

Ceramics: from the earth to the fire

Learning Goals:

- Know where clay comes from
- Understand what clay is

- Know what ceramic means
- Understand how the ceramic process works

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What does ceramic mean?

Ceramics are things made from materials which are permanently changed when heated.

Examples of ceramics:

- .Clay
- .Stoneware
- .Porcelain
- .Glazes



Clay as seen in nature

Clay = Alumina + silica + water.

What exactly is clay?

Clay minerals are hydrous aluminum phyllosilicates, sometimes with variable amounts of iron, magnesium, alkali metals, alkaline earths, and other cations (an ion with fewer electrons than protons, giving it a **positive charge**.)



Collecting clay for ceramics? Oxford Clay (Jurassic) exposed near Weymouth, England.

Where does clay come from?

Clay is a general term including many combinations of one or more clay minerals with traces of metal oxides and organic matter.

Clay minerals are typically formed over long periods of time by the gradual chemical weathering of rocks, made up of silica, carbonic acid, and other diluted solvents.



The Gay Head cliffs in Martha's vineyard consist almost entirely of clay.



Deforestation in Atlantic Forest Rio de Janeiro - Brazil. This hill was deforested in order to use its clay in civil construction (**brick making**) in Barra da Tijuca.

Oldest known ceramics

The oldest utilitarian ceramic objects discovered to date were made approximately **11,000 years ago** (9,000 B.C.E.)



Ancient Bowl (7th–6th millennium B.C., Halaf period : Syria, Tell Halaf)(...*painted diamond pattern similar to Hemaka Disk on the inner rim*)

Ceramics as a building material

The **earliest bricks** were *dried brick*, meaning they were formed from clay-bearing earth or mud and dried (usually in the sun) until they were strong enough for use. The oldest discovered bricks, originally made from shaped mud and dating before 7500 BC, were found in the Middle East.

Ceramic, or fired brick was used as early as 4500 BC (6500 years ago) in early Indus Valley cities (in the Middle East).



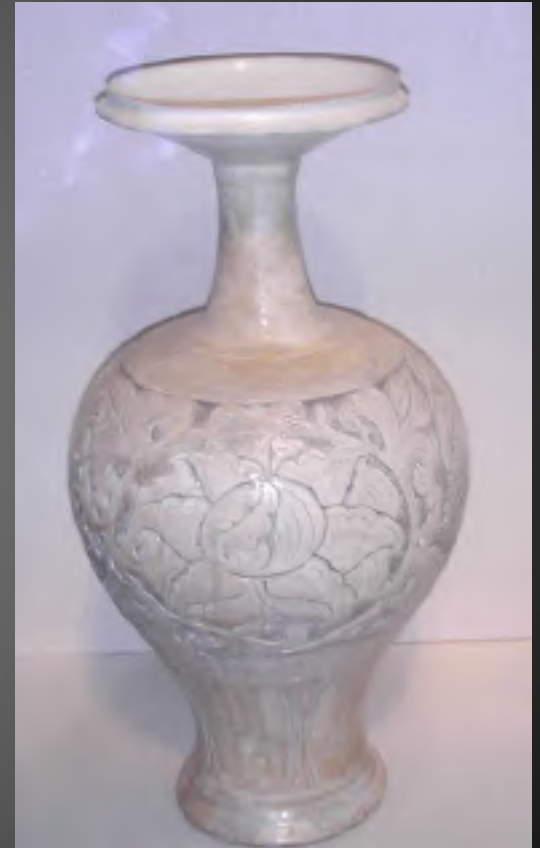
An old brick wall in English bond laid with alternating courses of *headers and stretchers*

Popular Ceramic Materials

Ceramic pottery and sculpture is generally made from one of two classes of ceramic materials:

Earthenware – The oldest, used for millenium, the kind we will use in class

Stoneware – believed to have been invented in China 900 or so years ago. It requires much hotter firing temperatures than earthenware, is usually only fired once, and is stronger than earthenware (e.g. more scratch-resistant, can be used as an electrical insulator)



Pictured: A Chinese Song Dynasty(960-1279 AD) cizhou-type stoneware vase with sgraffito decoration and carved white slip under a transparent colorless glaze; made in the 11th century, most likely in Dengfeng County of Henan province.

Greenware

Greenware - a pot that has been formed from clay and has not yet been fired. It can still be wet, or it can be completely dry.



Greenware: Leather Hard

Leather Hard: Stage of the clay between plastic and bone dry. Clay is still damp enough to join it to other pieces using slip. For example, this is the stage handles are applied to mugs.

The **leather hard stage** is the last opportunity to modify **your sculpture** before it is fired and hardened.

Most carving and trimming is done when the clay is **leather hard**, which is part of the greenware phase.

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Greenware: Before Firing

Greenware must be **bone dry** (completely air dried) before it can be fired.

Check for any cracks in the bottom and on handles and attachments. Determine how bad they are.

- If they are small, you can paint some slip mixed with vinegar into the crack to seal it.
- Unfortunately, if they are already large at this point, they are only going to get worse.

