Chapter 8: Clay

Clay

Some of the oldest objects crafted by humankind are made of clay, and the human body is often the subject of these early cultural artifacts. The Venus of Dolní Věstonice is a 26,000-year-old ceramic figurine from the Paleolithic era discovered in the Moravian basin south of Brno, Czech Republic. This literal clay body was fabricated using local terracotta mixed with powdered mammoth bone. (The introduction of bone ash from cattle bones was an innovation also employed tens of thousands of years later, in the invention of bone china in late 18th-century Britain.) Not only does the Venus from the Dolní Věstonice site represent the earliest known ceramic technology, she also represents one of the earliest known depictions of the female body and the earliest known use of animal bodies in the making of ceramic objects.[[1]](#footnote-1)

Clay is the basic building block of contemporary civilization. The oldest permanent cities, constructed some 10,000 years ago, were built from unfired mud bricks. Scientists theorize that this humble material also comprises the fundamental building blocks of life itself. One particular type of clay, Montmorillonite, is considered to be the material segue between matter that is not ‘alive’ and life, which began as a muddy stew of clay and water transformed into living matter by electrical charges from lightning, forming the first microscopic structures that one finds in living cells.[[2]](#footnote-2)

Clay is a combination of alumina, silica and chemically bonded water. Particles of clay are extremely small, .7 microns in diameter and .005 microns thick and they are usually easily found in riverbeds and deltas. Clay particles are flat, two dimensional and electrically charged. They touch on only 2 sides and when flooded with water, a strong attraction occurs which is what makes the clay particles bond to each other. The water also lubricates the particles, which is what allows them to slide and make the clay plastic and malleable.

Clay can be found in almost all parts of the world, it’s cheap, if not free, it’s colors range from white, to red to black with every shade and tint in between and when fired clay turns back into a stone like material that lasts indefinitely. [Figure 132] Most clay is fired at around 2000 – 2300 degrees Fahrenheit, which is the same temperature as volcanic gases and molten magma before they turn to rock. The heat of the kiln reenacts the metamorphic processes that created the earth.

While the first clay objects made by humans were figurines, the second were pottery vessels and these vessels were made specifically to be baked in an outdoor bonfire so they could be watertight and rock hard. Anthropologist speculate that women would put a fine layer of mud in their woven baskets to make them impermeable so they could hold water or fat as some of the earliest remnants of clay pottery show impressions of woven baskets in them. Subsequently, women began making pottery by hand using the coiling technique and made pots for storing water, grains, and fat for cooking. Evidence of the first clay pots appears in Japan around 10,000 BC[[3]](#footnote-3) in the agrarian culture of the Jamon. Simultaneously, around 10,000 BC the first houses were being made of mud bricks in the Mehrgarh region of what is today Pakistan. Mud bricks are made of a mixture of loam, mud, sand and water mixed with a binding material such as rice husks or straw. These houses coalesced into communities and cities made of mud brick that housed up to an estimated 5000 people in the Indus Valley Civilization.

The oldest existing earthen buildings are located in the abandoned city of Shahr-e Sukhteh in present day Iran built around 3200 BC. Eventually, people started to build clay furniture in the form of benches and beds next to the clay oven or fire pit where they could sleep. An early form of Egyptian pyramid constructed of mud brick, is called the *mastaba*, which literally means, mud bench. For thousands of years, in villages and cities all over the world, people lived in building made of clay, buildings that surrounded hearths made of clay where pots and vessels made of clay could be found for cooking and storage, creating entire domestic environments made of clay.

In northern Europe, clay pots were even inserted into the walls of the clay ovens. These pots sometimes faced in and filled up with the hot air inside the oven and more quickly transmitted heat into the room interior, and sometimes faced out and were known as “fist warmers”. If your hands were cold and stiff from working outdoors you could push them into the pots to warm them.[[4]](#footnote-4)

Earth constructions comprised of mud brick, rammed earth, cob, and wattle and daub, continue to be built all over the world. The largest existing mud-brick structure in the world is the Mosque of Djenne in Mali, Africa. It was built in 1907 and continues to be the center of religious and cultural life in Mali. Traditional buildings are not the only earthen architecture being constructed. The Center for the Blind in Mexico City, a contemporary work by architect Mauricio Rocha, is made of concrete, glass, and naturally compacted clay, called *tepetate*, that is cut out of the ground. The Eden Project Visitor Center in Cornwall, England by Grimshaw Architects is constructed of high quality china clay taken directly from the site and rammed into walls. Clay is one of our oldest building materials and it continues to be a viable and sustainable method of construction all over the world.

Ceramic bricks are mud bricks that are solidified by firing them in a kiln at high temperatures. Fired brick was first used in the Indus Valley around 3000 BC. Ceramic brick technology later was adopted, commercialized and disseminated by the Romans. Using mobile kilns, the Romans successfully introduced kiln-fired bricks to the entire Roman Empire. The bricks were then stamped with the mark of the legion that supervised the brick production. They differed from other ancient bricks in size and shape—they were round, square, oblong, triangular or rectangular and were generally 1 or 2 Roman feet long by 1 Roman foot wide. The Romans preferred this type of brick making during the first century of their civilization and used the bricks for buildings all over the empire including at the baths of Caracalla and the Pantheon.

