

→ = Advance Power Point Presentation (click mouse)

- 1) Introduction – Opening slide show
 - a) Hi my name is Pam East and I'm an Art Clay Silver Master instructor.
 - b) I have a lot of material to get through, but I've planned some time at the end for some Q&A. Please hold your questions until then.
 - c) I'm going to be showing you a lot of the problems I encountered and things that went wrong while figuring out how to use Copper clay. I want to make it clear from the beginning that this is not meant to discourage you. I've found that if you know what can go wrong and why, it will increase your own success. I've resolved most of the issues and will be sharing that information with you as well.
- 2) → The Adventure Begins – Secret Life of Beta Testers
 - a) Almost exactly 1 year ago I had the pleasure of meeting Bill and LaceyAnn Struve at the PMC conference in Indiana. For those of you who don't know, Bill is the inventor of Bronze and Copper clay. Bronze clay was just hitting the market and I was anxious to talk to them. My burning question was "Why not Copper clay?" As an enamelist I'm not interested in Bronze clay. You can't enamel it. But the idea of copper clay seemed to hold a lot of promise. Bill and LaceyAnn hinted that Copper formulas were being worked on, and I told them that when they had something ready to go, I would be very excited to test it for enameling.
 - b) → In December they contacted me. They had Copper clay test formulas and were ready for beta testers.
 - c) → And it's been quite the adventure.... Learning how to handle the product, learning what it would and would not do, running test classes to see what happens when you put it in the hands of students. It's been by turns, frustrating, exciting, confusing, and exhilarating.
 - d) → This is bleeding edge stuff. Aside from an initial suggested firing time and temp, the other testers and I had no manuals, no books, no technical experts to call. None existed. Over the past seven months, working with the other testers such as Catherine Pates Davis, Marco Fleseri and many others, we've been working out the kinks. So hopefully, you won't have to.
 - e) → Rio Grande released the product to the public at the end of May. By then we had the firing schedules worked out well enough for plain copper pieces, although I still had a little ways to go with regard to enameling.
 - f) → Over the last month I refined several details on the enameling front and am now getting very consistent results. With a product this new, I know we have lots of discovery still ahead of us, but I think we've gotten enough figured out to ensure success.
- 3) → Working with Copper clay
 - a) Working with copper clay is not exactly like working with silver clay. It has its own quirks and idiosyncrasies. The next few slides have to do with copper clay in general, not enameling.

- b) → **Warping**
 - i) On thinner pieces I've found it's somewhat more prone to warping. The first piece I made curled up like a potato chip.
 - ii) → One of the first things I found out is that if you're careful, you can actually unbend copper clay without adding any water. I was able to gently flatten this piece out again. To avoid the issue though, you may want to air dry thinner pieces.
- c) → **Puffing**
 - i) This was an odd experience. The piece came out of the sinter firing flat as can be, but it puffed up like a pillow when I was enameling it. It had me scratching my head at first, but I finally figured out what the problem was. The clay the inner layers weren't sealing together. It didn't puff up during the sinter firing because the carbon is an oxygen free environment. There was no air to get in there. . But enameling isn't done in the carbon, so that's when it reacted with the air.
 - ii) → In any case, it happens when your folding the clay and it's too dry. You need to make sure the clay is moist enough. You may also want to add it bit of water when folding the clay to ensure the layers are sealed together well.
- d) → **Attached pieces falling off**
 - i) The last issue I had with regards to just the clay itself was bails and other joined pieces falling off. Copper clay has a rubbery, almost oily feel to it. It doesn't adhere to itself the way silver does. I had tried making slip, paste and even syringes to join things together, but had little success with it.
 - ii) → Instead I learned to use softened clay to join elements together. Dampen the piece first and then use a rubber clay shaper tool to blend joined elements into the body of your piece.
 - iii) → Reinforce all seams and joints with additional clay.
 - iv) → When you're first starting out with copper clay, you may want to focus on single unit construction techniques until you get a feel for it.
- 4) → **Enameling problems**
 - a) When I started enameling I had no clue just how much of an adventure it was going to turn out to be. I just assumed that since the finished product was pure copper, it would enamel just like other copper forms. Straight forward, right?
 - b) → Well... maybe not.
 - c) → Enamels bubbled, Enamels pulled, enamels chipped and flaked. Enamels behaved in ways I have never seen enamel behave before. One even peeled and foamed. It's taken a huge amount of testing to finally get a handle on what was going wrong. I won't take you step by step through everything that lead up to the solution to the problem. Suffice it to say I went through about 4 kilos of clay trying to figure it out. Ultimately it was a tip from Marco Fleseri that got me on the right track.
- 5) **Problem identified**
 - a) → It turned out to be a binder and sintering issue.

