You can make up a glaze without any feldspar in it, and get something much closer to the formula you'd get for a fritted glaze, and these work too, but are tricky. In such glazes, starting with base parts by weight of 10-15 kaolin, 30-35 silica and a similar amount of silicate materials (Cornwall stone, wollastonite, etc) is usually a good place to begin. There are examples of each of these types of glazes in the Recipe Collection.

Many of the frits mentioned in books written in the last century are no longer in production, and not all frits are available the world around. The frits with which I am most familiar personally are Ferro 3110 and GC 106, now replaceable by Fusion Frit 413. I also use Ferro 3249 from time to time, and many others rarely (I mean, many other frits, not many other people).

Ferro 3110 is more or less the standard frit in the United States. It is a high-expansion, high-boron frit normally used for lower-fire glazes. 160/413 is a much simpler formulation. The basic glaze made from FF 3110 is 2:1:1 frit, zinc oxide and silica. This is a perfectly passable glaze

and one that works well at Δ10. In my experience, this glaze (I call it TGEU for "The Glaze Everybody Uses") is iffy at Δ9 and underfired at anything else. Nevertheless, it's a good starting point.

Fusion 413's/GC 106's version of TGEU seems to be 7:2:1 frit, zinc oxide and silica. I have had this glaze work fabulously one exactly one occasion; in all the rest, it fails in... well, pretty much any way it can think of, and randomly. As with the glaze above, there are Things you can add to it to fix this.

Jon Singer came up with a glaze based on Ferro Frit 3249 which is really something else again. Both of the glazes above, and all the variations of them I've used so far, craze at least to some extent. Most crystallieri accept crazing as part of the nature of the glaze. But Jon's XCR recipe (see the Recipe Collection) does not craze. No, really. I have on my desk as I type this two pieces he made with it, before my eyes, about ten years ago, on two different clay bodies. Not a craze on either of them.

The problem with XCR is that it is stiffer than the other glazes, so crystals grow, but slowly. One also has to carefully test the frit before committing to a large batch of it because sometimes it works a treat and sometimes it won't. I have one ten-pound bag of it here that's wonderful and one ten-pound bag that I am keeping only because I'm sure it's perfectly good for *something* and I hate throwing good stuff away.

I suppose this is the place to say something about the almost universally beloved Ferro Frit 3134. Almost everyone who starts mixing their own glazes seems to have a bag or six of it lying about the place, and eventually they ask if they can substitute it for 3110. Uhm... no. Not to worry, though, it has plenty of other applications!

No matter what you do, I STRONGLY suggest you make a DRIP TEST TILE like the one at right.

Whether you use a frit or a feldspar or both, every frit and every feldspar will work differently in every kiln, in every town, at every altitude, with every clay, *ad infinitum.* You need to be very clear about how every one of these things is going to work in *your* kiln, in *your* town, at *your* altitude, with *your* clay, etc.

Fig. 3.x. Drip Test Tile, comparing two commercial feldspars, one badly-prepared local feldspar, and six frits, on Laguna's 631 Porcelain.

How To Make A Drip Test Tile. Make a slab of clay, say, a large tile, and pull up a lip on the bottom to catch drips. On the surface, scoop out or press in (if you can make CERTAIN you can press each one EXACTLY the same way) circular indentation. Immediately below these, carve out a channel into which drips can flow. Connect the

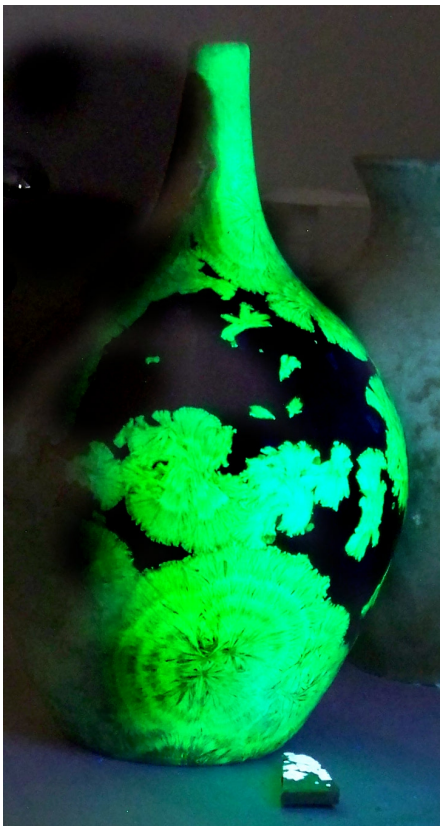
circular indentation to the channel with a small channel the width of the pin on a pin tool. (At this point, if you came up with something really good, make a mold of it so you can easily make more! You'll thank me for that advice some day. A press-mold will do.) Fire so the clay is mature, or at least very well bisqued.

Next time you fire, into each of the circular depressions, put a measured amount of each of your frits and feldspars. Put the same amount in the deepest part of each one. Make sure you write down what you put where! Fire with your next crystalline load, with the circular end raised up on a spare shelf-stand so that the melt can run into the troughs if it's going to. (You can use a tile too, or a spare cone pack. Just make sure you use the SAME one every time you fire a drip-test tile.)

When you take it out, carefully note how each material melts; how shiny, how transparent, how crazed—and which of them actually leak through that tiny outlet from the circle to the trough! All these qualities will help you decide which materials you want in your glaze.

My test here shows that the feldspars don't run at all (at Δ9), and all the frits craze spectacularly except Ferro 3249, which didn't craze. Ferro 3134 melted and ran thoroughly and I assume must have sputtered somehow because the entire area all around it is glazed and glossy. You can learn a lot from a thing like this.

(When I attended the Brooklyn Museum Art School back in the 1960s, there was one of these hanging on the wall in the ceramics classroom. Either the clay was very dark when fired, or was painted black, I was never able to tell; but the opalescence of some of those feldspars fascinated me back then, and I wish I could duplicate it. Ah, but that was a long time ago, and fired at sea-level in a walk-in gas kiln.... The Brooklyn Museum, I'm told, no longer has an art school, which is a crying shame as it was the most perfect possible place for one! Inspiration wherever you looked! One of the finest Egyptian collections outside Cairo... which I hear has been largely sold off.)



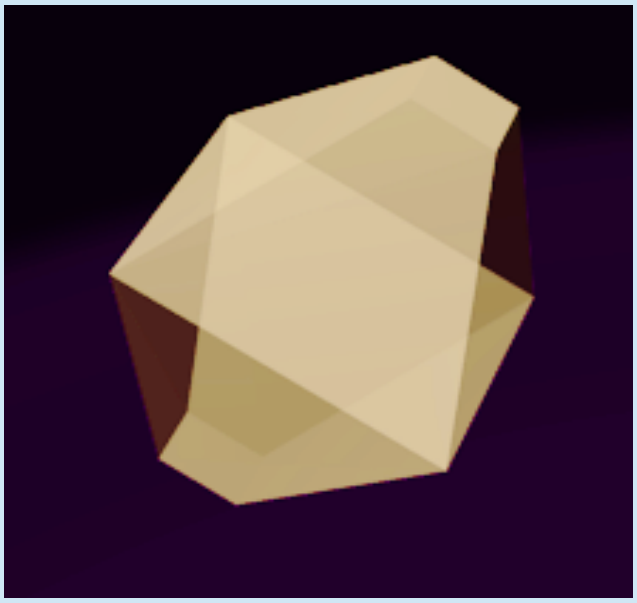
How much zinc oxide to add... the general rule is, the higher you want to fire, the more you should add. If you're firing to Δ6, 22% of the total batch weight is enough. If you're going all the way to Δ10, you can go as high as 27%. It all comes down to nucleation points, and the fact that the higher you go, the more you burn out. Twenty-seven percent will leave you with far too many in your glaze at Δ6, and you'll often get a piece entirely covered in crystals with no ground showing. On the other hand, if you use only 22% in a Δ10 glaze, you may have to seed your piece or you won't get any crystals at all. Crystalline glazing is a balancing act worthy of the Flying

Wallendas, which is why most people who start out in it eventually give up. Twenty-five percent of batch weight is always a good place to start.

Fluorescence in willemite glazes is... something else again. In nature, willemite fluoresces with a vengeance. In glazes, I've had it do just about everything. For example, in glazes made with a lithium feldspar such as petalite or spodumene, it's common for the ground to fluoresce and the crystals to remain dark. Take just about any glaze and add a little manganese, and you get green fluorescence bright enough to read by.

Additions of vanadium cause a lemon-yellow fluorescence to just about any glaze in which you put it. Iron, as usual, will quench fluorescence just to irritate you. (That's my story and I'm sticking to it.) The take-home message here, I guess, is that you can't use fluorescence to definitely identify a willemite crystal in a glaze.

POWELLITE



a.k.a.	"Moly crystal," Calcium Molybdate
Formula:	$CaMoO_4$
Mol. Weight:	200.2
Color:	pale orange to white
Fluorescence:	LW: weak butter yellow SW: strong butter. Colorants added to glaze will change this color slightly.
Hardness:	3.5 in nature, much higher in a glaze.
Streak:	pale yellow
Lattice:	Tetragonal - Dipyramidal
Habit:	coarse crystalline, granular naturally; in glazes, lamellar, as a single thin film.
Density:	4.3 on average
Fracture:	conchoidal
Cleavage:	distinct

4. MOLY (CALCIUM MOLYBDATE, POWELLITE) CRYSTALS

Of all the crystals I've grown in my days, the moly crystal, powellite ($CaMoO_4$) is the most infuriating. When it works, it's amazing. When it fails, it doesn't even bother to fail spectacularly. When it does work, it produces the most amazing, iridescent stars!

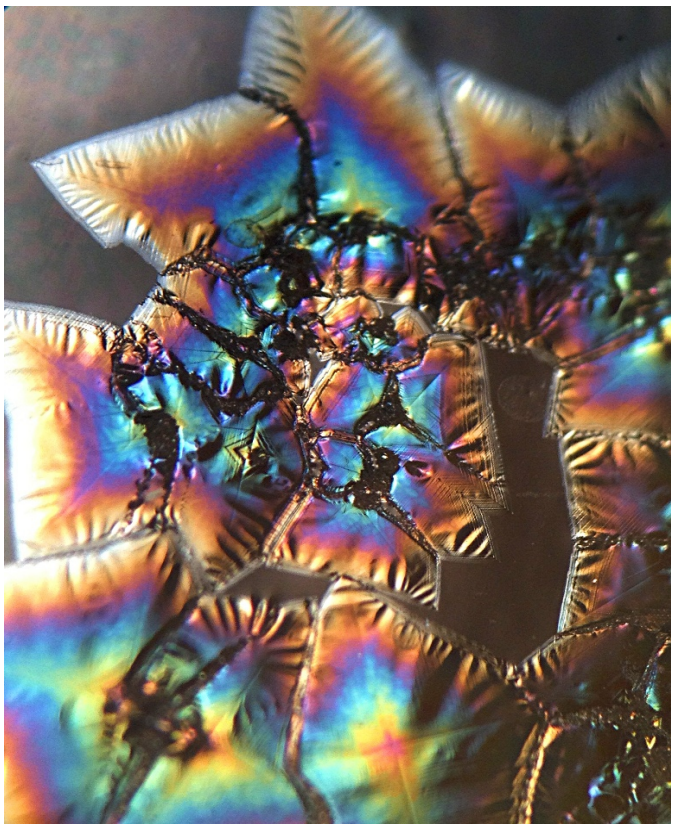


Fig. 4.1. 10x magnification of a set of Moly (powellite) crystals under glancing light.

Molybdenum stars are, on the whole, not large. My firing schedules usually produce them on the range of 1 to 2 cm across, but I have grown them larger (and also smaller, and in their zillions.)

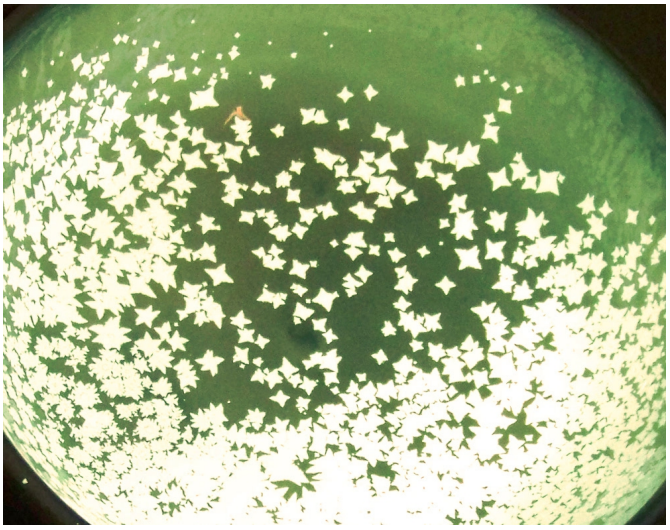


Fig. 4.x. Apropos of nothing, have a bowl of powellite stars under shortwave UV light.

Moly crystals grow mainly by deposition, rather than developing entirely within or atop the glaze as willemite crystals do. Molybdite, the oxide which is most usually used (there are two) has an extremely low melting point, beginning at 795°. It sublimes (goes directly from a solid to a gas) at 1155°. The sulfide does not melt, but directly sublimes at 1185°.

You can use either molybdenum oxide or molybdenum sulfate to grow moly crystals. I have found that the oxide works better, though I really couldn't say why. Trouble is, moly oxide is blazingly expensive nowadays, on the order, at the time of this writing, of about US$8 a *gram!* (Which is really, really strange because I just found some pure molybdenum powder on eBay, $9 for 50 grams!) This is particularly irritating since I live in Colorado, where molybdenum is mined. So, I use the sulfide. One can buy the sulfide (Molybdenite, MoS) either from ceramic materials suppliers, or as a lubricant for small parts. Molybdenite also contains small, but variable, amounts of rhenium, though isolating it is not within the purview of this book.