During the industrial era of 1800’s England, the production of bricks became mechanized. Bricks could be extruded, pressed, or molded by machines with incredible speed resulting in the construction of entire cities made of brick all over the world.

3D Printing With Clay

With the advent of additive manufacturing clay can also be used to make sculptural objects and figures, pots and vessels, bricks, blocks, tiles and entire earthen buildings. Organizations such the World’s Advanced Saving Project, WASP, use clay extruders to 3D print large structures such as columns and walls up to 12 feet high using their “Big Delta Wasp” printer. Their goal is to build a prototype for a sustainable village composed of 3D printed mud houses. The mud is sourced locally, there is little infrastructure required and no industrial or expensive materials are needed to make the building shell since they mix the mud with straw to strengthen it. Like traditional mud brick buildings or puddled mud buildings the 3D printed clay buildings printed by WASP will be baked solely by the sun.

Emerging Objects has developed formulas and techniques for 3D printing clay with both powder-based printers, and paste extrusion printers that use moistened clay. The *Cool Brick* specifically takes advantage of powder-based jet binding printing technology. Jet binding creates porous objects, which inspired the design of the *Cool Brick.* [Figure 136]

There are many technologies for keeping interiors comfortable in hot, arid climates. One technology, used for thousands of years and still in use today, cools interior spaces through the use of evaporative cooling. Called the *Mascatese* evaporative cooling window, the system employs the use of a porous ceramic vessel that is filled with water that is placed in a window. As cool breezes blow over the jug, the water that evaporates humidifies the air and subsequently lowers the temperature of the room. This is combined with a wood screen, called a *mashrabiya*, which keeps the vessel, and the room, in shade ensuring that both stay cool. The entire system is an ingenious strategy that requires no electricity or ozone depleting refrigerants. [Figure 135]

Inspired by the *Muscatese,* the *Cool Brick* masonry system collapses the ceramic vessel, wood screen, and window into a single building component made possible by 3D printing.

The *Cool Brick* is comprised of two scales of porosity. The first is a micro-porosity that absorbs water through capillary action and stores it within the brick itself. The second is a matrix of openings in the form of a three dimensional lattice that allows air to pass through the wall. As air moves through the 3D printed brick, the water that is held in the micro-pores of the ceramic evaporates, bringing cool, humidified, air into an interior environment, lowering the temperature using the same principle of evaporative cooling as the *Muscatese*.

The bricks are modular and interlocking, and can be stacked together to make a screen. [Figure 134] The three-dimensional lattice creates a strong bond when set in mortar and surface relief creates shade in order to keep a large percentage of the wall’s surface cool and protected from the sun, thus improving its performance.

In addition to powder-based printing, paste extrusion 3D printing has allowed Emerging Objects to explore radical 3D printing techniques resulting in the development of a series of objects entitled *GCODE.clay*. [Figure 137]

*GCODE.clay* is a series of objects that are fabricated using various clay bodies (b-mix with grog, paper clay, porcelain, basaltic clay with manganese, recycled clay, and local clays) that explore the creative potential of designing with Gcode. The exploration does not concern itself so much with the shape or profile of the object, but rather, the path that defines the movement of the 3D printer. Through this exploration, the 3D printer is pushed outside the boundaries of what would typically define the printed object, and we have created a series of controlled errors that create a new expressions in clay defined by the plasticity of the material, gravity and machine behavior. [Figure 138] One outcome of this experiment was the creation of textured surfaces that are reminiscent of textile knitting patterns.

Typically, extrusion based 3D printed ceramic objects are defined by the layers of clay whose striations are present on the surface of a 3D printed object but as demonstrated here, the surface quality takes on the appearance of a knitted textile, with clay being looped, purled, and knotted, as it droops away from the surface. Occasionally there is a dropped “stitch” which causes a loop to pull away from the surface making every print unique. [Figure 139]

In addition to patterning controlled by Gcode, paste extrusion offers the possibility to combine clay bodies. During the third debate of the 2016 United States presidential election, then candidate Donald Trump said he wanted to build a wall between the United States and Mexico to keep out the “bad *hombres”*. He was referring to bad “men”, but what he said sounded more like “bad ombrés” – which implies a very different connotation—something in opposition to what a wall engenders. Ombré, which literally translates from the French as shade - refers to that which progresses from light to dark. An ombré allows for unbroken transitions across borders and between landscapes, it crosses political boundaries fluidly and allows for continuous cultural connections to be made.

