COOL TOOLS

Gemstones in Metal Clay

Many natural gemstones can be set into metal clay and fired in place. Other gemstones will not survive the heat of a kiln and should be set after firing. The charts below show the results of kiln and torch tests that have been performed on both natural and synthetic gemstones, adapted with permission from the original testing by Kevin Whitmore of Rio Grande, with additional testing by Mardel Rein.

This information is for reference and should be used as a guide. There is always some risk of losing a natural gemstone even if others of it's kind have survived in the past. Gemstones may have internal flaws that can be liquid or gaseous filled, or contain crystals of other materials that can cause the gemstone to fail where it usually does not. This guide aims to help metal clay artists sort out gemstones that are known to survive under fire from those that are not.

Gemstones are minerals that are classified into groups based upon the constancy of their major properties. Each mineral family has one or more varieties contained within the group. When we sort the tested gemstones according to their mineral group, it becomes clear that an easy way to gauge the survivability of a gemstone is to look at the results of other varieties within that same group. Aquamarine and emerald, for example, are both varieties of the beryl group of minerals. The result of tests done on aquamarine and emerald indicate that minerals in the beryl group will not survive kiln heating. There are exceptions, as there always are in the natural world, but in general this method can be reliable for many varieties. For simplicity, many gems have been classified into their main group rather than their sub-variety.

These charts classify stones as No-Fire, Low-Fire, High-Fire, Torchable and Carbon-Safe. High-Fire stones are those that can withstand 1650F for at least 1 hour on an open kiln shelf with no color change. Low-Fire stones are heat sensitive with a risk of color change. No-Fire stones are those that must be set after firing. Torchable stones are those that can survive at least a 2 minute torch firing, and Carbon-Safe stones are those that can survive a carbon firing (carbon firing instructions are included at the end of this publication).

The Moh's hardness of each gemstone has been included to help dispell the myth that hardness determines survivability (additional information on the Moh's scale is provided on page 3 of this publication).

Natural Gemstone Firing Chart

All kiln tests fired at fast ramp

Maximum Suggested Firing/Temp Time

Gemstone	Mineral Group	Moh's Scale	No-Fire	Low-Fire	High-Fire	Torchable	Carbon-Safe
Aquamarine	Beryl	7.5 - 8	X				
Emerald	Beryl	7.5 - 8	X				
Malachite	Borate	3.5 - 4	X				
Rhodocrosite	Calcite	3.5 - 4.5	X				
Alexandrite[1]	Chrysoberyl	8.5			1650F/2H	✓	✓
Alexandrite Cats Eye[1]	Chrysoberyl	8.5			1650F/2H	✓	✓
Black Star Sapphire	Corundum	9			1650F/2H	✓	✓
Padparadscha Sapphire	Corundum	9			1650F/2H	✓	✓
Ruby	Corundum	9			1650F/2H	✓	✓
Sapphire	Corundum	9			1650F/2H	✓	✓

COOL TOOLS

Natural Gemstone Firing Chart *(continued)*

All kiln tests fired at fast ramp

			Maximum Suggested Firing/Temp Time				
Gemstone	**Mineral Group**	**Moh's Scale**	**No-Fire**	**Low-Fire**	**High-Fire**	**Torchable**	**Carbon-Safe**
Diamond[2]	Diamond	10	X			✓	✓
Almandine Garnet	Garnet	6.5 –7.5		1560F/30 min		✓	✓
Demantoid Garnet	Garnet	6.5 –7.5		1560F/30 min		✓	✓
Pyrope Garnet	Garnet	7 –7.5		1560F/30 min		✓	✓
Rhodolite Garnet	Garnet	7 –7.5		1470F/30 min		✓	✓
Tsavorite Garnet	Garnet	7 –7.5		1470F/30 min		✓	✓
Amazonite	Feldspar	6 –6.5		1200F/30 min		✓	✓
Labradorite	Feldspar	6 –6.5		1200F/30 min			✓
Moonstone –Gray	Feldspar	6 –6.5		1200F/30 min			✓
Moonstone –Peach	Feldspar	6 –6.5		1110F/30 min			✓
Moonstone –White	Feldspar	6 –6.5		1110F/30 min			✓
Sunstone	Feldspar	6 –6.5		1200F/30 min			✓
Iolite	Iolite	7 –7.5	X				
Hematite	Iron Mineral	5.5 –6.5			1650F/2H	✓	✓
Zircon	Neosilicate	7.5			1650F/1H	✓	✓
Peridot	Olivine	7		1470F/30 min		✓	✓
Turquoise[3]	Phosphate	5 –6	X				
Chrome Diopside	Pyroxene	5 –6		1200F/30 min			✓
Star Diopside	Pyroxene	5 –6		1200F/30 min		✓	✓
Jadeite	Quartz	5 –6	X				
Agate (Cameo)	Quartz	7	X				
Amethyst	Quartz	7	X				
Aventurine	Quartz	7	X				
Black Onyx	Quartz	7	X				
Chalcedony	Quartz	7	X				
Carnelian	Quartz	7	X				
Citrine	Quartz	7	X				
Rose Quartz	Quartz	7	X				
Rutilated Quartz	Quartz	7	X				
Smokey Quartz	Quartz	7	X				
Spinel	Spinel	8			1650F/1H		✓
Fire Opal	Silicate	6 –6.5	X				
Pyrite[4]	Sulphide	6 –6.5	X				
Topaz (all varieties)	Topaz	8	X				
Green Tourmaline	Tourmaline	7 –7.5		1200F/30 min			✓
Pink Tourmaline	Tourmaline	7 –7.5	X				✓
Tanzanite	Zoisite	6.5 –7		1600F/30 min		✓	✓
Denim Lapis[6]	Rock	5.5	X				
Lapis Lazuli[5]	Rock	5.5	X				