Moly crystals are virtually invisible at some angles of light, and wildly iridescent at others. Iridescence is caused by the refraction of light, and it seemed to me that the cause of refraction in Moly crystals would be caused by the crystals being made up with a lamellar structure. Then again, I had to wonder... the crystals would be caused by airborne molybdenum in the kiln, and what little remains in the glaze, meeting up with calcium in the glaze—so many lamellae are unlikely. Okay.... out came the microscope, and what I saw was utterly unexpected!

I had always thought I would see clear bands of color that blended into each other, like a rainbow or a nacreous cloud. Well, that's not really what happens. This is what happens:

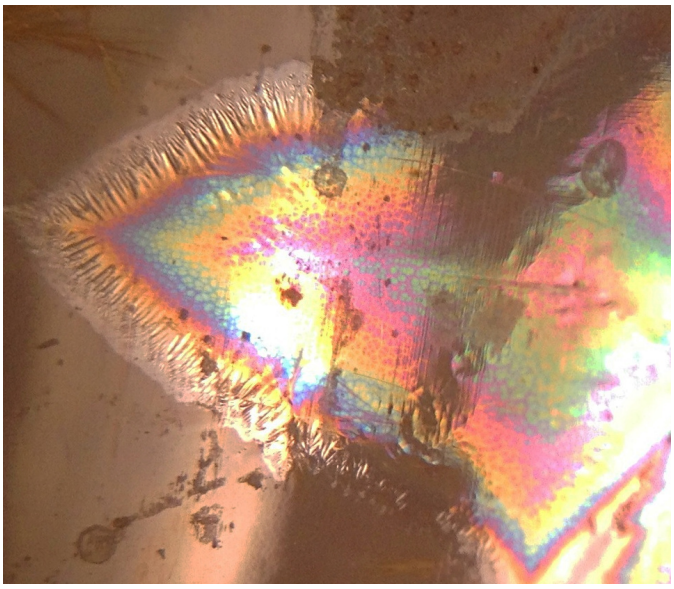


Fig. 4.x. "Leopard Spot" pattern of colors on a large Moly crystal, 30x magnification.

This "leopard spot" pattern is the very last thing I could think of expecting! *What causes it?*

When one looks at a moly crystal, it certainly appears that the crystal is a thin film on the top of the glaze. If this is so, it should be possible to use something harder than powellite, say, almost anything, as powellite is so very soft, to scrape it off the glaze.

So, I tried my Swiss Army Knife.

Difference made: NONE.

The first thing that might come to mind is, "Maybe these crystals aren't powellite after all." Nope, they are, indeed, powellite; that much was confirmed by three different tests, by D. R. Bassett in her 1978 Masters Thesis. So, what else could be going on?

I thought about it for a long time, and finally decided that alas, in order to see what's really going on here, I would have to sacrifice something with Moly on it, break it through a star (didn't want to chance cutting it with the diamond saw as this invariably causes the glaze to chip), and look at it crosswise. What have I got made with Moly that I can bear to part with?

Eventually I found a test tile I could bear to break in half. I couldn't photograph what I saw, the light was just too dim for my camera to produce anything remotely in focus, so here's a diagram:

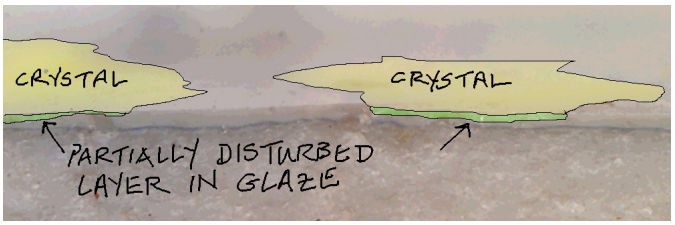


Fig 4.2. Powellite crystal "skin" on a glaze layer, analogous to the skin on on a bowl of My-T-Fine. (If you don't know what My-T-Fine is, you haven't lived.)

The best interpretation I can come up with given the materials and test equipment available to me is that the actual powellite crystals are a "skin," thin film layer on top of the glaze, perhaps but a single molecule thick in places. The disturbed area under the crystal probably results due to the change in glaze composition caused by the crystals selectively utilizing calcium and molybdenum (which has not fumed) from the glaze. In any event, this seems to strongly bond the crystal to the glaze.

You may have noticed that many of the crystals in the photographs shown here are "ripped" down the middle. This has to do with thermal expansion. We're familiar with this in glazes, but we don't give much thought to it in the crystals themselves. So, thinking that the "leopard skin" and wrinkly appearance of the crystals was probably due to the difference in CoE of the glaze versus that of the crystal, I decided to go find out what, exactly, the CoE of powellite was.

It turns out, powellite has two...

Acharney *et alii* have shown that the CaO part of the powellite molecule undergoes very high thermal expansion—specifically ... no, I'll get too technical and you'll all murder me. The reference is in the Bibliography if you want to follow the details, but what it boils down to is this: calcium oxide expands with heat, and molybdenum oxide doesn't. Because of the way the molecules are arranged to form the crystals, they expand along one direction (α_c) at close to double the amount they expand along the other (α_a). Scheelite, which we'll get to in a bit, shares this property.

This got me wondering what the results would be if I made sure I cooled very slowly when firing my Moly wares. If I cooled slowly, could I prevent large moly crystals from ripping?

8888888 tYADA YADA

Now, we face the problem of colorants.

Problem? Yup. Problem. Large problem.

It's hard enough to get moly crystals to grow on a glaze with no colorants in them. Adding colorants just makes you crazy. I twice got the usual moly crystals on a colored glaze. Usually what I get is much more interesting.

Take, for example, this thing.

This is the SRP Moly base glaze with 4% $CuCO_3$ added as a colorant. Matte olive green with flat, potch-opal grey blobs. Makes you wonder if there is actually any powellite in there, doesn't it?

Well, heck yeah there is! Check out the photo in the next column! The same vase under shortwave UV. You know how people collect fluorescent minerals? Maybe we should start collecting fluorescent pottery, because under shortwave, this thing is a trip!

Other colorants react with moly in various ways. Iron causes a whole new crystal, iron molybdate, to form, as well as a few of the usual—but small—moly crystals. There is almost no fluorescence. Cobalt encourages the formation of cobalt molybdate, a synthetic mineral, which is green, of a sort.

Copper is a little trickier. Sometimes it gives the response above, and sometimes one gets many, relatively large, but very wrinkled, crystals, as below:

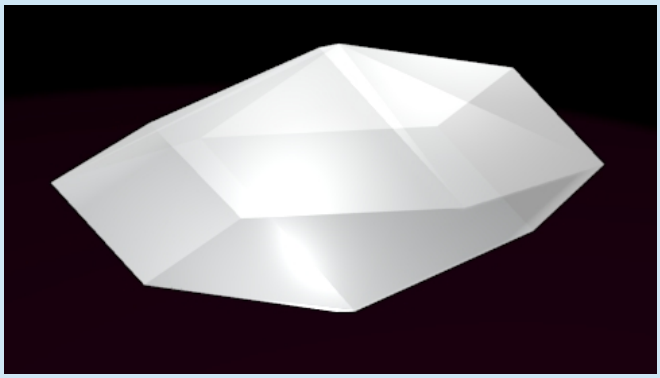
Fig. 4.X. Copper carbonate, and perhaps a touch of chrome, in a molybdenum glaze.

A small amount of copper sometimes gives the result above and sometimes gives Something Completely Different. In the photo below is a little vase made with 3% copper carbonate and fired in a slow kiln. There are a few of the usual moly crystals on the surface, but the entire piece is covered with these almond-colored dots.

I've gotten these with other colorants as well, most notably vanadium. Don't have a clue what they are. I originally thought they may be another form of powellite but they don't fluoresce.

While I'm on the subject, for those of you with a lively curiosity, perhaps I should delve a bit into the phenomenon of thin-film iridescence and exactly how it works. Knowing how it works may give you some ideas of other ways to get it.

SPHENE/TITANITE



a.k.a.	Calcium Titante. "Sphene" is the common term for the gem form of this mineral.
Formula:	$CaTiSiO_4$
Mol. Weight:	197.76
Color:	None, ruddy, greenish
Fluorescence:	LW: none SW: weak brown
Hardness:	5.5
Streak:	dull pink
Lattice:	Monoclinic-Prismatic
Habit:	in nature, fine-grained crystals; in glaze foliated, spreading
Density:	3.48 on average
Fracture:	sub-conchoidal
Cleavage:	distinct to imperfect

5. SPHENE/ TITANITE (CALCIUM TITANATE) CRYSTALS

"Sphene" is the name for gem-quality, colored titanite, $CaTiSiO_4$. These gems are olive-green to lemon-yellow to amber-red, colored with traces of aluminum and iron, and usually heat-treated to strengthen the colors. While the glazes I've come up with don't produce gemstones, they sure produce some lovely gems of pots!

Ramekin made by Suann Lester at the 2014 SRP Workshop. Absolute perfection in Sphene, to my mind. Copper carbonate color.

I've been getting Sphene crystals as ancillaries in crystalline glazes for twenty years, but it was only in 2013 that I began coming up with recipes meant deliberately to grow them. Many people don't see the point in bothering; sphene crystals are not nearly as showy as zinc silicate crystals. In order to really appreciate them, you need to take a good close look at a pot. Their colors can be subtle (muddied, someone once said) and they don't generally show growth rings, possibly due to their size. But they have a magnificent presence all their own, and personally, I enjoy the heck out of them.

I got the idea to try to grow titanite crystals one day when it occurred to me that if the basic recipe for the FF 3110 zinc-silicate glaze was 2 Frit : 1 Silica : 1 Zinc Oxide, what would happen if I substituted everything else in the studio for the zinc? Well, almost everything failed—well, failed to be interesting, at any rate—with the major exceptions of calcium carbonate (see the section on wollastonite glazes) and titanium dioxide. With the titanium, I was expecting to get lots of rutile crystals, and I was quite surprised then this turned out not to be the case.

Fig 5.2. Sphene crystals in a pool of glaze, showing the characteristic shape of sphene crystals as they grow in nature.

Well, clearly it wasn't rutile, so what was it? A quick look at the empirical formula gave me the clue: lots of calcium! So... off to WebMineral.com I went to see what might match what I was seeing, *et voilà!* There it was.

In Fig. 5.2, of a sphene variant by Evan Cornish-Keefe. you can actually see the crystal facets in these titanite crystals. But there's something odd going on here...

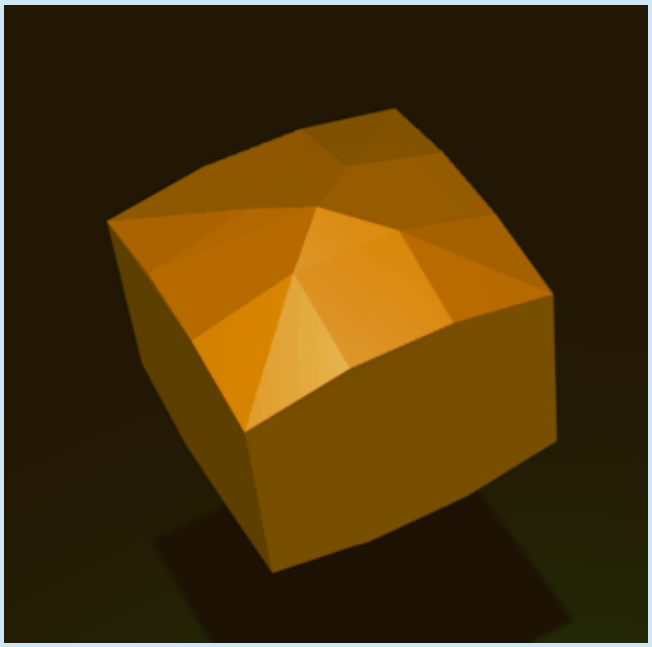
This photo, and many others I have, illustrate something about sphene crystals that I find incredibly curious: they tend to grow upright if grown on a tile, or on the bottom of a bowl. If you look at other crystals (hatrurite shows this particularly well), you'll notice that the orientation at which the crystals align themselves in the glaze layer doesn't really matter; they will point in just about any direction in which the seeds happened to form. Sphene crystals definitely prefer to grow upright on their long axis, or, perhaps, perpendicularly to the surface of the glaze where the glaze pools. The common shapes one sees on the surface of a sphene glaze are just the crystals becoming wider and wider until they run into one another.

Fig. 5.3. Transparent sphene and wollastonite crystals.

Here's another photo (Fig. 5.3), this time of a test tile (fired on end so you're looking down onto a wall) of the same glaze with no colorant, which shows something one rarely sees in crystals in glazes— glaze-crystal shapes which sometimes match, almost exactly, the "perfect" shape of the crystal. Unlike the previous photo, these crystals are oriented in the direction of flow of the glaze (to the lower right). It is vitally important to remember that almost all glazes designed to grow Sphene crystals will grow Wollastonite as well—or, sometimes, exclusively, depending upon thickness of application and colorant. Sphene and wollastonite crystals are easily distinguished by their shapes, with sphene being pointed and wollastonite typically being decidedly rectangular, often with long, arcing lines through them. More about this anon.

So far, my experience with colorants has been that Sphene takes all of them without complaint. I haven't tried stains with it yet, although I have used them over red-stained slip and the glazes work well.

