THE CRAFT OF FIRE

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NOTE FROM THE COMPILERS

The objective of this material is to serve as a reference for the persons and groups interested in developing the *Craft of Fire* at the workshops of the Parks of Study and Reflection. This document is a compilation of research and work performed at workshops located in different countries between the years 2002 and 2010.

The material is comprised of a framing regarding the interest of the crafts in general, and descriptions of the techniques corresponding to the various stages of this craft. The first stage consists of the conservation and production of fire. The next stage begins with cold materials (marble, resin, plaster, cement, etc.) and their corresponding molds. The following stage is dedicated to work at increasingly higher temperatures, in this order: first ceramic, and then metals such as pewter, aluminum, copper, bronze, and iron. Working with these temperatures implies the use of the appropriate molds, tools, and kilns.

The reference materials describe different techniques that do not always rigorously correspond to a single stage.

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FRAMING OF THE CRAFTS*

The crafts prepare one to enter into the works of the Disciplines. A craft teaches internal proportion and how to do things in a balanced way. One goes acquiring internal proportion thanks to these works with, what appears to be, external problems of accuracy and detail. There is a tone that associates internal states and external operations. A Discipline on the other hand presents a path of internal transformation. In the Crafts, one works trying to achieve carefulness, proportion and order at the same time that one goes achieving permanence.

One learns to work in a balanced way and these crafts can consist of various topics. They can involve work with materials, whether those used in the traditional plastic arts or perfumery, etc. They have their rules of work, their tricks and Craft secrets. We have only worked with ceramics, metal and finally glass. This range of work deals with kilns and substances that are transformed. This is different from perfumery where fire is rarely used except in the preparation of essences, or perfumes by means of distillation. In general fire plays no part in perfumery except when synthetics are involved. On the other hand, fire is involved in those Crafts that we know more closely, e.g. ceramics where it is essential. In any case, the material craft is an interesting work, as is the introduction to it—the work with fire, which allows us to recreate how fire originated and was produced. Its invention came a long time after its conservation was understood. At that point it was no longer about stealing and conserving fire but producing it. We work with different forms of conservation of fire but it is in its production that more care is required. The average person trying to produce fire today will not find it easy. The work with fire and kilns is important. The subject of the crafts is very wide-ranging and we are only at its beginnings. While we are learning the craft we go gaining internal proportion, thanks to this external work.

In general we say that those approaching a Discipline should have a minimal management of some craft.

It would be good to have workshops available in the Parks, Centers of Studies and Centers of Work; places where people can work and make relations between what is happening in their heads and these types of work.

* The four disciplines (Preparation, page 1); www.silo.net

GENERAL VISION OF THE CRAFT

TALK OF "THE STONE"

The following notes are a transcription of a talk given by Silo in the "Pyramid" Workshop on November 19, 2003 in Santiago, Chile. They have been reviewed by Silo.

…and in that respect it behaves like a metal. Out of a mold for glass, you take the blob of glass and blow, and you start to shape it, but you shape the molten material. This is no longer clay, where you have the form beforehand. Because with glass, just like with metal, the essential characteristics don't change, whereas with ceramics, they do. You go from clay or baked mud to ceramic, which is physically something else. Many of its characteristics change. Its sound changes, its hardness changes, its permeability changes, a qualitative change is produced. But not with metal, it remains the same molten metal that you can work with because it's molten, and with glass it remains glass, there is no change.

Question: But clay also becomes a bit like glass.

If you go too high with the temperature you convert it to glass. There are differences between clay and glass. But come on, roughly speaking, you can note the differences between the three works of clay, glass, and metal. Each involves very different things, they have very different techniques. And I think that we should start with that baked mud which is not yet clay, it's the mud of the Popul Vuh, the mud used by the Shapers, the Annunciators, the Grandmother of the Dawn, the Grandmother of the Day, to make the first human being. But they made the first human being, and the rains started and so the legs of the man of mud would bend and he would fall. And so they had to make another human being. That's proper to a pre-ceramic civilization; they lacked a temperature high enough to make an interesting human being. That is, they were getting to about 800°C. in that historical moment in which the Popul Vuh was written. Then they achieved higher heat and started making things out of ceramic. But that was baked mud, and baked mud works if it is burnished… baked mud, not ceramic. It can hold water for a while, and then it starts to leak, and finally it falls apart on you. And that's just like in the Popul Vuh. In any case, I believe we could start with baked mud. It's clay that you let dry out well so that it doesn't fall apart, and then you fire it to less than 800° (you can get to 800 or 700°C). It's a mud that all prehistoric civilizations have known: baked mud. It's not ceramic.

