Chapter 1: Salt

Salt

Buildings made of salt have existed since antiquity. Over 2000 years ago, when the Greek historian Herodotus journeyed to North Africa, he saw “masses of great lumps of salt in hillocks” where men dwell in houses that are built of salt blocks[[1]](#footnote-1). Herodotus was no doubt referring to the peculiar building technique where blocks of salt were taken from the nearby salt-water lakes and adhered together with an abundant mud mortar, also very rich in salt, in what is today the Siwa Oasis. Siwa is the only city in the world that uses this particular technique of making salt blocks that are a combination of both mud and salt – up to 80% salt. Similarly, 500 years later in Arabia Felix, Pliny the Elder wrote about his journey to “the city of Gerra, 5 miles in circumference, with towers built of square blocks of salt” that are “adhered together with copious amount of sea water” [[2]](#footnote-2) The city of Taghaza, Africa, in the country of Mali, is also uniquely built of salt, but of a very different process. Workers in the enormous salt mines at Taghaza live in houses, and pray in mosques, constructed from slabs of solid salt that are roofed with camel skins. Extreme geologic and climatic conditions allowed for the construction of these saline cities. Almost no vegetation in the desert regions of Africa and Arabia, requires builders to look elsewhere for materials, due to minute amounts of precipitation, which in turn prevents the salt blocks from eroding.

Traditionally, salt was harvested from either solar evaporation ponds adjacent to bodies of water, or mined from rock salt deposits deep below the surface of the earth. Therefore, salt has been used as a material for building both above, and below, the ground. One of the most interesting sites of salt harvesting in the world is the Wieliczka Salt Mine in Wieliczka, Poland. Extending 1072 feet below the surface, the mine, in operation from the 13th century until 2007, is a world heritage site and is often referred to as an underground salt cathedral because throughout its history, miners carved grand interior spaces, salt crystal chandeliers and intricate carvings of biblical scenes on various walls throughout the underground building as they excavated for table salt. The salt mine contains enormous rooms where galas for hundreds of people can be accommodated for banquet dinners, as well as private chambers where world leaders and scientists have confidential meetings without the worry of being overheard.

Other mines throughout the world are similarly intriguing for their sublime salinous spaces. In Grand Saline, Texas, Morton Salt mined a salt dome that is fifty seven stories underground and has walls of white salt rock rising in silent splendor up to 85 feet high. In contrast to the towering underground palace, above ground, the town hosts a small one story Salt Palace Museum on Main Street. The palace is constructed of salt rock from the mine below and is the fourth and smallest of the salt palaces the town has erected—the first three salt palaces melted! In it’s current iteration, the salt rock walls are made of salt rubble-style masonry and are protected by overhanging eaves. The building has been “re-salted” three times by a stonemason who replaces the salt rock veneer with new irregularly shaped salt rocks from the mine below.

There are more examples of salt block buildings currently in existence around the world. Constructed at the edges the world's largest salt flat in Salar de Uyuni, Bolivia, are three hotels, and many houses and restaurants, all made of salt block. The *salar*, an expansive salt flat that covers over 4,000 square miles, is comprised of a salt crust that varies in thickness from a fraction of an inch to 32 feet thick in some places. Because of the sheer abundance of salt (there are over 10 billion tonnes in the salar) most of the buildings in the area are constructed of salt bricks cut from the crust of the salt flat. The walls, domed ceilings, floors, and even the furniture of these buildings are often completely constructed of salt. The salt bricks are cut straight out of the ground in dimensions and proportions that vary but can be lifted and placed by hand reminiscent to an ashlar masonry wall. Colored layers present in the cut salt bricks indicate the vacillation between dry seasons and sediment deposit during the rainy seasons—a natural process which is repeated annually whereby the strata of sediment and salt creates a pattern of growth over time that can be seen on the surface of the building itself. The layers of salt and other sediments, coupled with the stacking of blocks, create a building that appears in stark contrast to the vast white planes of the expansive salt flat.

While salt has long been a traditional material, it can be found in contemporary architecture as well. One radical example of salt in architecture can be found in the application of salt used in glass facades as a chemochromic smart material. The technology is comprised of a light directing insulation glazing system that employs salt as a phase change material. It is composed of 4 panes of glass positioned one behind the other with external light directing prismatic plastic panels and internal transparent plastic containers that are filled with a thin (5/8 inch) layer of calcium-chloride-hexa-hydrate. An excellent thermal mass, the translucent salt hydrate can absorb as much heat as a 10 inch thick concrete wall. The use of salt here makes it possible to replace thick opaque walls with thin transparent surfaces. The salt-hydrate has a melting point at room temperature, and during the summer months when the building interior warms above this temperature, the salt melts and absorbs the thermal energy that would otherwise lead to overheating. However, because the salt is still translucent, light is transmitted to the interior. When the outside temperature drops below the melting point, the molten salt begins to recrystallize and heat is released warming the building interiors during the cooler evenings and nights. This application of salt used as a façade element is a great example of how the performative properties of salt can be exploited for their optical and thermal qualities to diffuse light and store heat, making salt a contemporary energy efficient building material and technology.

Another example of contemporary salt architecture is in the city of Shiraz, Iran. Architect Alireza Emtiaz has transformed salt from the Maharlu Lake, just outside of Shiraz, into twisting sculptural forms that evoke a cave to create the interior and façade for a new restaurant called "Namak", the Persian word for salt.The contrast between the soft undulations of the restaurant façade and the hard edges of the city makes the restaurant stand apart from the surrounding buildings. The loose salt crystals are mixed with a natural gum in order to make a thick coating that can be sculpted into the novel, doubly curved surfaces found in the restaurant interior and on the facade. The salty finish is that of stucco, and the architecture is evocative of an urban crystalline grotto emerging from the city.