RUTILE



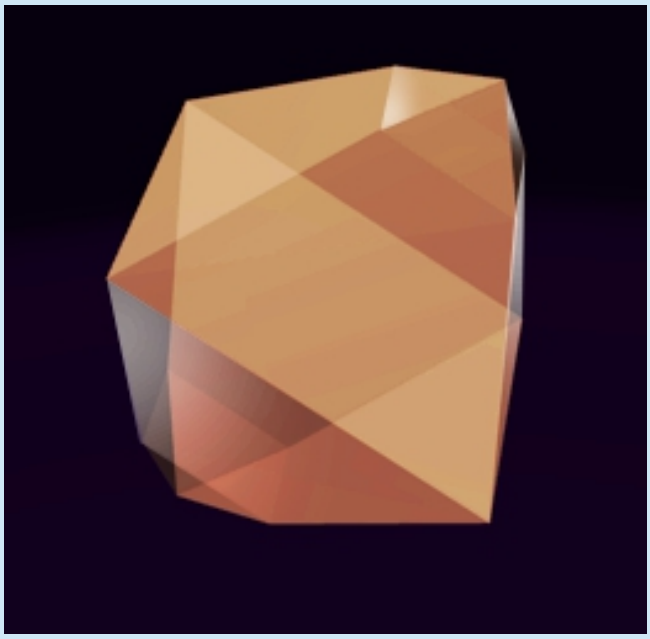
a.k.a.	Titanium dioxide
Formula:	TiO_2
Mol. Weight:	79.88
Color:	bronze-gold to red
Fluorescence:	none.
Hardness:	6
Streak:	dark grey
Lattice:	Tetragonal - Ditetragonal-Dipyramidal
Habit:	in nature, and glaze, acicular. In nature, very rarely granular or prismatic.
Density:	4.25 on average
Fracture:	flat, uneven
Cleavage:	distinct

6. RUTILE CRYSTALS

Rutile! Why not! We use a boatload of titanium in almost all of these glazes, so why not let it do its own thing?

I have only once seen in person rutile growing outside a matrix—generally quartz—and that sample, alas, wasn't for sale.

SCHEELITE



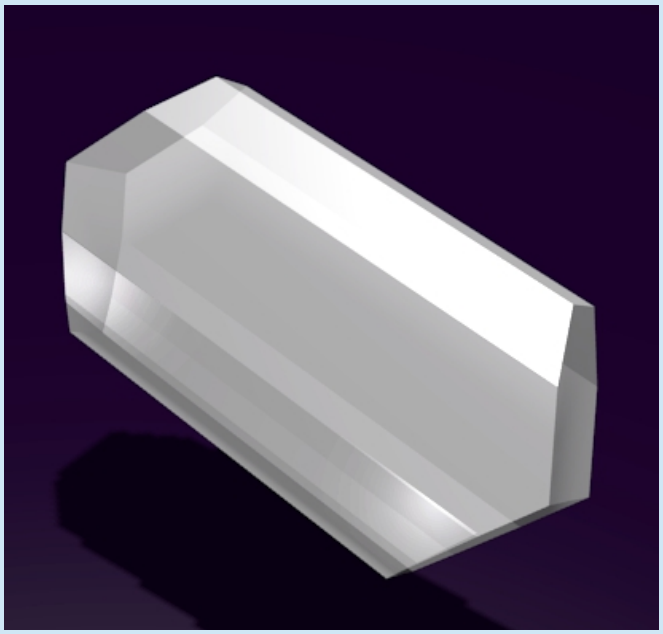
a.k.a.	Calcium Tungstate. "Sphene" is the common term for the gem form of this mineral.
Formula:	$CaWO_4$
Mol. Weight:	287.93
Color:	pinkish-orange
Fluorescence:	LW: none SW: electric blue
Hardness:	5
Streak:	white
Lattice:	Tetragonal-Dipyramidal
Habit:	in nature, columnar or massive; in glaze, massive, often in mounds.
Density:	3.48 on average
Fracture:	flat, uneven
Cleavage:	distinct

7. SCHEELITE CRYSTALS

Jon Singer gave me the idea to try Scheelite. He said he got the idea from Oliver Sachs. Wherever it came from, it's a great idea! Scheelite Crystals are way, way cool! Also fluorescent! On the other hand, tungsten oxide can be hard to come by, alas. Or keep. A friend once gave me a large amount of tungsten metal to make the oxide from. Alas, on my way home, the TSA relieved me of it. Probably sold it on eBay, the creeps. I swear, you need to fail an IQ test to work for the TSA, but I digress. Tungsten oxide is a greenish-yellow powder (beware, many sellers will try to substitute stuff—you want a pale olive green), and usually pretty expensive, especially if one is ~~cheap~~ thrifty. But it's worth it for the results!

I have grow scheelite crystals by themselves and along with willemite. If you are new to tungsten, you might want to try it as an additive to your favorite willemite glaze first. In its own glaze, scheelite appears as mounds of small crystals, like islands floating in the glaze.

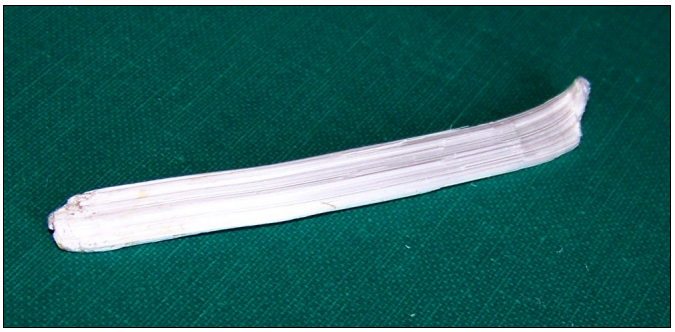
WOLLASTONITE



a.k.a.	Calcium Silicate.
Formula:	$CaSiO_3$
Mol. Weight:	116.16
Color:	grey, yellow, white
Fluorescence:	LW: none SW: electric blue
Hardness:	5
Streak:	white
Lattice:	Triclinic-Pinacoidal
Habit:	in nature,fibrous or radial; in glaze, fibrous, tabular.
Density:	2.85
Fracture:	splintery
Cleavage:	Perfect to good

8. WOLLASTONITE CRYSTALS

You can add powdered wollastonite to your glazes as a source of calcium. Or you could grow "Wooly" crystals because ... because you can!



Here's an actual wollastonite macro-crystal about 10 cm long. Interesting, isn't it?

Glaze recipes which produce sphene crystals often produce—and under some circumstances may only produce—wollastonite crystals. Why not? All the ingredients are there.

9. Chrome
10. Manganese

11. Tea-Dust (Pyroxenes)

12. AVENTURINES

When I was a kid, Duncan used to make a Δ04 aventurine called "Amber." I adored that stuff! Beautiful depth of color and SPARKLIES! What could possibly be bad?

Well, what was bad about it was that they stopped making it.

So I have had to come up with recipes of my own.

There are all kinds of things that look like aventurines, but in this section I'm going to stick with things that are technically aventurine. For purposes of sanity, I'm going by the definition of an Aventurine as something that produces small crystals in the body of the glaze, causing the glaze to sparkle.

Why is it called aventurine, anyway? Because it's said to resemble a mineral called aventurine or sunstone, a feldspar. Out here in Beautiful Downtown Metropolitan Hygiene, Colorado, dirt roads are paved with the stuff. Here are some I picked up this morning while walking the dogs.

Wait a minute, you are probably saying. No, they don't look like the sunstone beads you might have seen at bead shops, if you frequent such places. Those are costume jewelry. This is magnesium-rich K-Spar.

13. OIL SPOTS

Oil Spots are crystalline? Yup! In most cases, they are crystals of hematite. Take a look!

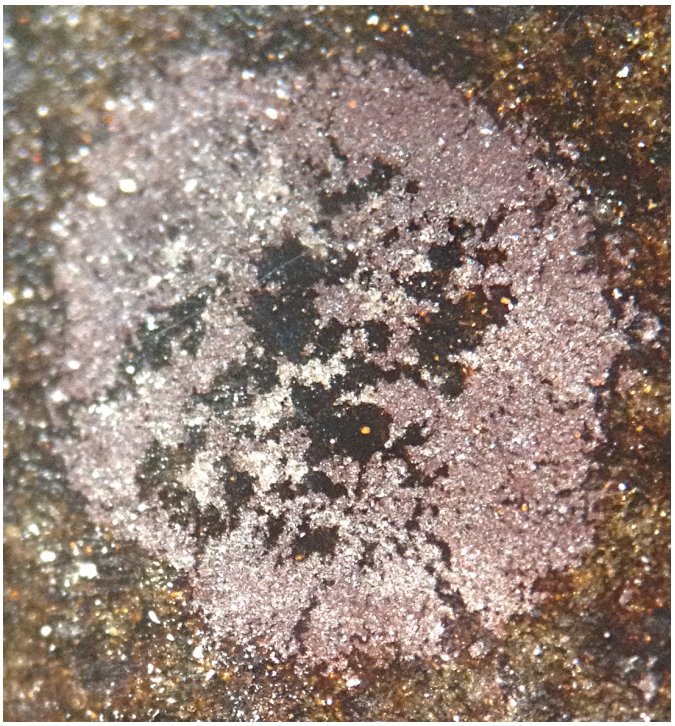


Fig. X.X. 30x magnification of an oil spot.

This is a 30x magnification of a single oil spot, showing the individual, though very small, crystals. You can just make out that the spot consists of small platelets of hematite, Fe_2O_3. This photo is of an oil spot on a piece that was fired with willemite, and you can see that various other crystals have also formed.

Oil Spot glazes are not as flamboyant as zinc silicate but they can be just as touchy and as mesmerising in their own way. In general, what one gets is a very dark brown or black glaze with silvery or reddish spots, but many other effects are possible with a little patience and experimentation.

Any glaze that has a very high proportion by dry weight of metallic oxide can produce the oil spot effect, but by far the most commonly used oxide is hematite, or Red Iron Oxide.

Two things happen when these glazes are fired. Firstly, some of the RIO you put in the glaze combines to form hematite crystals. Hematite's density is pretty much the same as the melt so given its druthers, it would prefer happily to stay suspended in the glaze. Secondly, some of the hematite breaks down so:

$$Fe_2O_3 \rightarrow 2FeO + O$$

For those of you who haven't read *Chemistry for Crystallieri,* that means that the iron reduces and an oxygen atom is given off. *(WARNING: OVER- SIMPLIFIED EXPLANATION FOLLOWS:)* Oxygen absolutely hates being alone, and would rather be O_2. Soon plenty of these O_2s get together and form a bubble. The bubble rises to the surface of the glaze and in doing so, the surface tension of the bubble causes any hematite crystals that touch it to come along for the ride. They are then left on the surface, where being flat little plates, they float.

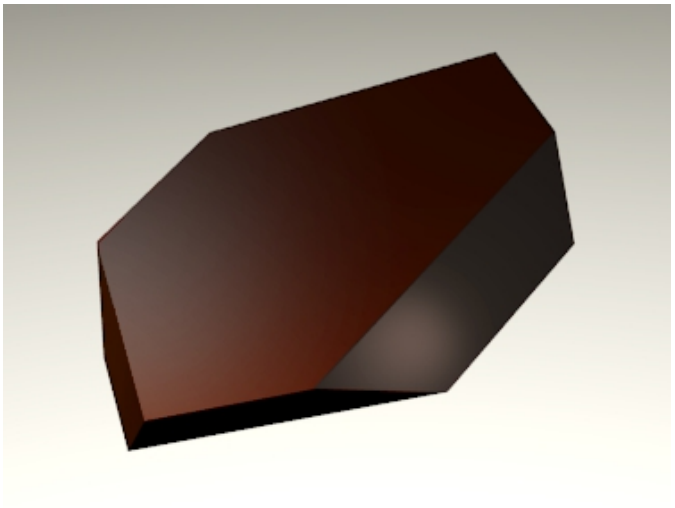


Fig. X.X. A single hematite crystal. They're usually flatter than this, but I expanded this one to show detail.

This keeps happening, over and over again. Bubbles tend to rise following the path of least resistance, keep depositing their little plates of hematite in roughly the same spot, making that spot ever larger.

Fig. X.X. The Oil-Berry Bowl. The first of a new glaze is always named and saved. This was made with slip from the Knik Glacier in Alaska, with a bit of crushed beryl powder mixed in because I had some and why not? The color of the oil spots changes as the angle of light changes.

I call the bowl above the "Oil-Berry Bowl," and it's cool because the oil spots change color as you hold it to different angles of light, as in the illustrations at the upper right. In direct light, the spots are a steely-silver. At more oblique light, the oil spots become increasingly pinker—the shade in the photograph is about their maximum shade.

Just about all oil-spot glazes do this to some extent, partially because hematite itself is pleiotrophic (it refracts light of different colors in different directions, though not as strongly as some minerals, such as Alexandrite, do). Part of the reason is a very slight structural color due to the size of the individual crystals. Some depends on colorants you may feel like adding to your glaze.

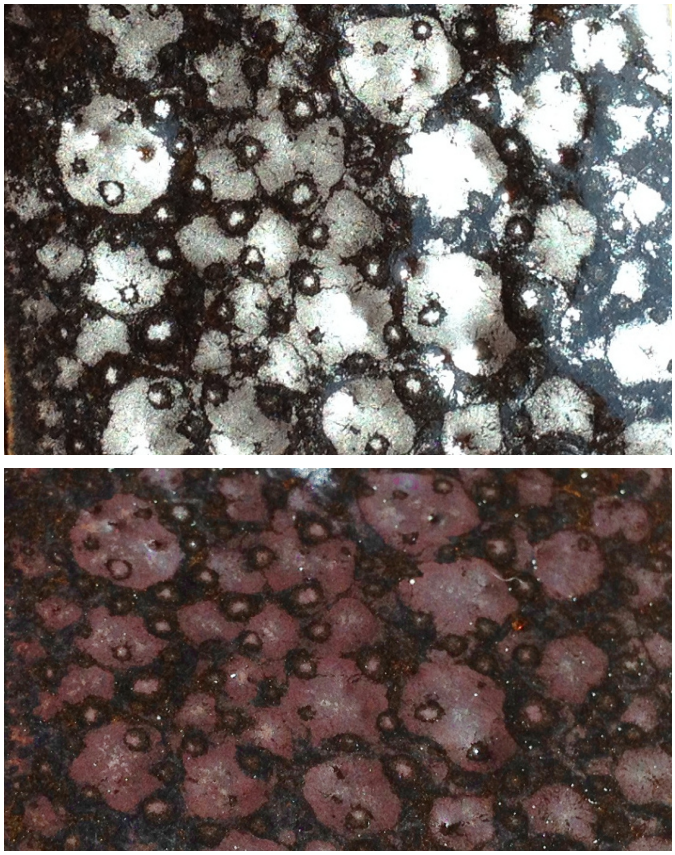


Fig X.X. Colors of the spots on the Oil-Berry Bowl in direct (top) and indirect (bottom) sunlight. Yes, the difference is real!