See Natural Gemstone Notations on page 3.

COOL TOOLS

Natural Gemstone Notations

[1] Some believe this stone is not available or is too expensive to fire in metal clay. It can be pricey, but there are plenty of sources for this stone, including Cat's Eye. Loupe the stone before firing. Do not fire if you see what appears to be bubbles in the stone.
[2] Diamonds are risky on an open kiln shelf, but there have been some firing successes. If you do fire, keep your time and temperature low. Diamonds can take a lot of heat, but not for long. Firing in activated carbon is a safe method for firing diamonds.
[3] Turquoise is a secondary mineral of hydrated copper aluminum phosphate.
[4] Pyrite is dangerous in the kiln. Pyrite contains sulphur which can be explosive when heated.
[5] Lapis lazuli is not a mineral, but a microcrystaline rock composed mainly of the mineral luzurite, with some pyrite and white calcite.
[6] Denim lapis is a low quality lapis with less lazurite and more white calcite.

Lab Gemstone & Cubic Zirconia Firing Chart

All kiln tests fired at fast ramp

			Maximum Suggested Firing/Temp Time				
Gemstone	**Mineral Group**	**Moh's Scale**	**No-Fire**	**Low-Fire**	**High-Fire**	**Torchable**	**Carbon-Safe**
Lab Alexandrite	Synthetic	8.5			1650F/2H	✓	✓
Lab Emerald[1]	Synthetic	7.5 –8		1470F/30 min			✓
Lab Opal	Synthetic	5.5 –6	X				
Lab Ruby	Synthetic	9			1650F/2H	✓	✓
Lab Sapphire	Synthetic	9			1650F/2H	✓	✓
Lab Sapphire Orange[2]	Synthetic	9			1650F/1H	✓	✓
Lab Sapphire Yellow[3]	Synthetic	9			1650F/1H	✓	✓
Lab Spinel	Synthetic	9			1650F/2H	✓	✓
CZ Amethyst	Simulant	8.5 –9			1650F/2H	✓	✓
CZ Champagne	Simulant	8.5 –9			1650F/2H	✓	✓
CZ Emerald/Bright[4]	Simulant	8.5 –9		1110F/10 min			✓
CZ Garnet	Simulant	8.5 –9			1650F/2H	✓	✓
CZ Light Amethyst	Simulant	8.5 –9			1650F/2H	✓	✓
CZ Olivine/Dark[5]	Simulant	8.5 –9			1650F/1H	✓	✓
CZ Orange[6]	Simulant	8.5 –9		1560F/20 min		✓	✓
CZ Pink	Simulant	8.5 –9			1650F/2H	✓	✓
CZ Tanzanite[7]	Simulant	8.5 –9		1110F/10 min			✓
CZ Yellow	Simulant	8.5 –9			1650F/2H	✓	✓
CZ White	Simulant	8.5 –9			1650F/2H	✓	✓

Lab Gemstone & Cubic Zirconia Notations

[1] Temperature given is for hydrothermal grown gems.
[2] This stone may darken slightly at 2 hours. The color may become a bit more orange, more intense.
[3] This stone may darken slightly at 2 hours. The color may become a bit more orange, more intense.
[4] All bright green CZ's are extremely oxygen sensitive. Fire at 1110F/10 minutes for any bright green stone, regardless of color name. Carbon firing recommended.
[5] CZ's in the darker olive hue are stable up to 1650F/1H. Lighter olive colors are stable to 2 hours.
[6] Orange CZ's can be fired up to 2 hours at 1650F, but color will fade slightly.
[7] Tanzanite CZ's incur a very slight darkening, but no color loss at 1110F/10. Do not extend time. Extremely oxygen sensitive. Carbon firing recommended.