The technique used to create the salt stucco of the "Namak" restaurant is similar in some ways to the process used in 3D printing salt by Emerging Objects. In both cases salt from a body of water is harvested and used in its granular form which allows the salt to be shaped and the salt is mixed with an environmentally friendly resinous materials and in both cases it is strong and waterproof.

3D Printing with Salt

The *Saltygloo* is an experiment in 3-D printing using locally harvested salt from the San Francisco Bay to produce a large-scale, lightweight, additively manufactured structure. In the landscape of the San Francisco Bay Area, employing only the sun and wind, 500,000 tons of sea salt are produced each year, making salt a locally available building material. [Figure 8] The salt is harvested from 109-year-old salt crystallization beds in Newark, California where salt water from the San Francisco Bay is brought into a series of large evaporation beds. Over the course of three years, the brine evaporates, leaving 5-6 inches of solid crystallized salt that is then harvested for food and industrial use. From this landscape, a new kind of salt-based architecture—created through the lens of 3D printing and computer-aided design was realized. Inspired by traditional cultures that employ the building material found directly beneath their feet, such as the Inuit Igloo, Emerging Objects embarked upon a similar process. Named *Saltygloo*, because it is made of salt *y* glue, it is made of a combination of salt harvested from the San Francisco Bay, and glue derived from natural materials, which makes for an ideal 3D printing material, one that is not only strong and waterproof but also lightweight, translucent and inexpensive. [Figure 9][Figure 10]

The form of the *Saltygloo* is drawn from the forms found in the Inuit Igloos, but also the shapes and forms of tools and equipment found in the ancient process of boiling brine. [Figure 11] Additionally, each tile is based upon the microscopic forms of crystallized salt. [Figure 12] The 330 - 3D printed salt tiles that make up the surface of the *Saltygloo* are connected together to form a rigid shell that is further strengthened with lightweight aluminum rods flexed in tension, making the structure extremely lightweight and able to be easily transported and assembled in only a few hours—in many ways it is a salt tent. [Figure 13] [Figure 14][Figure 15][Figure 16] The translucent qualities of the material, a product of the fabrication process and the natural properties of salt, allow for light to permeate the enclosure and highlight its assembly and structure revealing the unique qualities of one of humankind’s most essential minerals. [Figure 17] [Figure 18]

Objects:

*GEOtube Tower*

The*GEOtube Tower* Proposal is a scale model for a Vertical Salt Deposit Growth System for Dubai designed byFaulders Studio. The model’s modular components and unique material formulation for 3D printing were fabricated and developed by Emerging Objects to be extremely translucent and consistent with the designer’s proposal of a building constructed of salt.

Faulders Studio’s idea for the *GEOtube Tower* was born from Dubai’s unique environmental conditions to create a new kind of urban sculptural tower. Gravity-sprayed with adjacent Persian Gulf waters, its building skin is intended to be entirely grown rather than constructed— in continual formation rather than fully completed— and is created locally rather than imported. The world’s highest salinity for oceanic water is found in the Persian Gulf (and the Red Sea) The result is a specialized habitat for wildlife that thrives is this environment, and an accessible surface for the harvesting of crystal salt. [Figure 19]

*Twisting Tower*

The *Twisting Tower*, 3D printed in salt, explores vertical aggregation along with techniques for stacking by interlocking. Its form is comprised of undercuts, twists and bends that make it extremely difficult to cast. [Figure 20]

*Salt Shakers*

Salt can be 3D printed and formed into objects that we are familiar with such as 3D printed saltshakers. Each has a solid 3D printed exterior that has captured the loose salt held within the interior. Holes are printed into the top that allows for the loose interior salt to be sprinkled onto food and used for seasoning. The binders and additives in the salt formulation are edible and non-toxic. [Figure 21]

*The Haeckel Bowl*

The form of the *Haeckel Bowl* is inspired by Ernst Haeckel’s Radiaolaria book published in 1862. [Radiolarians](http://en.wikipedia.org/wiki/Radiolarian) are tiny protozoa that produce intricate mineral skeletons made of silica. Because silica is impervious to many acids that often dissolve shells they make up a huge proportion of the sludge found on deep-sea beds. The filiform skeletons typically have radial symmetry and are composed of ornate polyhedral lattices and sub-structures. The Haeckel bowl is printed in every Emerging Object material. Its form is used as a test case, to study strength, due to the cantilever, wall thicknesses, and dimensional variability of the lattice like structure, which becomes progressively thinner as they move away from the center. The entire structure is very shallow, less than two inches thick, and can be printed very quickly.

The salt version of the *Haeckel Bowl* is translucent and glows when light passes through it. This material attribute is remarkably similar to the glass like qualities that the deep sea radiolaria possess themselves, for when they are observed with an optical microscope, radiolaria are found to be low contrast, light-scattering objects. [Figure 22]

1. Herodotus (ca 484-425 BC), *Histories* (IV. 181-5) [↑](#footnote-ref-1)
2. Pliny the Elder (Gaius Plinius Secundus, AD 23-79), *Natural History* Book XXXI, 73-92 (Baily 1929; Healy 1929) [↑](#footnote-ref-2)