One can make oil spot glazes out of all sorts of things, but local slips often give the most satisfactory result. Slips can be found wherever there is shallow, slow-running water, and their composition varies enormously. Some will require that you add extra iron oxide, and some, like the Knik Slip I use, does not. They're all worth trying, because you never know!

14. TENMOKU

First, is it “tenmoku” or “temmoku?”

Well, as someone who married into a Japanese family whose name demonstrates the phenomenon, and speaks just enough Japanese to make a complete ass of herself overseas, let me explain.

In Japanese, except for doubled consonants, the only consonant which may come before another consonant is “n.” Our name is actually *Shin* (“new”) *bo* (“to keep, to maintain”). However, when speaking fast, it’s common practice to change the “n” sound to “m,” especially before a “b” or a “p” probably because it’s just easier to do. So if you want to get technical, it’s transliterated *shinbo* or *tenmoku* but pronounced *shimbo* or *temmoku.* When Bob’s grandfather immigrated to the United States, he decided that this branch of the family would spell our name “Shimbo” to differentiate us from a “Shinbo” family which was already here. As for me, I transliterate it *tenmoku*. I also call the thing we fire in a kilN, not a kill, because to me, both of those words sound cooler that way, and as for my own ethnicity, I am a genuine, Brooklyn Mixed-Breed Geek Girl.

Then, there’s the question of, no matter what you call it, what actually *is* it?

Well, I searched around for a definition that everyone seems to agree on, and never found one. So the definition I’m going to use here is, “a broken, brown, high-iron glaze which is neither oil-spot, hare’s fur nor tea dust, but which contains a variable amount of crystalline features.” That’s my story and I’m sticking to it.

15. Matte Glazes

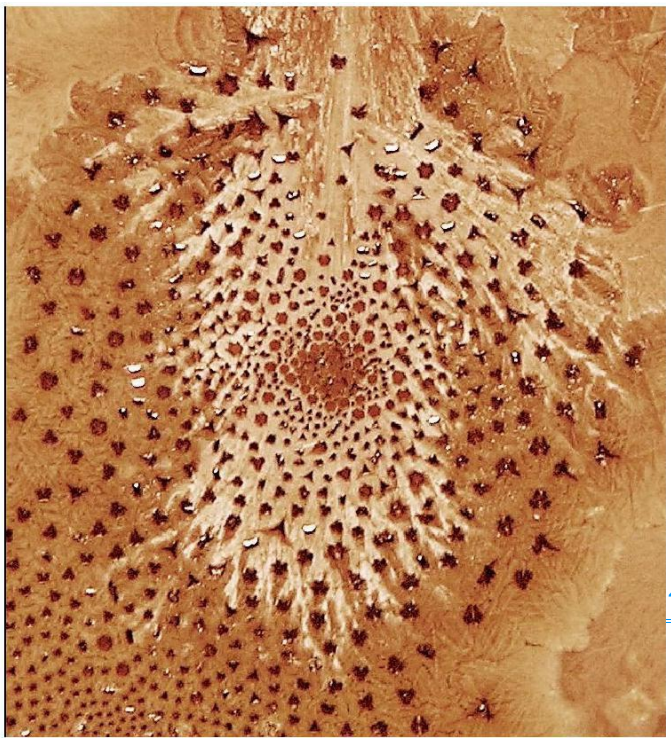
16. ANCILLARIES

Ancillary crystals, also known as secondary crystals, "a big mess" and "those stupid things," come in an enormous variety of forms, some of which I *think* I have tentatively identified (until someone gives me an EDS machine for Chanukkah alas I won't know for sure).

These crystals are usually quite small, often extremely numerous, and always intriguing when seen under a microscope. Sometimes you get them regularly, one might almost say, inevitably, some only under certain conditions. So far, I haven't come up with a way to grow them specifically. But I will. After all, titanite and wollastonite crystals were "just ancillaries" once. Here's a selection of these.

}HATRURITE (Calcium silicate, Ca_3SiO_5)

Hatrurite. It's funny stuff. At high soak temperatures, it gives a beautiful, "gemmy" amber to maroon crystal. There seems to be a very specific "breakpoint," however, when these crystals suddenly leave their beauty behind and... well, they seem almost to grow hair (or, perhaps, another kind of crystal grows attached to them?).



For reasons of which I'm not sure, hatrurite seems to grow most readily in glazes high in manganese. I have seen it elsewhere, but only rarely. There must be something about manganese that encourages these crystals to grow.

Above, hatrurite crystals which grew on a plate. The glaze is Bory 1 with 3% manganese dioxide added for colorant. Below, perfect (computer generated) crystals showing some of the various orientations that produce the shapes seen above.

Hatrurite crystals are always colored, and this is so in nature as well.

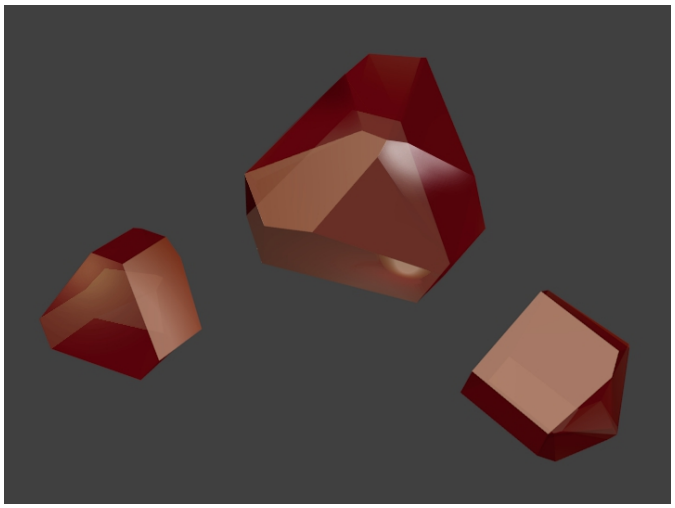


Fig. X.X. Three views of a perfect crystal of hatrurite.

As you can see from the photomicrographs, these crystals grow in a specific and interesting way—they seem to radiate out fro a central point, appearing to push each other out of the way as more grow. What appears to be happening is that many hatrurite crystals form on one small spot together. After they have formed, cristobalite (about which more anon) begins to grow on the hatrurite crystals, pushing them

apart, outermost ones first. The same thing seems to happen with fayalite (about which more anon, too). Reminds me of the universe expanding.

Here are some really cool hatrurite "birds" by Evan Cornish-Keefe. What you're seeing are the tops of the crystals, with the main body of each crystal. submerged in the opaque glaze.

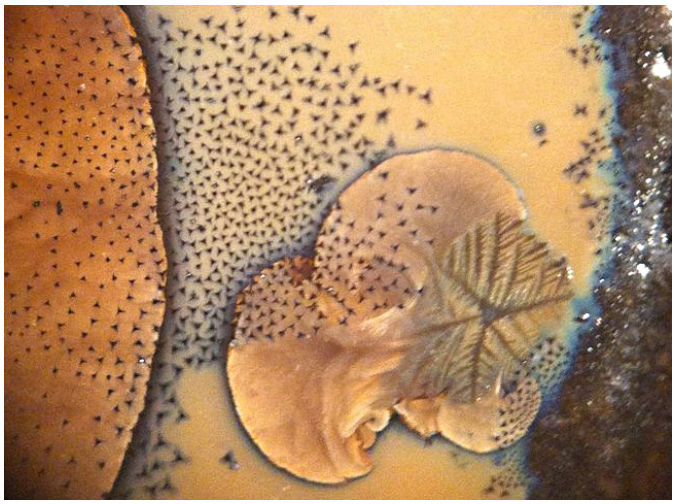


Fig. X.X. A flock of partially-submerged hatrurite crystals, with a zince silicate and a tröostite crystal thrown in for good measure. The triangular shape is indicative of hatrurite. Compare these with the hexagonal stars of fayalite, below. Photo: Evan Cornish-Keefe.

Very occasionally, and if one is lucky beyond the dreams of avarice, one gets "gemmy" hatrurite, and in this case, nearly a hatrurite aventurine. Just imagine! I get gemmy hatrurite very rarely, and I once got these (photo at right). I will now go off and try to get them again, and bigger!

It should be kept in mind that hatrurite is a calcium silicate, and while it is always some shade of amber, it can be further tinted by whatever colorant you use in a glaze. It probably occurs in a great many different glazes, I just haven't noticed them there yet. I'll have to check my catchers. (This is one good reason to keep old catchers around somewhere. Especially if you write on them what the glaze you used was, they can teach you a lot! Just keep in mind they're sharp.)

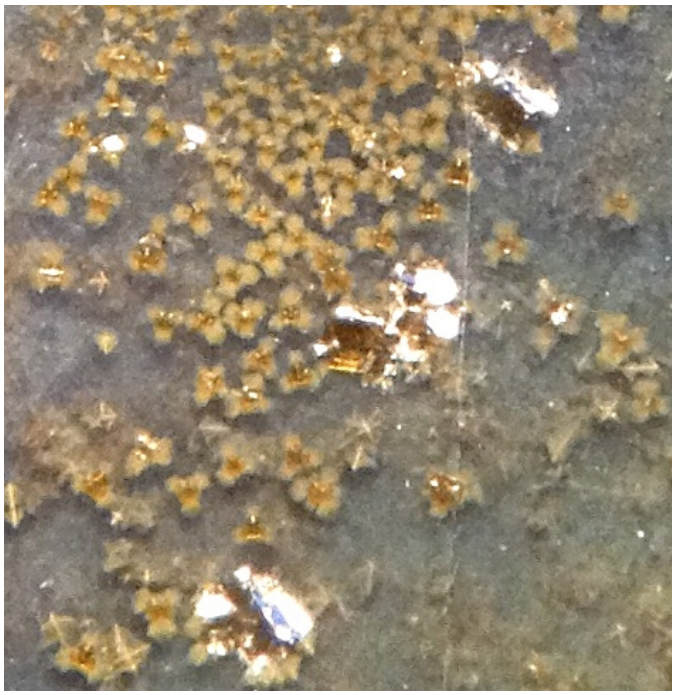


Fig. X.X. 30x magnification of hatrurite crystals in a glaze colored with a very small amount of manganese. A couple of them have grown quite large. Makes one wonder...

}FAYALITE (Iron Crysolite, Fe_2SiO_4)

High-iron glazes often produce crystals of fayalite, as tiny, very dark six-sided "snowflakes" or sometimes in long, thin needles resembling rutile or ilmenite.

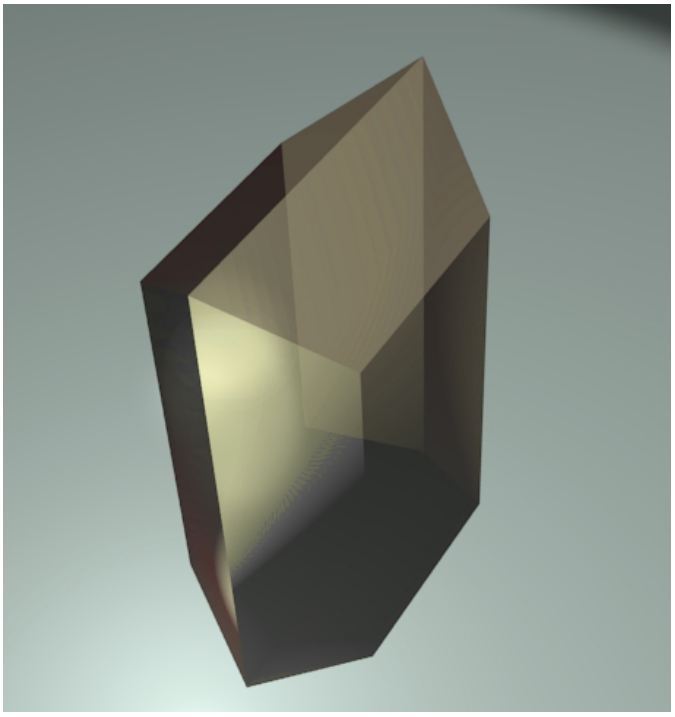


Fig. X.X. A single fayalite crystal. In nature they are this transparent only if very, very small, but this should give you an idea of the shape.