- b) First, organic binders do not fully burn out in an oxygen free environment. Instead of turning to ash and dissipating, they leave a residue. In fact, burning organic materials in an oxygen free environment is one of the ways activated carbon is made.
 - c) Second, the copper wasn't fully sintering. Residue left behind by the incompletely burned out binders leaves the piece more porous than it should be.
- 6) Problem Resolution
- a) → The resolution to the problem turned out to be a two phase firing schedule.
 - i) → Phase one allows the binder to burn out completely. The piece is fired on an open shelf, not in carbon. The ramp speed is kept very low, just 500 degrees per hour for pieces up to 2 to 3 mm thick. If the piece is thicker than that I would slow it down to 200 degrees per hour. You're only going to 560 degrees and then holding for just 15 minutes, so it doesn't take that long to do this firing. Once fired, the piece will be black and brittle. Handle it as you would greenware.
 - ii) → Phase two completes the sintering process. Bury in activated coconut carbon and fire using full ramp to 1750 for 3.5 hours. Allow the kiln to cool below 300 before removing the pieces. Since I usually set my copper firings to run at night, it's cooled when I get up in the morning. All the black copper oxide will revert to copper during this firing, and the piece will sinter fully. Once I figured out this firing schedule and started using it consistently, the strange issues I was having with the enamels on copper clay disappeared. This is not to say all my enamels come out perfectly each time, but at least now the problems are known enamel issues and not copper clay issues.
 - iii) → In this photo you can see the unfired size, the size if fired directly in carbon without pre-firing, and the size if the two phase firing is used. The clay should shrink about 20%. If it doesn't you may have a problem with it when it comes to enameling. Also, when the pieces come out of the carbon they should be bright copper color. If they are dark or mottled looking, they may not be sintered well enough for enameling.
 - iv) One more important note on this subject. If you have a piece that was originally fired in carbon, re-firing using the two phase schedule may not fix the problems with regards to enameling. It will help some, but it still won't be as good as a piece that started right out with the open shelf firing. Bill Struve and I discussed this and speculate that when you start with a carbon firing, it somehow locks the molecular structure of the piece in a more porous configuration that is not remediated with subsequent firing. With out access to scanning electron microscopes, there is no knowing for sure, but I can say that I got more bubbles and pits in pieces that were "re-fired" than in those that were fired correctly to begin with.
- 7) → Metal Preparation
- a) Even though the copper has been fully sintered, it's still porous and needs to be heavily burnished, just like silver clay. I recommend tumbling for a minimum of two hours. I often tumble for as long as 6 hours.

- b) → Prior to enameling, it's important to clean the copper. It may have soaps from the tumbler on it, oils from your fingers, or other impurities. Also, if it's been sitting out for any length of time at all, it will have started normal copper oxidation. All this must be removed before enameling. I use PennyBrite, a commercial copper cleaner and a glass brush to scrub the piece. Then rinse it thoroughly to remove all traces of the cleaner.
- 8) → Need to know
 - a) One of the beauties of enameling on silver clay, is that fine silver doesn't oxidize. Copper on the other hand, does oxidize and badly. Since enameling over oxidation will discolor your enamels, this makes for additional steps during the enameling process.
 - b) → Welcome to the wonderful world of firescale. The term "firescale" just refers to the rapid oxidation that occurs at high temperatures. It's the black stuff you see all over the copper after it's been in the kiln in an oxygen environment.
 - c) There are a number of things you can do to reduce the impact of firescale, and I'll be discussing those as we go along.
- 9) Enameling copper clay
 - a) → Counter Enamel
 - i) One of the first things you can do to reduce the amount of firescale you'll have to deal with, is to apply both the front enamel and the counter enamel at the same time. Counter enamel is just a fancy name for the enamel that goes on the back side of the piece. It's necessary to prevent cracks in the enamel, and on copper it also serves to protect the metal from additional firescale.
 - ii) → The easiest way I've found to do both sides at once is to use Thompson Liquid Counter Enamel or LCE and oversift it with 80 mesh enamel. The LCE comes as a powder and is mixed with distilled water to a creamy consistency. It's much stickier than other forms of enamel. The 80 mesh will stick to it very well. I even go so far as to press the 80 mesh into the LCE and then give a light mist of Klyr-fire spray for good measure. At this point you will be able to turn the piece over without the counter enamel dropping off. Then you can apply the enamel on the front and place the whole thing in a trivet for firing.
 - b) → Flux
 - i) Flux is another fancy term for something that's really very simple. It's just the first layer of enamel fired on to the copper. Traditionally flux is either clear or white, although those are not the only choices.
 - ii) → The main thing is, you don't want to fire medium or dark colors direct on copper. They will end up very dark and you won't like the results much.
 - iii) → The colors show up much better if you use clear or a very light color to start with. Notice how much clearer the pattern is underneath the enamel.
 - iv) → This is flux test piece I did. I tried a variety of light color enamels to see how they looked on the copper. I can affect my finished enamel by what color flux I choose. A light blue flux will give me a base cool tone. A yellow will give me a warm base tone to build on.