In response to Donald Trump’s “bad hombres” statement, Emerging Objects created a collection of 3D printed vessels, called *Bad Ombrés*, which smoothly transition from one material to another. The clay bodies used in the *Bad Ombrés* collection come from different regions around the world and are combined in a single tube that extrudes clay continuously. [Figure 140]

The *Bad Ombré* vessels have colors and tones that blend into each other, where one clay body is graduated into another, from light to dark and from translucent to opaque. [Figure 141] Black Mountain and Cassius Basaltic clay, some of the most opaque and black clays available, transition to Polar Ice porcelain, which is mined at the Matauri Bay clay pit in New Zealand, and is the world’s whitest clay. This unique clay is delicate, resonate and translucent when struck with light. It is derived from the geologic transformation of volcanic rocks and the clay body includes alumina-silicates and plasticizers to make it more workable. The Black Mountain clay bodies are a combination of fireclays, ball and red clays that come from pits deep in the southern part of the United States that are mixed in California to create a newer, stronger clay body that is easily workable.

Through the use of varying clays, the *Bad Ombrés* are intended to create new geographic and geologic landscapes- they are objects that transcend borders- they are simultaneously rooted in the ground from which they emerge yet they are global and inclusive. No ombré in this collection will ever be recreated exactly the same way again, failure, individuality, distinct character, unique markings are all what make these pieces special – their differences make them one of a kind but the ombré itself ties them together. [Figure 142] [Figure 143] [Figure 144][Figure 145]

Objects:

*Planter Brick*

The *Planter Bricks* are custom designed masonry units that have the potential to passively mediate the exterior climate surrounding a building. The *Planter Bricks* counter the heat island effect in big cities through evapotranspiration and pollution conversion. The plants in the wall help mediate the temperature of the microclimate surrounding the building, buffer sound and help filter the air and the whiteness of the clay reflects light and heat. The fine particles of the 3D printed clay bricks are held together with an organic binder and the bricks are fired – burning off the organic materials and leaving behind a strong ceramic object. The *Planter Bricks* are standard dimensions and can fit within existing masonry wall systems and can be glazed any color. [Figure 146]

*FLO*

*FLO* is a 3D printed ceramic vessel composed of spheroids that flow into one another. [Figure 147]

*Wursterware*

Is it possible to 3D print directly from the ground beneath one’s feet was the question explored in the development of *Wursterware*. The bottom floor of Wurster Hall, on the University of California Berkeley campus was undergoing renovation, and an excavation exposed the clay-rich soil atop of which the College of Environmental Design building was constructed. Taking advantage of this opportunity, several large buckets of this local clay was gathered, sifted and reconstituted to create a series of functional earthenware vessels.

[Figure 148] [Figure 149] [Figure 150]

*The Berkeley - Rupp Prize*

Emerging Objects is honored to have the opportunity to design the physical representation of the *Berkeley—Rupp Prize* for Architecture, which awards $100,000 biannually to a distinguished practitioner or academic who has made a significant contribution to promoting the advancement of gender equality in the field of architecture, and whose work emphasizes a commitment to sustainability and the community.

The history of architectural medals comes from the first use of medals, the first one given by Alexander the Great for military contribution and they were intended to be used as jewelry. Medals were also used as a form of propaganda, often given to politicians to show their support for a particular lobby. Today, all architectural medals are made of precious metals and their design still reflects the earliest military medals.

In contrast to a medal, the physical representation of the *Berkeley-Rupp Prize* is crafted from the humblest of materials, clay, and is spatial and non-hierarchical— the design is a 3 dimensional object fabricated under the new paradigm of additive manufacturing to represent a new worldview about the role of architects in today's society.

The first documented trophy was made of clay—a ceramic amphora filled with oil and given to the winners of the Olympic games. The *Berkeley-Rupp Prize* comes in a contemporary amphora, digitally crafted using materials and processes developed by Emerging Objects.

[Figure 151] [Figure 152] [Figure 153] [Figure 154] [Figure 155]

*Seed Stitch*

*Seed Stitch* is a 3D printed ceramic cladding system that serves as a rain-screen. Designed for easy assembly, the *Seed Stitch* tiles are designed to be hung as a building facade or interior. The surface of each ceramic tile visually emulates a knitting technique called the seed stitch. The Gcode technique is used to control each line of clay, as it is 3D printed to create loopy texture that looks like scattered seeds across the surface, hence the name seed stitch. While all ceramic tiles are printed from the same file, each tile is intentionally unique as a product of fabrication, which pulls at the delicate surface of tile giving them a distinct machine direction that is different every time. [Figure 156] [Figure 157] [Figure 158] [Figure 159] [Figure 160]

1. Vandiver P, Soffer O, Klima B, Svoboda J. “*The Origins of Ceramic Technology at Dolni Vestonice*, Czechoslovakia.” *Science*. Vol. 246 (1989), No. 4933:1002-1008. [↑](#footnote-ref-1)
2. "Clay may have been birthplace of life on Earth, new study suggests”, last modified November 5, 2013, http://www.sciencedaily.com/releases/2013/11/131105132027.htm [↑](#footnote-ref-2)
3. “Jomon Culture (ca. 10,500–ca. 300 B.C.)”, last modified October, 2002,

   http://www.metmuseum.org/toah/hd/jomo/hd\_jomo.html [↑](#footnote-ref-3)
4. Suzanne, Staubach, *Clay: The History and Evolution of Humankind's Relationship with Earth's Most Primal Element* (Lebanon: University Press of New England, 2013), 24. [↑](#footnote-ref-4)