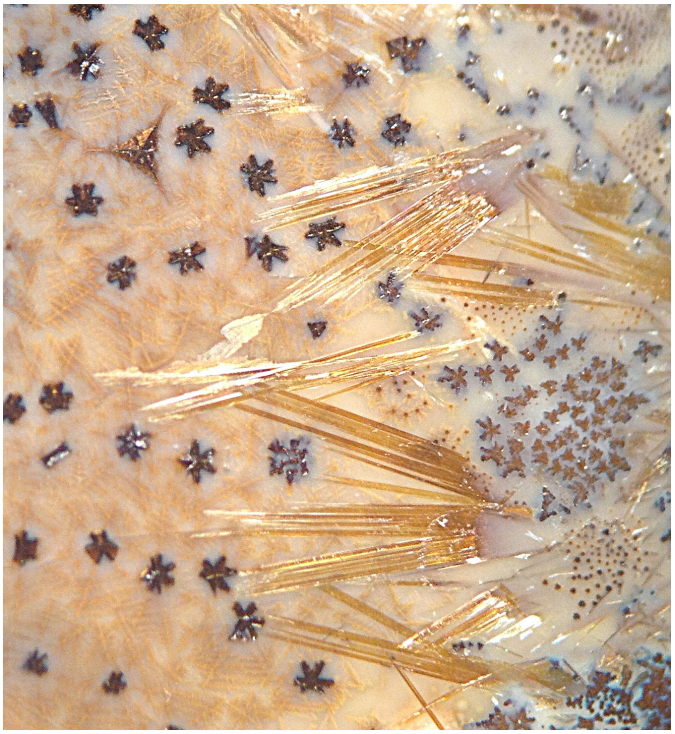


Fig X.X. Fayalite stars. This hexagonal twinning is the norm for fayalite in a glaze. Also visible are cristobalite and rutile crystals.

Fayalite looks very similar to hatrurite at first glance, largely due to the way it forms, in small, spreading "clouds." It is different, though, both in color and appearance, as well as composition, with hatrurite being colored by manganese and usually transparent, while fayalite is colored by iron and almost always opaque.

Nevertheless, it is important to remember that both of these minerals might be found in an iron-bearing glaze. In the photo below left, the little hexagonal stars show clearly. Also visible in this photo are rutile and cristobalite crystals, and at least one large hatrurite crystal (upper left).

}CRISTOBALITE (Silica polymorph, SiO_2)

Cristobalite stumped me for a long time. It has a great number of different forms, and resisting the urge to get technical, the one we usually see is, I think, b-cristobalite. In any case, it takes a very characteristic form as it grows in a glaze, like a pyramid with every other layer left

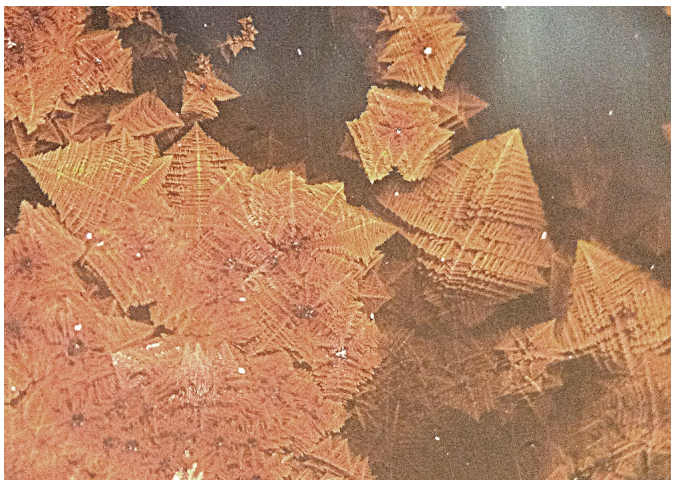


Fig. X.X. Pyramids of cristobalite growing in a high-iron, high-titanium glaze.

out.

Cristobalite is a polymorph of quartz. Silica can take an enormous number of crystalline forms, depending upon the environment in which it grows. I've found cristobalite most likely to grow in a glaze where titanium, iron and/or nickel is present. Why these conditions? No idea.

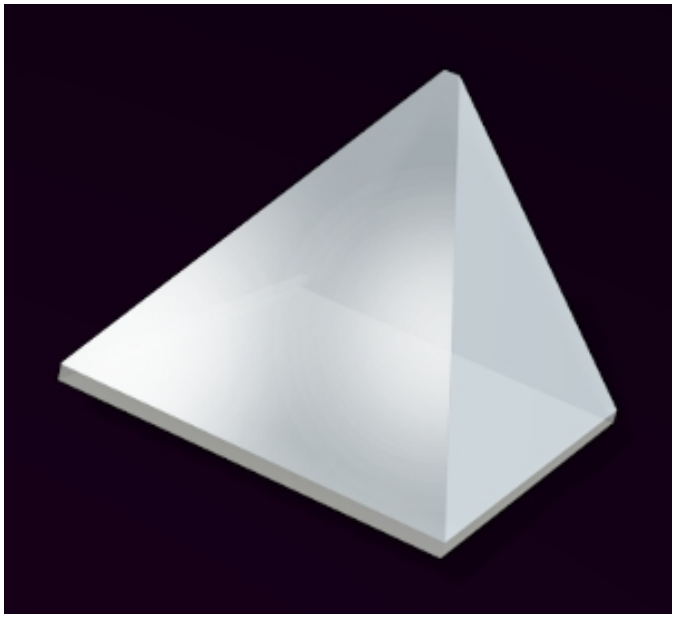


Fig. X.X. Natural form of cristobalite.

Cristobalite can grow by itself, as in Fig. X.X., but more usually I see it surrounding hatrurite and fayalite. Both of those appear to grow at high temperatures/viscosities in a glaze, and stop when a certain point is reached. Very often (but not always), cristobalite will seed itself onto these crystals and grow, pushing them apart.

KOTOITE (Magnesium Borate, $Mg_3B_2O_6$)

Here's another ancillary that puzzled me for the longest time. It doesn't contain molybdenum normally, but I can grow it reliably in Moly glazes when they are fired with other crystalline wares. They are produced in glazes with almost all colorants, but the best ones (or at least the "loudest" are those in nickel and copper-bearing glazes. No matter what colorant is used in the glaze, kotoite crystal masses appear white, or at best very pale. I think this is the "sugar phenomenon;" the crystals are actually transparent, but so small and so crowded together that light reflecting off their many small surfaces makes them appear white. No matter what, they're pretty cool.

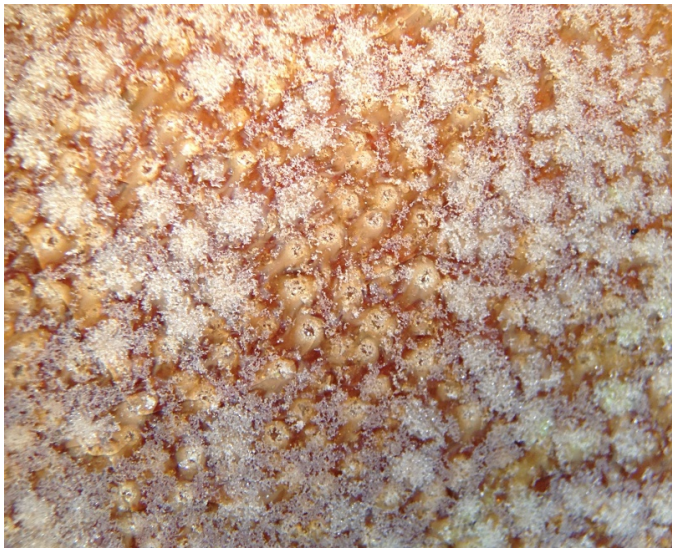


Fig. X.X. Kotoite masses bubbling through a glaze. The entire piece was uniformly covered with them. The glaze was colored with nickel oxide.

In nature, and in glazes, it forms as distinct masses of miniature crystals. The masses typically range in size from 1 to 3mm in diameter.

Kotoite crystal-masses sometimes do break the surface of a glaze, and spatter crystals on the top. I guess this makes such glazes technically oil-spot glazes, but I think most people would find that these crystals are way too small (though still easily visible) to qualify as such. Overall, the

glaze is lightly textured.

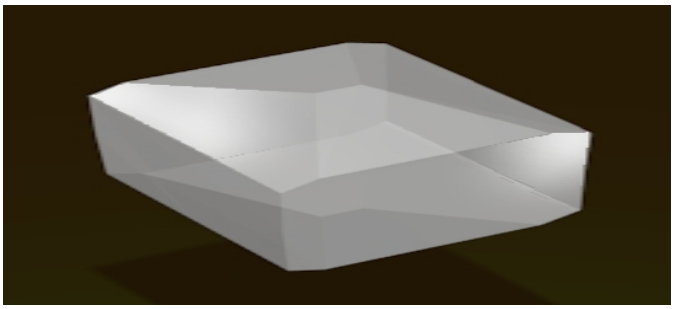
}LIEBENBERGITE (Nickel Magnesium Silicate, $(Ni,Mg)SiO_4$)

Liebenbergite occurs so reliably in some nickel-bearing glazes that one can actually grow them to a respectable size and with relative ease. I even have a beautiful piece with Liebenbergite as its only crystals, at least on the top (this side) of the piece.

Fig. X.X. Plate with a nickel glaze, showing a fine collection of liebengergite crystals.

While nickel glazes seem to encourage ancillaries of just about every kind, liebenbergite is the only one which fluoresces red to orange. The crystals on the piece below do that, but you'll have to take my word for it. The fluorescence is too weak for my camera.

I have found two ways to encourage the growth of liebenbergite ancillaries. One is to use a glaze high in lithium—Celestite (see Recipe Collection) will do. Another seems to be to leave the nickel glaze wet in a jar for a month or so. The longer one leaves the glaze, the more crystals.



Liebenbergite crystals generally appear as having a shape very similar to that of wollastonite. Wollastonite does not usually form the circular flowers one sees on the picture at left.

}TRIDEMITE (Silica polymorph, SiO_2)

Tridymite crystals can appear in almost any glaze, and I se them often in rare-earth glazes. They show up as little, sparkling stars that lie entirely on the surface of a glaze, and are most likely to form where the glaze is thick. Their dark red fluorescence gives them away, but keep in mind, it's a weak fluorescence and difficult to see.

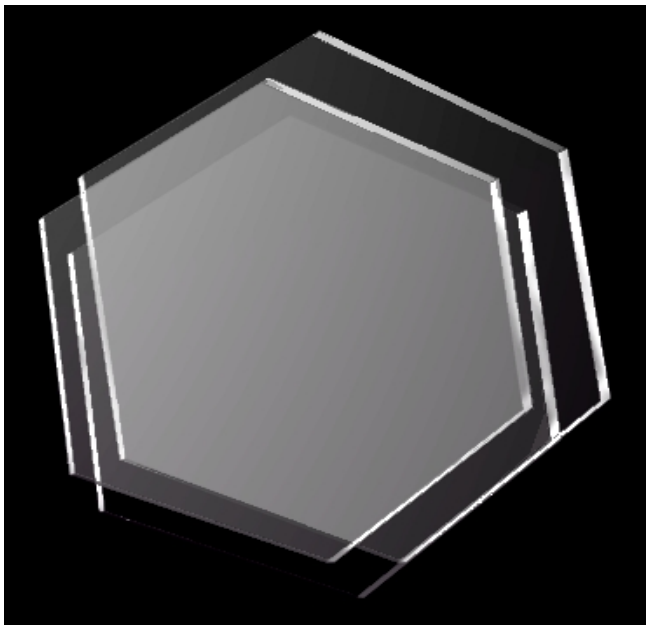


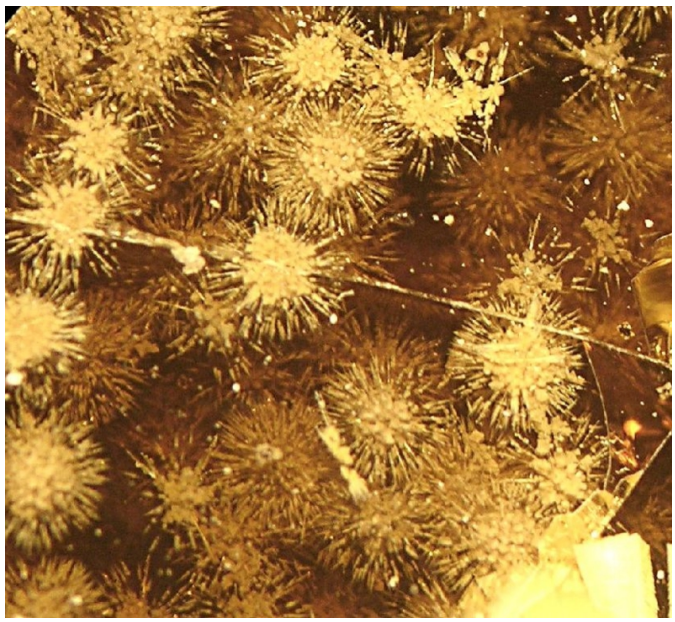
Fig X.X. Tridymite prefers to grow in overlapping plates, in both nature and in glazes.

Tridymite's exact shapes are temperature dependent, but they all share a basic feature: they are extremely brittle and crack readily. Because of this it often seems they have opaque centers; this is a refraction phenomenon.

Fig. X.X. Tridymite "flowers" surrounding a willemite crystal.

And those are the ancillaries I have tentatively identified. I may be entirely wrong—should better information arise, I would love to have it! I'm easy to find. I'm the Only Fara Shimbo On The Internet, after all. So if you find something, tell me!

Are these the only ancillaries one can grow? Heck no! There are plenty that I've gotten over the years that I still haven't a clue what they are. These "sea urchins," for instance. I grew them in an iron-manganese glaze, several times. What are they? No idea. Not a clue. I got nuthin.'



On the following pages is a shortened version of an Ancillary Crystal Guesser I made up in 2014. These are by no means the complete list of crystals you could hypothetically grow, but I included the majority of them because they are identifiable by their fluorescence, which is probably the most reliable test lay-folk can employ. "Massive" means that the mineral is seldom or never found as identifiable crystals in nature. "Microscopic" means that crystals of this mineral require a microscope to see, obviously. If you would like more information on these minerals, might I suggest this cool new thing called the Internet!