- c) → Firing Enamels on Copper
 - i) I recommend firing at 1550 for 1.5 to 2 minutes. This is much hotter and faster than I would use for silver enameling.
 - ii) Using a high fast firing will accomplish two things. The less time a piece is in the kiln, the less time there is for firescale to form. Also, at high temperatures oxides on the surface of the copper will be absorbed into the enamel leaving the copper underneath clean and bright.
 - iii) → This piece was fired at 1450 for 2 minutes. You can see a reddish cast to the copper underneath. That's copper oxide.
 - iv) → After re-firing the piece at 1550 for 2 minutes you can see the reddish surface has completely disappeared and the copper is clean and bright, making the enamel color stand out much better.
- d) → Cleaning fire scale between firings
 - i) You need to clean off firescale because it can pop off and get stuck in your enamel on subsequent firings. These gray flecks here (point to photo) are bits of loose firescale that have popped off.
 - ii) It's very easy to clean this with hot water, Pennybrite, and a toothbrush. The hot water activates the citric acid in the Pennybrite and makes it work better. You only need to clean it enough to prepare it for the next layer of enamel.
- e) → Step away from the pickle
 - i) Pickle is not your friend. These are a couple of examples of what happens to enamels if you try to use traditional metal pickles on copper clay.
 - ii) The piece on the left is the one that actually foamed and peeled. I've never seen anything like it. I tried cleaning it and adding more and more enamel in an attempt to cover up the problem, but it just got worse and worse. The enamel is peeling, cracked, clouded and a very odd consistency.
 - iii) I tried another experiment on the piece on the right. I used the pickle, but then I simmered the piece in a solution of baking soda and water to try and neutralize the acid. The first coat of enamel seemed to go on fine, but you can see what happened on the second coat.
 - iv) The problem is the porosity of the material. When you soak the piece in the pickle, it gets down inside the piece and there's no getting it back out until you fire it, at which point it wrecks your enamel.
 - v) There's really no need for pickle at this stage though. Pennybrite works fine for removing the fire scale, and doesn't cause these problems.
- f) → Finishing
 - i) What's needed for final finishing will vary depending on the piece.
 - (1) For Basse Taille finishing very easy and straight forward. Just use an alundum stone, followed by a series of finer and finer sandpapers to polish up the edges. Avoid sanding or grinding the surface of the enamel and no additional firing will be needed. All sanding and grinding must be done wet. That's true of all glass finishing.
 - (2) → For Champlevé it gets a bit more complicated since you're going to have to grind the enamel itself. Start by removing as much firescale as possible with the Pennybrite. Then the entire surface will have to be

ground smooth with an alundum stone. Follow this up with finer and finer sandpapers until you have it mostly polished.

(a) At this point you have a choice. You can polish it all the way, and leave the enamel matt finished. This is a valid choice and I've done it on a number of pieces. This green piece is a good example. If you do a good job with the polishing the matt finish can be lovely.

(b) → If you want it glossy though, you will need to flash fire it. You should still do the majority of your sanding first. The smoother the metal is prior to flash firing, the better it will come out after. Be sure and clean the enamel with a glass brush and ammonia before re-firing, or left over grits could cause your enamel to cloud. After flash firing, use penny bright to clean up the metal. If you're careful to avoid the enamel, you can also use the higher grit sandpapers to remove any stubborn firescale. Once the firescale is off, tumble it. Yep! You can tumble enamels! That will finish polishing up the metal and will not harm the enamel.

10) → Enameling Issues. The following issues have to do with copper enameling in general, and will apply to either copper clay or sheet copper.

a) → Enamel clouded

i) There are two things that will cause your transparent enamels to come out cloudy. First is the presence of super fine particles of enamel. These "fines" as they are called, should be washed or screened out prior to enamel application.

ii) The second thing that can cause clouded enamel on copper is under firing. If you fired at too low a temperature, or for not enough time, the enamel may become opaque. This can be fixed by the simple means of re-firing it.

iii) The example on the left is heavily clouded. It also pulled, which could have been because of finger prints at the edges or I could have put on too heavy a layer of enamel initially. In any case, the second sample was clouded in the same manner, but after I re-fired it, it cleared right up. These are the same color of enamel.

b) → Fire scale on front

i) If you end up with firescale coming through in enameled areas, you applied the first coat too thin. Unfortunately, once it's there, there is no getting rid of it. You can enamel over it, but it will still show through.

ii) This can be used for effect if you want to do it on purpose, but it's highly unpredictable.

c) → Dark line at edge of enamel

i) You will usually see a dark line outlining the edge of the enamel. This is completely normal for copper enamel and should not be seen as a flaw.

ii) These are my color tests by the way. I always test color combinations and layering before committing them to a piece of jewelry. It's a good practice and one I recommend highly.

11) → Q&A

a) That's the end of my formal presentation. I can now take questions.

MCWC - Enameling on Copper Clay by Pam East