COOL TOOLS

The Moh's Scale

The Moh's Scale is a non-linear scale of hardness defined as resistance to scratching or abrasion.

On the Moh's scale, 10 represents the hardest material and 1 the softest. A diamond can scratch another diamond and anything softer than itself. A corundum can not scratch a diamond, but it can scratch another corundum and anything softer than itself, and onward down the scale to talc.

In viewing the Moh's scale, it would appear that corundum is almost as hard as a diamond, but the Moh's scale is deceptive because it is non-linear. It has steps from 1 to 10, but they are not equal steps. If we compare the same chart of minerals on an absolute hardness scale it is apparent that rubies and sapphires (corundum minerals) are actually 1/4 the hardness of diamond; not 90% as the Moh's scale would seem to suggest.

Mineral	Mohs Scale	Absolute Scale
Diamond	10	1600
Corundum	9	400
Topaz	8	200
Quartz	7	100
Feldspar	6	72
Apatite	5	48
Fluorite	4	21
Calcite	3	9
Gypsum	2	3
Talc	1	1

Carbon-Safe Firing

When looking at the maximum recommended firing time and temperature for a given gemstone, it can be disappointing to discover that some stones are so sensitive that they can only stand a few minutes at a very low temperature. That means that some stones can only be embedded in low-fire clays, and if you wanted a very strong product or wanted to use a clay that required a 2-hour firing, you'd have to select a different gem.

The kiln and torch firing tests conducted on natural, lab and synthetic gemstones were all originally conducted before the introduction of bronze and copper clays. The gems were tested either by firing them alone in the kiln on an open shelf, firing the stone alone by torch, or firing a stone embedded in silver clay. So, in every case, oxygen was present during firing.

The new copper-based bronze and copper clays are buried in activated carbon during firing to avoid the creation of fire-scale that is difficult to remove from the surface of the fired metal. Fire scale, or fire-stain is created when copper is heated in the presence of oxygen.

Carbon is used as a firing media for copper-based clays because one of it's properties is the ability to absorb oxygen. Since oxygen is the element that causes fire-scale to form when copper alloys are heated, it follows that it should also protect gems that are sensitive to oxygen.

I have conducted new firing experiments to test my theory that oxygen is the culprit in the burning of many types of gems. I have found that gemstones that can survive only a few minutes in open air can survive for many hours when buried in activated carbon. It turns out it was not the heat so much that burned some stones, but the presence of oxygen that caused the stone to oxidize and darken.

COOL TOOLS

Firing a Carbon-Safe Stone in Bronze or Copper Clay

Firing gemstones in copper-bearing clays is very simple. Embed your chosen stone in your bronze or copper clay, dry and fire as usual in activated carbon.

The carbon adsorbs oxygen during firing, and the lack of oxygen protects the stone from burning. Any stone marked as Carbon-Safe is oxygen-sensitive, but can be safely fired when protected by activated carbon.

Firing a Carbon-Safe Stone in Silver Clays

With this technique, you can safely fire stones in all forms of silver clay at the ideal temperature without sacrificing the stone or the integrity of the final product.

The method is simple. Pre-burn the binder from the clay before burying it in the activated carbon. The binder must be burned away first because it will not combust in activated carbon with silver clay present.

To pre-burn the binder, place it on a bed of vermiculite to allow air circulation around the entire piece and ignite it with a flame. Allow the flame to burn itself out, then turn it over and repeat on the back side to be sure no binder remains. When igniting the clay, use a flame with no oxygen added to it (such as a standard lighter). A cool flame is needed so the stones are not overheated during burnout.

After burnout, bury the item in activated carbon and fire at any temperature up to 1650F for your desired hold time.

For a PMC Standard firing, which requires a 2 hour hold time, set your hold time to 2 hours and 30 minutes if you are using the standard bronze or copper clay firing vessel. The time must be extended because the carbon delays the heat reaching the interior of the container by 30 minutes.

For PMC PRO firing, no pre-burn is needed. Simply bury the item in the activated carbon and fire at 1450F for 1 hour.