☞THE SHIMBO RESEARCH POTTERY☜

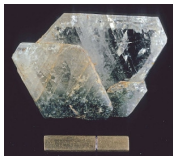
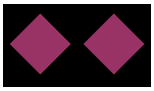
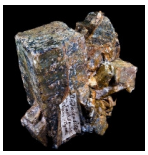
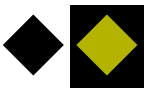
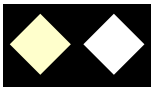
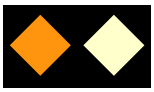
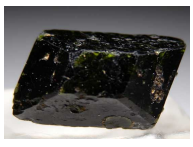
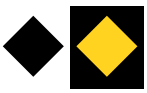
HANDY-DANDY

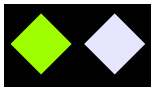
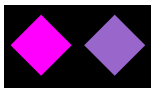
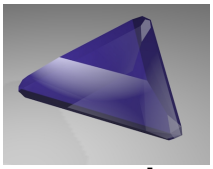
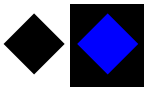
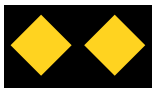
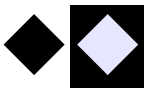
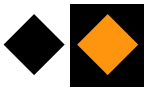
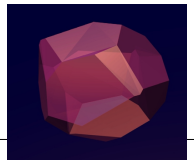
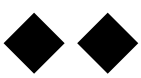
CRYSTAL IDENTIFICATION GUESSER!

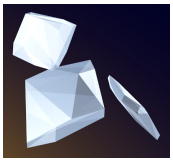
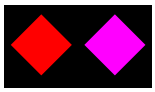
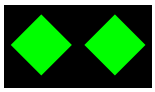
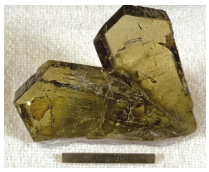
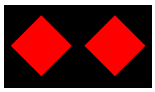
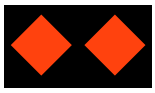
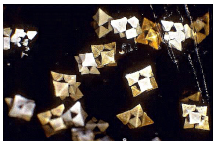
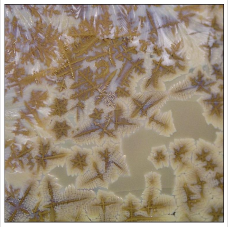
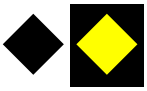
COLLECT THEM ALL! BE THE ENVY OF ALL AROUND YOU!

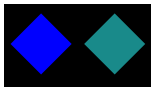
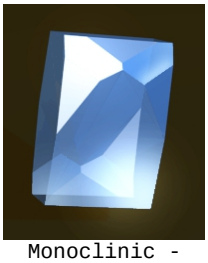
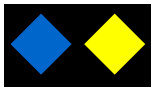
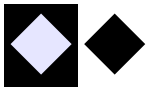
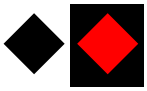
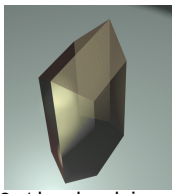
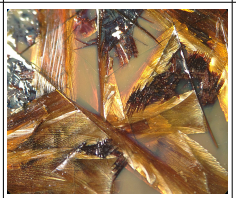
Check off the boxes in the rightmost column as you find a match. Find all of them?

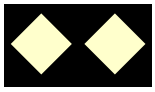
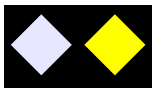
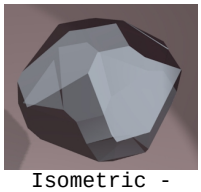
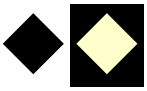
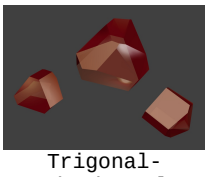
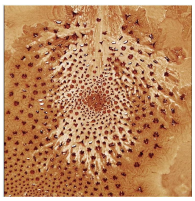
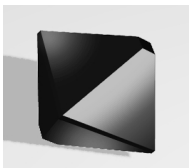
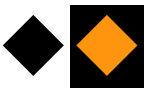
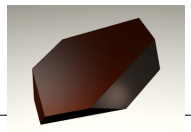
You win!

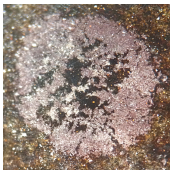
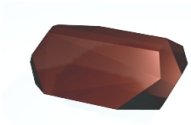
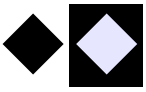
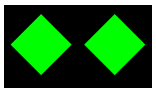
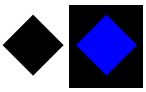
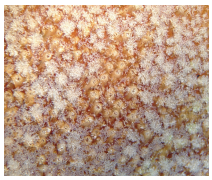
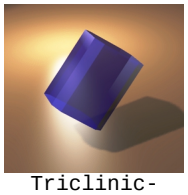
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
ALBITE Sodium Aluminum Silicate	 Triclinic-Pinacoidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
ANDALUSITE Aluminum Silicate	 Orthorhombic-Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
ANORTHITE Calcium Aluminum Silicate	 Triclinic-Pinacoidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
ANORTHOCLASE Sodium-Potassium Aluminum Silicate	 Triclinic-Pinacoidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
AUGITE Clinopyroxene with Iron, Titanium and Manganese	 Monoclinic-Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

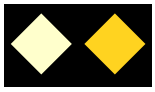
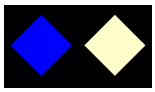
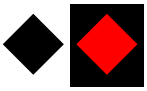
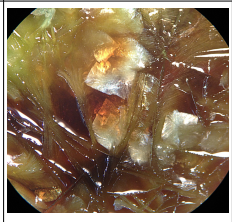
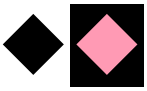
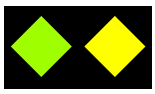
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
BANALSITE Barium Sodium Aluminum Silicate	 Orthorhombic-Pyramidal	massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
BARYLITE Barium Beryllium Silicate	 Orthorhombic-Pyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
BENITOITE Aluminum Silicate	 Hexagonal-Ditetragonal Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
BERYL Beryllium Aluminum Silicate	 Hexagonal-Pyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
BRANNOCKITE Potassium Lithium Tin Silicate	 Triclinic-Pinacoidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
BRAUNITE Manganese Silicate	 Monoclinic-Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
BROWNLEEITE Meteoric Manganese Silicate		Microscopic	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

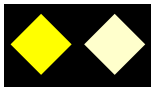
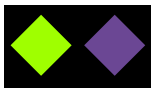
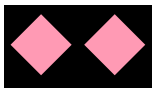
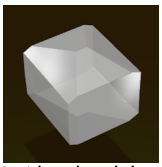
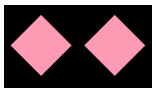
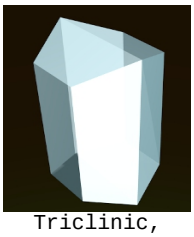
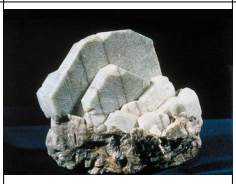
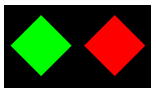
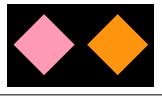
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
	Isometric-Tetroidal				
BUSTAMITE Manganese Calcium Silicate			Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
CHKALOVITE Sodium Beryllium Silicate	 Orthorhombic-Pyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
CHRYSOBERYL Aluminum Silicate	 Orthorhombic-Pyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
CORUNDUM Aluminum Oxide; Sapphire, Ruby	 Trigonal-Hexagonal Scalenohedral		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
CRISTOBALITE Silica Polymorph	 Tetragonal-Trapezohedral				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
DALYITE Potassium Zirconium Silicate	 Triclinic-Pinacoidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

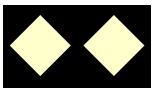
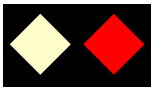
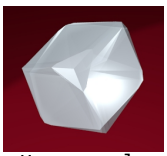
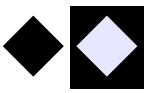
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
DANBURITE Calcium Boro-Silicate	 Orthorhombic - Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
DAVANITE Potassium Titanium Silicate			Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
DIOPSIDE Calcium Magnesium Silicate	 Monoclinic - Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
ENSTATITE Magnesium Silicate	 Orthorhombic - Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
EUCRYPTITE Lithium Feldspar	 Trigonal - Rhombohedral	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
FAYALITE Iron Chrysolite	 Orthorhombic - Dipyramidal				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

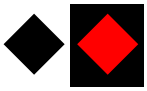
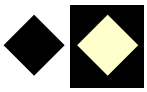
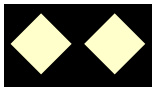
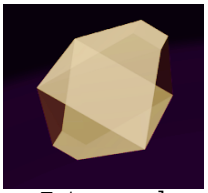
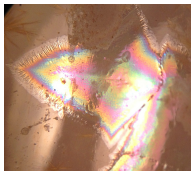
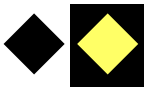
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
FOSTERITE Olivine; Peridot; Magnestium Silicate	 Orthorhombic - Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
FRESNOITE Barium Titanium Silicate	 Tetragonal – Ditetragonal Dipyramidal	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
GAHNITE Zinc Aluminum Silicate	 Isometric - Hexoctahedral		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
GITTENSITE Calcium Zirconium Silicate	 Monoclinic- Prismatic				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
HATRURITE Calcium Silicate	 Trigonal- Ditrigonal Pyramidal	massive			☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
HAUSMANNITE Manganese Dioxide	 Tetragonal- Ditetragonal Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
HEMATITE (HAEMATITE) Red					☐ Composition ☐ Structure ☐ Color ☐ Fluorescence

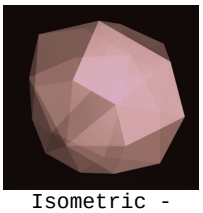
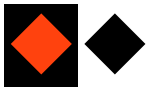
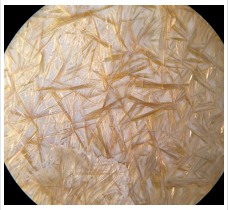
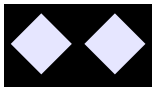
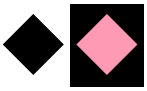
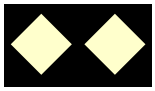
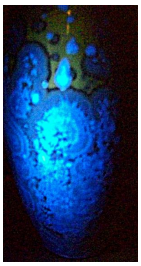
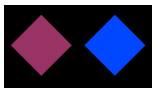
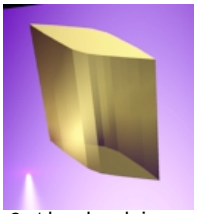
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
Iron Oxide	Trigonal-Hexagonal Scalenohedral				Glaze Used:
HUBNERITE Manganese Tungstate	 Monoclinic-Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
JADEITE True Jade	 Monoclinic-Prismatic	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
JOHACHIDOLITE Calcium Aluminum Borate	 Orthorhombic - Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
KOTOITE Magnesium Borate	 Orthorhombic – Dipyramidal				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
KYANITE Aluminum Silicate	 Triclinic-Pinacoidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

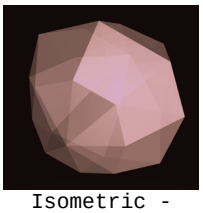
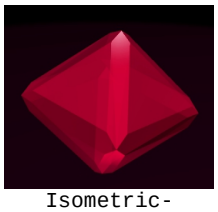
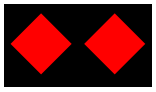
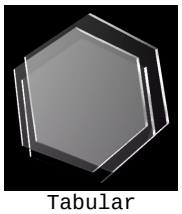
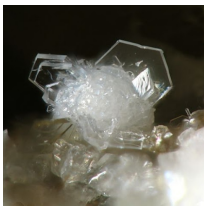
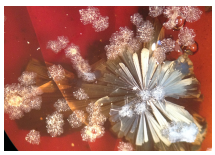
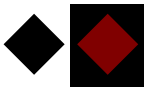
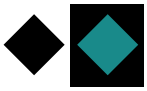
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
LEUCITE Potassium Aluminum Silicate	 Tetragonal - Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
LEUCOSPHENITE Barium Sodium Titanium Borosilicate	 Monoclinic-Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
LIBERITE Lithium Beryllium Silicate	 Monoclinic - Domatic	Microscopic	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
LIEBENBERGITE Nickel Magnesium Silicate	 Orthorhombic - Dipyramidal				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
LISITSYNITE Potassium Borosilicate	 Orthorhombic-Disphenoidal	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
LORENZEITE Sodium-Titanium Silicate	 Hexagonal-Pyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

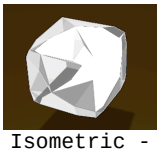
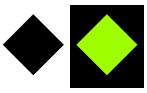
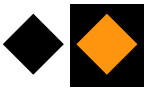
Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
MAGNESIO-FERRITE Iron Spinel	Isometric - Hexoctahedral		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
MALAYAITE Manganese Silicate	 Monoclinic-Prismatic	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
MALINKOITE Sodium Borosilicate	 Hexagonal-Pyramidal	Microscopic	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
MERWINITE Calcium Magnesium Silicate	 Monoclinic-Prismatic	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
METAMUNIRITE Sodium Vanadate	 Orthorhombic-Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
MICROCLINE Potassium Feldspar	 Triclinic, hexagonal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
MONTICELLITE		Massive	Paste Picture Here When You Identify A		☐ Composition ☐ Structure ☐ Color

Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
Calcium Magnesium Silicate	Orthorhombic - Dipyramidal		Specimen In A Glaze.		☐ Fluorescence Glaze Used:
MULLITE Clay	 Orthorhombic - Dipyramidal	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
NATISITE Sodium Titanium Silicate	 Tetragonal – Ditetragonal Dipyramidal	Microscopic	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
NATROSILITE Sodium Silicate	 Monoclinic – Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
NEPHELINE Sodium Potassium Aluminum Silicate	 Hexagonal-Pyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
ORTHOCLASE Potassium Feldspar	 Monoclinic-Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
PABSTITE Barium Tin Titanium Silicate	 Hexagonal-Ditrigonal	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
	Dipyramidal				
PANUNZITE Potassium Feldspar	 Hexagonal-Pyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
PARACELSIAN Barium Feldspar	 Monoclinic-Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
PARAKELYSHITE Sodium Zirconium Silicate	 Triclinic-Pinacoidal	Microscopic	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
PERICLASE Magnesium Oxide	Isometric - Hexoctahedral	Microscopic	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
PETALITE Lithium Feldspar	 Monoclinic - Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
POWELITE **"Moly"** Calcium Molybdate	 Tetragonal Dipyramidal				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
PYROPE Garnet Magnesium Aluminum Silicate	 Isometric - Trapezohedral		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
RUTILE Titanium Oxide	 Tetragonal – Ditetragonal Dipyramidal				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
SANBORNITE Barium Silicate	 Orthorhombic - Dipyramidal		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
SANIDINE Sodium-Potassium Feldspar	 Monoclinic- Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
SCHEELITE Calcium Tungstate	 Tetragonal - Dipyramidal				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
SILLIMANITE Clay	 Orthorhombic - Dipyramidal	Massive			☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
SPESSARTINE Manganese Aluminum Silicate, Garnet	 Isometric - Trapezohedral		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
SPINEL Magnesium Aluminum Silicate	 Isometric- Hexocahedral		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
SPODUMENE Lithium Feldspar	 Monoclinic- Prismatic		Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
TITANITE Gem variety: Sphene	 Monoclinic- Prismatic				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
TRIDYMITE Silica Polymorph	 Tabular				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
TROOSTITE Variety of Willemite with Manganese	 Trigonal - Rhombohedral				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

Mineral	Single Crystal	"Wild" Crystal	Crystal in Glaze if known/suspected	Fluorescence Black = none LW SW	Found it?
ULVOSPINEL Iron Titanate	 Isometric - Hexoctahedral	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
VLASOVITE **Garnet** Magnesium Aluminum Silicate	 Monoclinic - Prismatic	Massive	Paste Picture Here When You Identify A Specimen In A Glaze.		☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
WILLEMITE Zinc Orthosilicate	 Trigonal - Rhombohedral				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:
WOLLASTONITE Calcium Silicate	 Monoclinic- Sphenoidal				☐ Composition ☐ Structure ☐ Color ☐ Fluorescence Glaze Used:

NOTES:

Fluorescent colors refer ONLY to that mineral with no additives. Colorants will change the fluorescence; for example, Willemite with iron will show no fluorescence at all, and with manganese will fluoresce a brilliant traffic-light green. Iron will quench fluorescence in almost all minerals to which it is added. Vanadium will cause fluorescence in almost every glaze to which it is added.

Everything on one piece, why not!

Glaze Additions and Colorants

Now that you have your lilies, you'll surely want to gild them! Here are some short (for me) descriptions of various things you can add to your glazes to change the color, shape and character of your crystals. If you'd really like to explore these ingredients in depth, please see *Chemistry for Crystallieri.*

ALUMINA

Alumina (aluminum oxide, Al_2O_3) is what makes difference between a glass and a glaze. Alumina stiffens the melt and makes the glaze stay where you put it.

And that, dear friends, is why we use so little of it.

There has been a lot of contention over the years over how much alumina is too much. This has, indeed, proven to be a difficult point to test, since it is nearly impossible to add alumina by itself to a glaze and thus have a test with just one variable (or as close to one as makes no odds). Alumina added to a glaze does not become part of the melt, it just sits in suspension in the glaze. My experience has been that the only effect one sees is a general yellowing of the color of whatever one has.

Antimony
Ash, various
Barium
Bentonite
Beryl
Bismuth
Boron
Cadmium
Calcium
Chrome
Cobalt
Copper
Cornwall Stone
Cryolite
Dolomite
Erbium
Feldspars
Fluorospar
Ilmentite
Iron
Lead
Lithium
Magnesium
Manganese
Miscellaneous Rare Earths
Neodymium
Nepheline Syenite
Nickel
Phosphorus
Potassium
Praseodymium
Precious Metals, Misc.
Rutile
Silver
Strontium
Talc
Tin
Titanium
Tungsten
Uranium

Wollastonite

Zirconium

Found and Local Materials

After-effects

Strike-Firing

Post-Fire Reduction

“Lighting Up” High-Copper Crystals

Etching

Clay bodies

Commercial Bodies

Beware Fake Porcelains (which contain titanium)

Make Your Own (White Stallion etc)

Red Slip—you need to bisque it, because zinc and cadmium don’t mix.

Drip Catchers

How to make a catcher that will come off by itself, or you can just pull off.

Firing—electric or fuel?

Know your kiln! Sweet spots, cool spots.

Never let ANYONE load your kiln!

Schedules

RECIPE COLLECTION

WILLEMITE GLAZES

All these glazes produce lovely crystals, and when fired to the cones indicated will work reliably. Some of them have special parameters, but all will produce crystals when an appropriate hold is applied. All temperatures are given in Centigrade unless otherwise noted.

BORY 1, Cones 8-10
ⓒ Shimbo Research Pottery

Ferro 3110:	50
Zinc Oxide:	27
Silica:	16
Titanium Dioxide:	4
Gerstley Borate:	3

RO/R_2O		R_2O_3		RO_2	
Na_2O	.234	Al_2O_3	.035	SiO_2	1.566
K_2O	.023	B_2O_3	.056	TiO_2	.123
MgO	.005				
CaO	.124				
ZnO	.615				

CoE: 684.72 (Crazes) LoI: 0.88

Firing: Use your favorite method of getting to Δ9. No top hold is necessary. Crystals grow best in the 1100º to 950º range, and fastest at 1075º.

This is my go-to glaze for just about all purposes. It's the most reliable recipe I've come up with so far. Accepts colorants well (leave out the titanium if you want to use it with nickel, or you'll be sorry!) and etches like a dream.

I have tried some of the manufactured borates with it. They all work, some work well, but good old Gerstley works best of all.

TIN FOIL II, cones 8-9
ⓒ Shimbo Research Pottery

Ferro 3110:	50 pbw
Zinc Oxide:	25 pbw
Silica:	16 pbw
Dolomite:	5 pbw
Tin Oxide:	3 pbw
Titanium Dioxide:	1 pbw

RO/R_2O		R_2O_3		RO_2	
Na_2O	.224	Al_2O_3	.037	SiO_2	1.551
K_2O	.022	B_2O_3	.000	SnO_2	.99
CaO	.151				
MgO	.049				
ZnO	.614				

CoE: 689.26 (Crazes)
LoI: 2.38

Firing: As per Bory 1.

NOTES: The inclusion of tin in a zinc-silicate glaze encourages macro-crystals to grow in a dandelion-petalled form as opposed to the flat-petal form usually seen.

I originally experimented with tin oxide in glazes not as an opacifier, but to bring out the cyan tones one can get with copper. This glaze does the job admirably with small amounts (up to 4%) copper carbonate. It has no readily apparent effect on other colorants.

Tin Foil's crystals grow more slowly, or perhaps less readily, than do crystals in other bases, which makes this base particularly useful for seeding. I've gotten some really lovely spirals with it.

CELESTITE, Cones 8-10
© Shimbo Research Pottery

```
Ferro 3110:          50
Zinc Oxide:          25
Silica:              15
Spodumene:            5
Talc:                 4
Titanium Dioxide:     1
```

RO/R_2O		R_2O_3		RO_2	
Na_2O	.228	Al_2O_3	.058	SiO_2	1.566
Li_2O	.021	B_2O_3	.034	TiO_2	.123
K_2O	.023				
MgO	.053				
CaO	.113				
ZnO	.562				

CoE: 643.09 (Crazes)
LoI: 0.26
Si/Al: 28.82

Firing: Happy with just about any firing schedule you'd like to throw at it.

NOTES: When non colorants are added, crystals have a slight aquamarine tint. This does not seem to affect most colorants, but it does give Nickel a lovely zing.

I have a lot of recipes which call for added lithium in various forms, and this is one of my favorites. It grows lovely big crystals on an absolutely transparent ground. I have fired it as low as 6 with good results. It's happy with all colorants including nickel.

Curiously enough, now that I look back on things I've made with it, Celestite seems to be the least likely of my glazes to produce ancillary crystals, even after sitting for a week or so wet in the jar.

Fa's Base No. 2, cones 8-10
** Shimbo Research Pottery**

```
Ferro Frit # 3110 47
Zinc Oxide        23
Flint             23
Whiting            3
Titanium dioxide   3
Dolomite           1
```

RO/R_2O		R_2O_3		RO_2	
Na_2O	.234	Al_2O_3	.034	SiO_2	1.871
CaO	.161	B_2O_3	.035	TiO_2	.076
K_2O	.023				
MgO	.013				
ZnO	.569				

```
CoE: 652.1
LoI: 1.91
```

Firing: Prefers the higher top temps, very likely to make strongly acicular macro-crystals.

Notes: for Faux Favrile, add: silver powder, 2; or silver nitrate, 4.

So far, this has been by best glaze base for use with silver, resulting in the "Faux Favrile" effect when reduced. This is one of the very few glazes I have which produces more crystals the higher you fire it.

Fa's Octal, cones 8-10
ⓒ Shimbo Research Pottery

Ferro 3110: 51.0
Zinc Oxide 24.0
Silica: 15.4
Dolomite: 4.8
Titanium dioxide: 2.9
Spodumene: 1.9

RO/R_2O		**R_2O_3**		**RO_2**	
Na_2O	.231	Al_2O_3	.043	SiO_2	1.567
Li_2O	.008	B_2O_3	.035	TiO_2	.066
K_2O	.023				
MgO	.048				
CaO	.153				
ZnO	.538				

CoE: 691.26
LoI: 2.29

Firing: A good low(er) firing crystalline glaze. Seems to be happiest at about Δ8.5 but is a good seeding base at Δ6.

Notes: Remarkably opaque crystals on an extremely smooth, very transparent ground. Reduce titanium diox or leave out altogether for nickel.

I made up this glaze many, many years ago just to see what a fairly high-calcium glaze would do. What it does is make, on tiles at least, crystals with very pronounced, high (looking) centers that look like aerial views of volcanos, hence it's name. Just a little something different. Takes all colorants happily and accepts most stains well. Sometimes produces wollastonite crystals as ancillaries.

SRP All-Opaque, cones 7-9

Ⓒ Shimbo Research Pottery

Ferro 3110	46
Zinc Oxide	18
Silica	20
Dolomite	9
Titanium Dioxide	6
Talc	1

RO/R_2O		R_2O_3		RO_2	
Na_2O	.226	Al_2O_3	.034	SiO_2	1.717
CaO	.202	B_2O_3	.034	TiO_2	.149
K_2O	.022				
MgO	.111				
ZnO	.438				

CoE: 680.06
LoI: 4.35
Si/Al: 51.09

Firing: Happy no matter what you do with it.

Notes: May not produce crystals on tiles unless seeded. AVOID nickel!

If you want a glaze that produces multi-shaded crystals, matures at a relatively low temperature, or has a ground the same (more or less) color as the crystals, this is it. I've gotten some really excellent seeding results with it, and if mixed just right, it will give you blue-on-blue with cobalt rather than the blue-on-mustard (cobalt titanate) you usually get. Why? Not sure. But give it a try.

I suspect this glaze will etch like a champ.

SRP Matte No. 3, cone 9

Ⓒ Shimbo Research Pottery

```
Custer:          30
Zinc Ox:         22.72
Barium Carb:     16.36
Kona/Minspar     10.9
Ferro 3249:       4.55
Talc:             4.55
Silica:           4.0
Whiting:          3.64
EPK:              2.73
```

RO/R_2O		R_2O_3		RO_2	
Na_2O	.050	Al_2O_3	.167	SiO_2	1.214
CaO	.094	B_2O_3	.036	TiO_2	.622
K_2O	.072				
MgO	.090				
ZnO	.535				
BaO	.036				

```
CoE: 660.14 (crazes)
LoI: 6.05
Si/Al: 7.25
```

Firing: Note that there is a good deal more alumina in this glaze than is usual, so make sure you give it a FULL Δ9. Longer-than-usual holds for crystal growth may be necessary. This is one of the few glazes I've made that fires better in a gas than an electric kiln.

A tricky glaze, but when it works, it's gorgeous. You can get some lovely violet crystals with cobalt. If you can't get FF 3249, 3134 will work in a pinch.

SRP NoSi, cone 8-10

© Shimbo Research Pottery

```
Ferro 3110:      45
Zinc Ox:         25
Wollastonite:    15
Gerstley Borate: 10
Spodumene:        2.5
Neph Sye:         2.5
```

RO/R_2O		R_2O_3		RO_2	
Na_2O	.184	Al_2O_3	.048	SiO_2	1.076
CaO	.305	B_2O_3	.083		
K_2O	.019				
MgO	.022				
ZnO	.416				
LiO	.009				

```
CoE: 7.59 (crazes)
LoI: 3.29
Si/Al: 22.24
```

Firing: Fire as any any Zn glaze. It's happy no matter what you do with it.

I ran out of silica at one point, and not wishing to drive to (feh!) Denver to get any, I made up this recipe instead. The unity formula might look a little off compared to the other glazes I've made, but this glaze works like a champ! It's particularly good for etching if you're into that sort of thing.

SRP ZuZu, cone 8-10

Ⓒ Shimbo Research Pottery

```
Fusion 413:      65
Zinc Ox:         25
Petalite:         5
Talc:             5
```

RO/R_2O		R_2O_3		RO_2	
Na_2O	.325	Al_2O_3	.054	SiO_2	1.747
CaO	.011				
MgO	.088				
ZnO	.560				
LiO	.015				

```
CoE: 686.65 (crazes)
LoI: 0.32
Si/Al: 32.36
```

Firing: Fire as any any Zn glaze. It's happy no matter what you do with it.