As clay is dried and fired it continues to shrink, which will worsen any cracks.

If the crack is too large to save, it is often best to abandon the pot while it can still be recycled into usable clay.

Slaking

Greenware can be recycled into usable clay. This is called **slaking**. Wet the clay/combine it with water in order to re-use it. **Pug Mill** - A machine for mixing clay and recycling clay.



Firing

Firing ceramics is the process of controlling the heat rise in the kiln to produce the desired results.

This accomplishes two things for the ceramics.

1. First, it heats the pottery just to the point of maturity, bringing out it's highest quality and function.
2. Second, it allows the potter to manipulate the fuels to create special glaze and surface effects.

Firing: Vocabulary

Maturing Point The temperature (during the bisque fire) at which clay becomes hard and durable

Reduction - Firing with reduced oxygen in the kiln.

Oxidation - Firing with a full supply of oxygen. Electric kilns fire in oxidation. Oxides show bright colors.

Vitrification - The firing of pottery to the point of glossification, the transformation of a substance into a glass

Peephole - A small observation hole in the wall or door of a kiln.

Kiln

A furnace of **refractory** (retains its strength at high temperatures) clay bricks for firing pottery and for fusing glass.



Inside an Electric Kiln

Kiln Furniture:

Refractory posts and shelves used for stacking pottery in the kiln for firing.

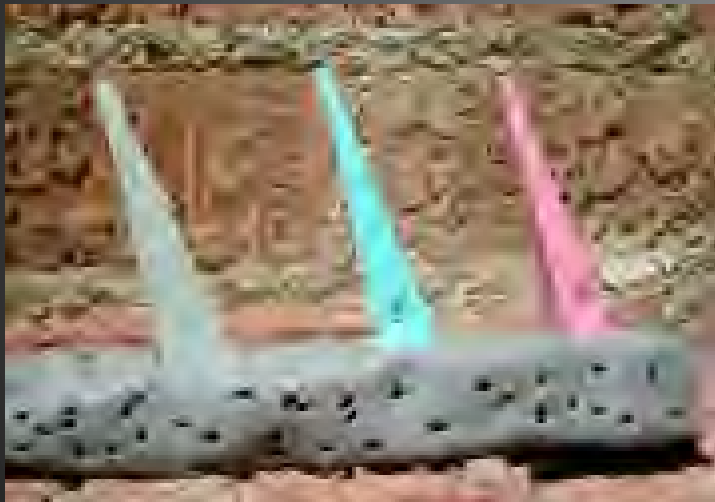
Kiln Wash:

Mixture of Kaolin, flint and water.. It is painted on one side of the kiln shelves to separate any glaze drips from the shelf.



Pyrometric Cones

When firing pottery, the most common and reliable method to determine when the pottery has reached the maturation point is with **pyrometric cones**



Cone pack before firing. The different colors are for different temperature cones. They are also stamped with the cone number.



Cone pack after firing. The lowest temperature cone has melted.

Pyrometric Cones

Here is a list of the cone numbers from lowest temperature to highest:

022, 021, 020, 019, 018, 017, 016, 015, 014, 013,
012, 011, 010, 09, 08, 07, 06, 05, 04, 03, 02, 01, 1, 2,
3, 4, 5, 6, 7, 8, 9, 10.

Notice how the lower temperatures have a "0" in front of them.
Higher number = **lower temperature**.

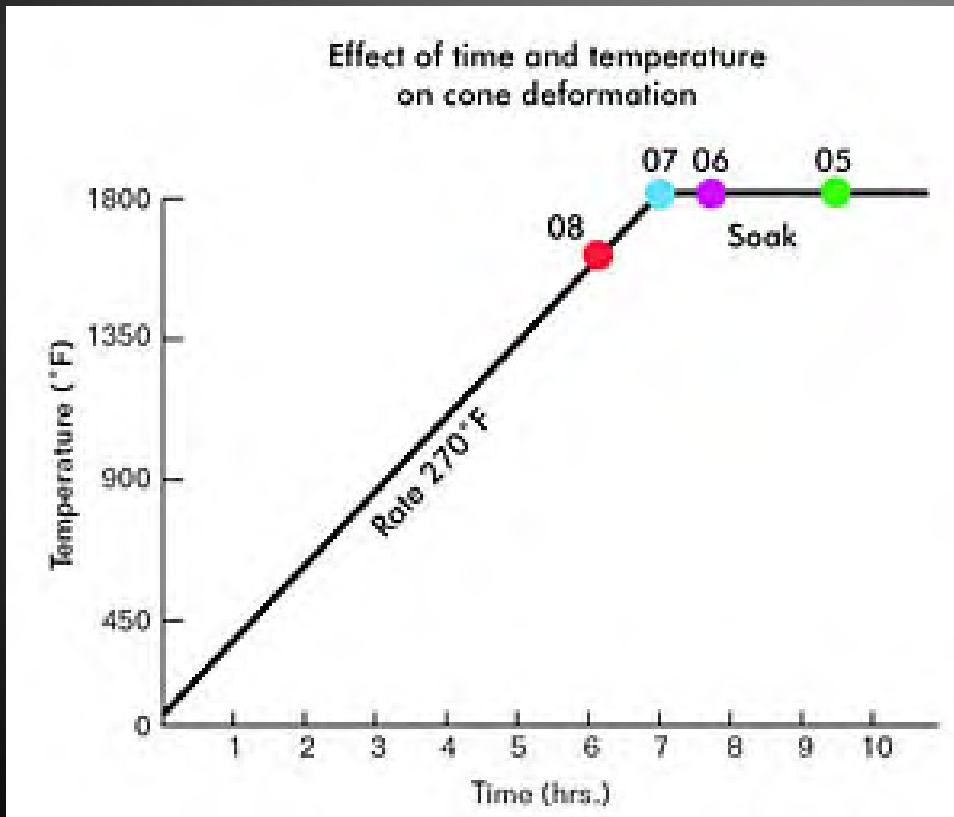
TIP: think of the "0" as having the same value as a "-" sign