…in Mesopotamia (between the Tigris and the Euphrates rivers), a man is made with the same model. And so Enkidu is born, and he is the double of Gilgamesh. The same as him, but hairy. Like adobe is. It has straw to give it strength... Out of these kinds of things a myth is made. This is wonderful, it's very beautiful and very intelligent.

...A "burner" is sufficient, a blowtorch that includes an air inlet. It's the principle of the Bunsen burner, like the one we're looking at. If we had a "burner," Pancho, with a propane tank and a regulating wheel for the air inlet, you could adjust it until the giant uncontrolled butane flame begins to get smaller, turn blue, and raise the temperature through pressure....

...This other kind of oven, a wood kiln. It's interesting and paradoxical. You work with it from the outlet, not from the entrance as you would imagine. If you give it too large an outlet, it draws so much that you need a very high-calorie fuel. If the outlet is like this then you fill everything up with smoke. If the outlet is too large the air is unstable, it has oxygen and other gases as well. If the inlet is too large, other gases enter, too. None of them supports combustion like oxygen, which makes up only 18% of the air. Nitrogen and the other gases put out the fire. There is a point in the combustion equation that is just right, and for that you need to regulate the incoming air flow.

...And so the whole trick of the ceramic kiln is a trick of reaching as uniform an environment as possible; above, below, on this side and the other, in back, in front. You try to get the environment to be the same throughout. With metal and glass, the principle is different. You can apply the fire directly. But here you cannot apply direct heat. You have to reach a uniform ambient temperature. Not in one point. There's a timing to it. The timing needs to be slow and well managed, and also the fire shouldn't hit the object directly. That's why the big kilns have a firebox and a firing chamber. They're different. From the firebox, there are small channels that emerge and they run below and almost to the end of the firing chamber. At the end there's an open space where the fire rises into the firing chamber, it goes around it, and out through a chimney below again... Meters of fire! When it wraps around it's creating a more or less uniform environment in the firing chamber. The fire goes underneath, from the firebox to the firing chamber, it comes out the side... starts to climb up, it touches the ceiling, goes down again looking for the exit which is… below, the exit to the chimney isn't above, it's below.

Question: The flame enters the tube?

And how! And you can see it, you can see a three-meter tube with flames above... look how far it has had to travel! Do you remember the kiln of the Center in Moreno? It was a very big wood-fired kiln that could work at 1,200 degrees C. The small variations that might exist between one firing and another tend to be given not by the form, which is always the same, not by the amount of wood which tends to be similar, but rather by the quality of the wood. For example, some wood is very resinous and burns hotter than non-resinous wood. The diameter of each log is also a factor.

Opinion: And the dampness as well, the dampness of the wood.

The theme is the construction of the kiln so that it works by environment and not by direct fire. The placement of the pieces is also important. The design of this kiln that we're looking at is very good. The fire goes around and all of that. It should circulate, go out another way, underneath, and create the environment. If there's an updraft, then it is forced to go around but it covers all the objects, until it exits through the chimney. As it covers the objects, the objects are receiving direct fire, and direct fire is the enemy of ceramics. This one is good, but we could still “sharpen the tip of the pencil.” If we got to 1,000 degrees C. and we stopped feeding it at that point, we'd get it so that direct fire wouldn’t reach there, and we could then maintain that ambient temperature...

…Don't raise the temperature more unless you want to make a glazed ceramic. And then the ceramicists will get angry. They're not going to like it. Ceramicists say, “Glass-workers make glass, they don't make ceramic.” There's a dialectic between them which is historical. They don't like each other. The fight between theses guilds is interesting.

(Referring to industrial muffles). You need certain materials to handle the thing very well. Look at how they're built. We have: hollow refractory bricks, not completely hollow, they have a small channel. Each one of those bricks allows an electrical resistance wire to be inserted. They are refractory; the heat bounces from the brick to the center. And so, we have a cubicle filled with refractory bricks with small channels where the resistance wires go. Outside of the refractory brick, there is a blanket. Not too thick. And there’s a stainless steel exterior to give it solidity. And inside with the electrical resistance you're getting, uniformly, 1200ºC. It doesn't have refractory cement or concrete, or anything else.