Note: This glaze is even better with the frit it was meant for, General Color 106. 106 is gone now, to the sorrow and loss of us all.

Age test. Guess how this glaze got its name?

This glaze produces absolutely lovely blues with copper. It prefers the higher end of its firing range.

SRP Shimbo Green, cones 8-9
** Shimbo Research Pottery**

```
Fusion 413 OR
CG 106:          65
Zinc Ox:         23
Petalite:         5
Gerstley:         2
Silica:           3
Dolomite:         2

By addition: 4 Red Copper Oxide
```

RO/R_2O		R_2O_3		RO_2	
Na_2O	.315	Al_2O_3	.058	SiO_2	1.881
CaO	.035	B_2O_3	.015		
MgO	.049				
ZnO	.553				
LiO	.016				

```
CoE: 687.51 (crazes)
LoI: 1.54
Si/Al: 32.51
```

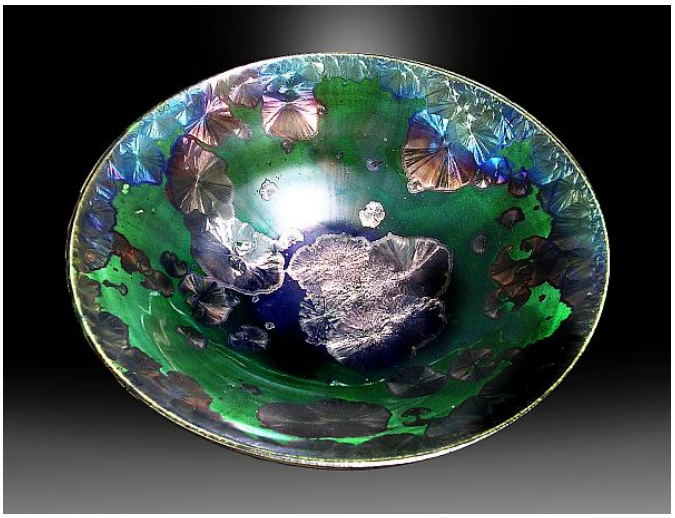
Firing: Fire as any any Zn glaze. It's happy no matter what you do with it.

Feel free to substitute any kind of colorant you want here, but this is the base I use for one of my favorite glazes, Shimbo Green. It's called Shimbo Green because the green it produces is the same color as our Shimbo-no-Mon, or our Shimbo Family Crest.

This is one high-copper glaze you don't want to etch! You may, however, want to bring out a torch and light the crystals up. You get things like the bowl at the top of the page.

Shimbo Green (and any other color you make with this) seeds well and actually grows crystals more easily at lower temperatures if seeds are available.

If you add even more red copper oxide, you will get black crystals on a black ground.



I love this bowl. I have a feeling I sold it, though, because I can't find it to take a better picture. *Zût alors.*

SPHENE GLAZES

SRP Sphene, Cone 8
** Shimbo Research Pottery**

Ferro 3134: 20 pbw
Ferro 3110: 50 pbw
TiO2: 10 pbw
Silica: 15 pbw
Petalite: 5 pbw

RO/R_2O	R_2O_3	RO_2
Na_2O .514	Al_2O_3 .087	SiO_2 3.397
K_2O .040	B_2O_3 .278	TiO_2 0.409
CaO .419		
Li_2O .027		

CoE: 672.85 (Crazes)
LoI: 0.0

This is the third of a series of sphene-crystal glazes which I developed in 2013, and the only one of that group which really worked well. It needs a thin application—which is to say, about the same thickness a normal glaze would take. For reasons that still elude me, crystals will not typically grow where the glaze is too thick, or where it pools.

RUTILE GLAZES

SRP GRANITE, Cones 8-9
** Shimbo Research Pottery**

Ferro 3110 48
Zinc Oxide 22
Silica 20
Titanium Dioxide 10

RO/R_2O	R_2O_3	RO_2
K_2O .026	Al_2O_3 .038	SiO_2 1.959
Na_2O .260	B_2O_3 .039	TiO_2 .275
CaO .119		
ZnO .595		

CoE: 681.60

LoI: none

Si/Al: 49.38

Firing: Adapts well to any firing schedule for zinc silicate glazes.

This is a great glaze useful for a good deal of things quite apart from generating rutile crystals. If you add the tiniest touch of RIO to it, and fire it to cone 8, you get a wonderful pumpkin-orange matte. In a slightly reducing atmosphere, lovely rutile purples can appear. This is a hybrid zinc-silicate/rutile glaze.

SRP RUTILE 3, Cones 8-9
ⓒ Shimbo Research Pottery

Ferro 3110 50
Ferro 3134 20
Silica 15
Titanium Dioxide 10
Light Rutile 5

RO/R_2O	R_2O_3	RO_2
K_2O .041	Al_2O_3 .063	SiO_2 3,275
Na_2O .528	B_2O_3 .285	TiO_2 .275
CaO .439		

CoE: 718.89

LoI: 0.1

Si/Al: 52.5

Firing: Adapts well to any firing schedule for zinc silicate glazes.

This

MOLYBDENUM GLAZES

Maki Moly 2, Cone 9
(Shimbo Research Pottery, after a recipe from H. Sanders)

Kona F-4 Feldspar:	42
Silica:	24
Gerstley Borate:	7
Whiting:	7
Zinc Oxide:	7
Barium Carbonate:	2

RO/R_2O		R_2O_3		RO_2	
Na_2O	.159	Al_2O_3	.240	SiO_2	2.639
K_2O	.065	B_2O_3	.194		
MgO	.046				
CaO	.427				
ZnO	.271				
BaO	.032				

CoE: 487.03 (No crazing)
LoI: 8.98

blah blah blah

SRP Moly, Cone 9-10

Custer Feldspar:	33.66
Silica:	21.78
Gerstley Borate:	19.80
Whiting:	7.92
EPK:	3.96
Zinc Oxide:	2.97
Barium Carbonate:	1.98

RO/R_2O		R_2O_3		RO_2	
Na_2O	.104	Al_2O_3	.268	SiO_2	2.294
K_2O	.133	B_2O_3	.273	TiO	.356
MgO	.065				
CaO	.532				
ZnO	.131				
BaO	.036				

CoE: 534.81 (No crazing)
LoI: 10.44
Si/Al: 11.99

Firing: Do not fire as fast as you would regular crystalline glazes. No hold is necessary although crystals will grow with a regular crystal-glaze firing, but a slow cooling helps. With a large kiln, just a regular cool-down is sufficient, but smaller kilns require a deliberate slow-down for at least an hour after peak temperature is reached.

This is my go-to Moly crystal glaze though alas it doesn't work for everyone, and sometimes it doesn't work for me either. It needs a high fire and a slow cooling, and when it works well, you can get some really nice star-shaped crystals from it!

WOLLASTONITE GLAZES

SCHEELITE GLAZES

AVENTURINE GLAZES

OIL-SPOT GLAZES

SRP Oil Splotch 1, Cone 9
© Shimbo Research Pottery

```
Silica:              21.20
Custer Feldspar:     17.00
Kona F-4 Feldspar:   16.85
EPK:                 16.80
Gerstley Borate:      8.5
Dolomite:             8.5
RIO:                  9.0
Manganese Diox:       5.05
```

RO/R_2O		R_2O_3		RO_2	
Na_2O	.106	Al_2O_3	.639	SiO_2	4.523
K_2O	.143	B_2O_3	.167	TiO_2	.004
MgO	.275	Fe_2O_3	.277		
CaO	.420				

CoE: 438.27 (no crazing)
LoI: 8.96

Firing: *Requires* a full Δ9.

Notes: Apply fairly thickly. May run a bit, but with care will not run off the pot.

This was the first time my oil-spot recipes gave me splotches instead of spots. It's an interesting glaze, with a nice glossy/slightly pitted surface, and interesting silver splotches, with other features in sunlight. Would probably fire to Δ10 without batting an eye, but it is VERY under-fired at Δ7. I've tried re-firing under-fired pieces; they do not change. You get one chance only, to do it right.

SRP Sea Spot Run, Cone 5-9
© Shimbo Research Pottery

Kona/Minspar:	39.12
Silica:	20.40
Gerstley Borate:	10.42
EPK:	9.56
Red Iron Oxide:	8.87
Dolomite:	6.07
RIO:	8.87
Titanium Dioxide:	3.55
Petalite:	1.74

RO/R_2O	R_2O_3	RO_2
Na_2O .106	Al_2O_3 .588	SiO_2 4.610
K_2O .234	B_2O_3 .207	TiO_2 .237
MgO .219	Fe_2O_3 .296	
CaO .416		
Li_2O .015		

CoE: 474.39 (no crazing)
Si/Al:7.48
LoI: 7.36

Firing: Fire to target temperature, hold at max temperature for at least 1 hour or until (if possible) you can see no more bubbles on the surface of the glaze.

Notes: RUNS!!! CATCHERS REQUIRED!

This is not a traditional oil-spot glaze, but it gives the same kind of result over a wide range of firing temperatures. If you fire high, you'll get your best results where the glaze pools. Fire a little (I have fired it as low as Δ4 with great results!) and the turquoise-ish or aquamarine Tyndall spots will coat the piece. It runs even as low as Δ4. Try leaving out the petalite, or adding varying amounts of TiO2 for more fun effects.

Stuff To Make You Want More Stuff

- Temperature Conversion Chart
- Materials Substitutes

WORKSHOP ETIQUETTE

After the last workshop I gave, I swore I was never going to give a workshop at Shimbo Research Pottery ever again. I'm now a member of a makerspace and will be giving workshops there, but not at home.

Nope.

No.

Non.

Nein.

Ikke.

Het.

Ei.

Não.

Non est.

Saa.

Jo.

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Nese.

Nae.

Όχι.

Do I make myself perfectly clear? If I left out your language, let me know.

Why am I up in such arms? Because Some People Who Shall Remain Nameless do not seem to see themselves as required to obey these simple rules of workshop etiquette.

1. Never, but NEVER, load or unload, or even re-arrange anything, in any kiln that is not your own.

Ever. Only the owner of a kiln knows where the sweet spots—and the bad spots—are in any particular kiln, and every kiln, even the newest, has both. Only the owner of a kiln knows the best way to pack a particular kiln.

Years ago, behind my back, someone entirely unpacked and repacked my gas kiln in order to get in as much of their own stuff as they could. The result: the entire firing was ruined. That kiln just won't fire correctly if it's tightly packed. But did they consider that? No. Did they even ask? No. They just considered themselves, wasted my propane, and wasted not only my time, but the time, money and effort of all the other students. DO NOT TOUCH the teacher's kiln. There is no excuse. *Hands off.*

If you are giving a workshop at someone else's facility, ask the facility manager to ask someone on staff to pack, or at least help you pack, the kilns there.

2. Arrive ON TIME. It seems the current generation feels this is no longer the case, but when I was raised, arriving on time no matter where you're going was considered part of being able to keep your word, and arriving late was just plain rude. The teacher is making this time available for you, out of what is otherwise a very busy life of their own. At least show some respect by being present when the class is set to start.

Speaking of politeness...

3. If the class bores you, please excuse yourself and leave, quietly. Showing off how little you're getting out of the teacher's

experience by, to cite a recent example, pulling a book off their library shelves and ostentatiously reading it in the middle of a class is a direct insult to the teacher. Believe it or not, I have had this happen, and it was only a desire not to make a scene in front of the other students that I didn't skin the perp alive. Getting up to do one's own thing, quietly, is ... acceptable, I suppose. But turning on the loudest piece of machinery in the place and forcing the class to reconvene outside so we can hear each other, is not.

4. Your mother doesn't live here. Clean up your station! No matter how I tell people to clean up their places at table before they leave—and to cap all bottles and put things away—only half of them ever actually do it. The other half knock stuff off the shelves. So, at the end of every session, clean your place.

5. Put your name on stuff. Really. Put your name on ALL your stuff. Just do it. You may think you're going to recognize it once it's fired, but ....

6. ASK before going through the teacher's drawers, or using tools not your own or not designated as class tools. Yes, I've had people rifle through my drawers looking for "the good tools, I know you have them." The last few years, I've taken the good tools and hidden them in a whole 'nother building.

GLOSSARY

Acicular "Needle shaped." This refers to crystals which tend to grow preferentially from their terminations rather than their sides, resulting in very long, very thin crystals.

Annealing

Annealing Twinning

Boundary Layer

Calcining removing chemically bonded water and/or organic materials from a material by heating.

Cleavage

Conchoidal Said of the fracture of a crystal; a "shell" (conch) shaped divot rather than a straight line.

Diapheny A measure of how opaque (low diapheny) or transparent (high diapheny) crystal of a mineral is.

Face A flat surface of a single crystal, also known as a **plane.**

Feldspar

Fluorescence

Fracture

Gemmy said of a mineral specimen, in such a condition that the specimen could easily be made into a gemstone. Especially unflawed and/or transparent.

Growth Ring see Halos

Habit

Halos

Hardness, Mohs

Lattice

Phosphorescence

Streak When rubbed on a porcelain "streak plate," minerals leave a line of characteristic colors, which can be useful in identifying them. When one talks about the "streak" of a mineral, one is usually referring to this color.

Tenmoku/Temmoku Properly "Tenmoku" but the n-*consonant* combination is often pronounced "m" in Japanese (our name is actually "Shinbo" when written in Kanji ... it's a long story.)

Termination The end of a crystal, as it normally grows; the "points" on the ends of long crystals. Most crystals one can obtain are "Single terminated," that is, showing this characteristic point at only one end, with the other end broken. Very rarely, one can find "doubly-terminated" crystals with both pointed ends intact.

Unit Cell The smallest part of a crystal (a collection of like atoms or molecules) having the properties of the entire crystal, in relative face length and angles.

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