- e.g 05 = -5

On the other hand, the higher temperatures don't have the "0".
Higher number = **higher temperature**.

Pyrometric Cones

Cones are placed inside the kiln with the pottery. Because they measure both heat and time exposed to heat, they provide a very accurate measurement of the amount of heat the pots have absorbed.



KILN FIRING CHART

Firing covers various work. Rock fired, glazes fired, firing, double firing, As the temperature in a kiln rises, many changes take place in the clay and surrounding vessel during the firing process. The following chart provides highlights of what happens when firing clay.

Temperature (°C)	Temp (°F)	Color	Cone (approx.)	Event
1400	2552	Efficient white	14-12	Final porcelain range
1300	2372	White	11-9	End of stoneware range
1200	2192	Yellow-white	8-6	End of earthenware and oven (1000)
1100	2012	Yellow	5-4	Between 1000-1200°C, vitrification increases but stops of vitreous when clay starts converting to glass. Clay and ceramic particles start to melt together and form crystals. These changes make the material more as a ceramic than clay. Soaking (holding the end temperature) completes the structure of fused matter and the amount of chemical action between the fuses and the more refractory materials.
1000	1832	Orange	3-2	
900	1652	Red-orange	1-0	
800	1472	Red	0-10	Between 800-900°C, softening begins. This is the stage where clay particles begin to bond. Vitreous together to create a hard, fused solid product.
700	1292	Dark red	0-13	Between 600-700°C, the temperature must be held steadily and ample air must be present to permit the complete burning of carbonaceous materials (impurities in the clay along with paper, wax, etc.) At 600°C, the clay surface will dry or melt off, exposing unburned carbonaceous materials and sulfides, which could cause bloating and blackening.
600	1112	Dark red glow	0-12	Quartz inversion occurs at 573°C. When clay is vitrified for a glass firing, quartz crystals change from an alpha to a beta structure to a beta (β) crystal structure. The inversion is reversed on cooling. This conversion causes stresses in the clay so temperature increases and decreases must be slow to avoid cracking the work.
500	932	Black		Between 400-500°C chemical water (referred to as "free water") is driven off.
400	752			Upon cooling, crystalline, a crystalline form of silica found in all clay bodies, will melt below 720°C. Fast cooling of this temperature will cause more to melt.
300	572			Water boils and converts to steam. Trapped water will bubble out of the clay as air water should be evaporated before 100°C. Rapid firing by soaking the kiln below 100°C and off water, has implications.
200	392			
100	212			

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Bisque Fire

Greenware must be properly dried before it can be **bisque fired**, which **transforms it into a ceramic material that cannot be slaked**

Your greenware pot is then **fired slowly to bake all of the moisture out of the clay.** This first partial firing or bisque ceramics firing hardens the greenware so it can be handled without breaking.

After the pot has been fired once it is called **bisque** or **bisque ceramics**



Bisque Fire

To the right are *greenware* pots being loaded into the kiln to be bisque fired.

If you look closely you can see how they are packed in very tightly, even touching each other and the *kiln posts*.

You can also see that some have been stacked carefully inside one another. *This can only be done with greenware because it has not been glazed yet.*



Maturing Point

The temperature (during the bisque fire) at which clay becomes hard and durable

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Bisque and Glazing

Ceramics which have been **fired once** are called **bisque pottery**.

At this stage they are **glazed**.

Glaze - **A thin coating of glass**. An impervious silicate coating, which is developed in clay ware by the fusion under heat of inorganic materials

Gloss Glaze - A shiny reflective gloss.

Matt Glaze - A dull glaze surface, not very reflective when fired. It needs a slow cooling period or it may turn shiny.

Satin Glaze - A glaze with medium reflectance, between matt and gloss.

Transparent Glaze - Transmits light clearly.

Glaze Firing

Glaze firing - The final firing, with glaze.

Crazing - The cracking of a glaze on a fired pot. It is the result of the glaze shrinking more than the clay body in cooling process.

Crawling - A bare spot (from the shrinking of a glaze) on a finished piece where oil or grease prevents the glaze from adhering to pottery.

Glazed Pottery