… and the resistance wires go on the inside?

Along the inside of the brick which faces the center. And that's it. And then you have big kilns built the same way, with refractory brick channeled along where the resistance wires go, everything is surrounded by resistance wires: the two lateral walls, the back one and the floor. All of that has resistance wire. Not in front, because in front it's all door. The door has a blanket. The door also has refractory brick but without the small channels. And so the limit is the door, and you raise the temperature, and you manage it with a regulating thermostat, and you leave it, for example, until it reaches 500 degrees. 550ºC disconnect, 450ºC and connect, and there it is, around that 500ºC average.

What we're looking at is how all of this is built. It's just refractory brick, with small channels and resistance wires, and on the outside, the blanket. The stainless steel has nothing to do with its functioning. And so, it's possible to do it all with refractory brick, cover it with a blanket, and put the blowtorch through the side. You can make a great kiln with nothing more than refractory brick and the blanket.

Of course, it all has to be well built, everything has to fit tightly.

In this kind of kiln that we've been talking about for a while, that Pancho spoke about, you put insulating brick on the floor when you make the fire go under the floor. You have the insulating brick on the floor, and above you have a channel through which the fire passes, and only then will the fire enter from the side. Since you don't want the heat to escape through there, you put insulating brick there, not refractory. So that the floor is more or less cold. And then the heat enters from the side. There you have a case in which you use insulating brick to isolate the fire that goes underneath, isolate it from the floor where you are going to put your objects.

Question: And this kiln has refractory bricks on the inside too?

Yes... and on the sides and everywhere, it's refractory so it reflects, they're like mirrors. The refractory brick has the function of deflecting the heat wave. The blanket is not like it was before, made of asbestos or amianthus, which were carcinogenic. It's now a very interesting blanket, like of fiberglass. This little blanket is amazing. We start by reducing it all to the most simple, which is what elegance is, like in mathematical formulas, something more simple, more elegant. The less the better, the less you have to control, the less variables there are. If there are few variables then it's possible to know how the thing is, you can perfect it more if there are few variables. That's the ideal, a kiln that is as simple as possible. This can be very satisfying, but be sure that the flame doesn't hit the object directly, and that's it. If you can reach the temperature, then just be sure the flame doesn't hit the objects and you'll have a fantastic kiln. If you put a little wall there, there'll be more heat absorption. And so then if you put in a lot of ceramic and you put in a lot of brick, in the end you won't reach the temperature you're after because the brick wall is absorbing it... a little brick where the flame hits, unless you want to make a “flame breaker” on purpose.

Different questions about Raku.

You put the pieces in, you add sawdust all around and then cover it. And outside, the fire. Outside the box. Inside the kiln, but outside the box. And so in the little box, an oxygen-reduced combustion begins, without oxygen, it keeps decreasing and starts to go black, and if you break a piece it's black inside, it's not a painted, blackened layer: it's all black. Some older types make a hole in the floor, they put rocks down there and heat it up with branches and wood and the temperature starts rising. And that's when they add the sawdust and the objects and cover it up. They leave it for a day or two. The sawdust burns from the heat because it doesn't have oxygen, it burns slowly. When you add the sawdust to that tub it's about 600 to 700 degrees C, you put in the object and it keeps working for a few days. That technique arose in Japan during the shogun civil war. There couldn't be too much smoke because they'd be seen and attacked, so they had to conceal everything.

...in old, sunken boats, they've found vessels with wine inside, with honey, with oil and with olives. They're ceramic vessels, not baked mud. But even though you can't get such results with baked mud, very interesting things can happen anyway. Thanks to baked mud you start to get a handle on it, you start giving it shape, and it will have its physical characteristics that you'll notice when you convert it into ceramic. You have it fired already, one more little step, you put it in the kiln, you put it in again and raise the temperature and you convert it to ceramic.

Let's talk about safety. The propane tanks must be far away from the kilns! With a good long hose, three to five meters, far away. Put soap on the connecting point with a sponge and when you open the gas valve, you can see if it bubbles up. Soap, not a match. “...Here lies Jimmy Blast, who lit a match to check for gas.” We should get a thicker hose from the gas people, five meters long, and make sure everything is fine, but moreover check how the thing is with the soap. Because this thing of starting with kilns... is very serious.

Second issue: ceramic is okay, but then comes glass and metal. Molten metal falls on your shoe (he shows his shoe with aluminum melted on the sole), because they were doing castings, some aluminum fell on the floor, I came in and stepped on the aluminum that was on the floor and it got stuck to my shoe, and burned it. In the castings, the molten metal should be poured from the crucible into a stainless steel ladle covered with refractory cement. And from there you take the molten metal to the mold and pour. Crucible, ladle, and mold. We have the appropriate tongs for all of that.

Going back to our theme of ceramics, remember that you're taking this nearly prehistorical element and you’re inserting it into the year 2003 with all the speed and rush of this age, where everything has this speed. There's a “thermal shock” because your speed and the speed that the materials being fired have are different, there's a clash there. So it's the other way around, you have to regulate your speed, that's what is called “patience,” the regulating of speed. It has to do with that historical thing where this was done in an age in which things were slow, and by bringing them now into this day and age, these collisions are produced. And so one wants fast results and you go forcing the material. The material won't accept something so fast, it breaks apart, it cracks and you don't understand why. It's because of your speed, your timing, which isn't the timing with which these things work. The material has its drying time and its firing time; you have to respect the material.

…As for that scrapped forge that you got, it needs a sheet filled with perforations. The fire, the heat, will come up through the perforations, and so it's no problem that it's a bit fragile. The fire will come up through the perforations, the fire always goes up, just like in the nozzles; it's away from where the gas comes out. And so everything goes here: the parabola, and then you put refractory brick in that parabola, and you take advantage of the heat to make a forge that you can use to melt metal. What do you want all this for? To forge iron? Hardly. You want it to melt metal.

And so the fan goes here. A small fan, a cheap one, often they're used to take smoke out of kitchens, an extractor. You reverse that extractor and it blows air. Everything reversed. 1200 degrees C, molten bronze! 1300 degrees C, molten iron! And now, since there's a good distance you leave the little hole, you put the grate down and then start lining it with refractory brick to shape it. You put the crucible on the grate and you add the coke. In any case, something always falls down and that's why you have this ash tray down here, and so when you finish the work you open it up and throw out what's inside so that it doesn't fill up, because if it fills up then the air can't get in. And that's it. You light it and when the coke starts to burn you give it some air, sliding the door of the blower open, a bit, and then you keep sliding the air outlet open, and all the coke lights up, until at the end you open it up completely.

You've been putting the coke around the periphery of the burning center. What's inside, beside the crucible, is what is hottest, and so you go on moving it from the outside and what's closest is what is hottest. And so you go on filling it up from the outside, and you keep moving it in. And like that, in half an hour, you're melting iron. So of course for this you need a crucible, and that's already another theme. Some crucibles are made of silicon carbide, up to 1200 degrees C. We've also made graphite crucibles that have gotten red-hot, we've put water on them and they've withstood the thermal shock. It's a good material, able to withstand 1500 degrees C.

...With bronze, to take out the slag you throw in ground glass, and since all the waste rises up to the surface, it sticks to the glass, and with your ladle you take out the glass with all the waste. And then you do the casting. With a long ladle. If it doesn't have the right temperature, it gets cold on you and it hardens and everything fails because you've rushed it, because of a lack of patience. This can’t be. You have to give it 200–300 degrees extra, and like that you have enough to do things, have a coffee. It has inertia. You can't be at the limit. The limits are always complicated.

...Your question is difficult to answer. Historically they reached 1600 degrees C. Except the Chinese. The Chinese used six cascading chambers. The hot air came out of the first chamber and was injected into the second. It was already hot, and they gave it more heat, the temperature would rise, it would go into a third chamber, and each time the air was hotter. And by the sixth one they had reached 2000 degrees C. That's how they made porcelain. There is a porcelain of 2000 degrees C that is so fine that you can look through it as if it were glass. They'd go on raising the heat and putting in different pieces, and at the end they'd get to the ceramic which needed a higher temperature. In the first one, they'd put the vessels and the 800 degrees C objects, in the second, the 900 degree ones, 1000 degree ones, etc. And at the end they'd put their porcelain objects. They are the ones who reached the highest temperatures, before the others. And they fed each kiln. They added fire to each kiln, and like this they added and added and added. And the air would feed it too. The second kiln wasn't fed with air from outside. It was fed by air coming from the first kiln. That's the draft of the first one, which connects with the second.

And notice that it's not just hot air that came from the first one, but also gas from the combustion that hadn't been fully burned. You take a piece of newspaper and you make a cone with the newspaper, as if you were going to put a big scoop of ice cream in it. Do it now. Take a piece of newspaper, make a paper cone, light it below, a small little hole, light it, and it starts to burn below and gas starts coming out. It's already burned, right? No, it hasn't burned completely. Take a match, light it up here and it lights on fire. That means that that gas is still combustible. The second kiln receives hot air, and more hot gas that burns in turn in the second kiln. And air and gas that has not finished burning passes to the third kiln, and there it goes on being produced. Test this out and you'll see how you lose a certain amount of gas that allows for more combustion. It's the principle of the turbo. Try it out. Put fire to it and you'll see.

Unfired porcelain looks like ceramic. It's a kind of clay. Of kaolin. Kaolin, like feldspar, quartz, mica, are the basis of those kinds of clays that withstand very high temperatures. Kaolin is a high-temperature clay. It is composed of silica and is rich in aluminates. There are different silicas...

(In the suggested experiment, flames come out of the paper cone and a match is lit above and you can see how the gas above ignites.)

...Glass and metals will appear to be very similar. Glass will appear very similar to ceramic in that both work with fire, but they will seem totally different since with ceramic the form has to be prepared beforehand, while with glass the form is not prepared beforehand, it is melted. And molten glass can be put in a mold, and there it takes the form, or else you make a bubble and blow and shape it. We're talking about working on the material while it’s hot. Whereas ceramic is formed in cold. When you have everything prepared you add heat and it changes its physical characteristics when it changes from clay to ceramic. And so both use heat, but glass takes its shape hot and the other takes its shape cold. It's there where glass seems similar to metals, because they take their shape while hot. You take metal and melt it and you cast it in the mold. Putting the molten metal into the mold, it takes the shape of the mold. It takes its shape there. And in that it is similar to glass. You cool the metal and everything's fine. Cool down glass too quickly and it breaks, and in that it seems more like ceramic than metal. Not so much in the raising of the temperature but in the lowering. If you cool down ceramic too quickly, it'll break on you, and if you cool glass down too quickly, it'll break. That's where they're similar, in the lowering. In the danger of the lowering the behaviour of glass is similar to the behaviour of ceramic and not to that of metal.

And so you'll find in those three aspects, those three variables, you'll find things in common and things that are different. Tempered glass is nothing more than a variation of temperatures, it's not cooled. You lower it and then you raise it up again. You're at 1000 degrees C and then you lower it to 800 degrees, and when you've held it there for a while at 800 degrees you raise it up again to 1000 degrees and you temper it. To temper metal you cool it or you add other substances. For example, carbonates. When you want to make tempered steel you can put it in alcohol, for example. Alcohol has a lot of carbon and hydrogen. You put it in alcohol and temper it. Previously they used to temper it with Christians. Lots of carbon... with the fat of the infidels. But they shouldn't get cocky because the Christians did it with the Muslims, too, marking out the universal history of infamy. Oil can also be used for tempering. And the most elemental way to temper is in water, and if possible dirty, muddy water.

Carbonized iron becomes steel, steel of the lowest quality; then comes chromium vanadium, chromium cadmium, incredible kinds of steel, this is industrial steel. Some have greater flexibility, others have greater resistance, some are brittle but very strong, others are flexible and also very resistant, some can withstand compression very well and others withstand tension, etc. These are different characteristics that they've achieved by adding elements at different temperatures. The steel industry is something serious. Here we're talking about primitive iron that was tempered by the force of hammering, heat, hammering, heat, water, heat, oil, and on you go. We're not talking about industrial laminated steel. The Japanese did lamination, they'd take the sheet and hammer away at it and leave it very, very fine, and then once heated, they'd go on bending it and hammer away, and they'd put sheets on top and then when everything was good they'd press it down tight, and like that they'd get layers of different qualities. Some were flexible and others were hard. And so in the end you'd have a sheet of sabre that was flexible and hard. There are some that are flexible but not hard. And there are others that are very hard and you strike them and they break. This is what happened with bronze. When the ones who had already forged iron came along and attacked the ones who had bronze weapons, the bronze would break. They came with iron and broke the bronze of the others. Let’s get out of here! It was ridiculous. Terrible.

They had to run because their bronze would break. And so they began to go from the Bronze age to the Iron age. The people of bronze had a superior civilization, they had a great production, but of course, they hadn't produced iron. And these other primitive types around where they lived hadn't melted bronze, they melted iron and defeated the ones with the superior civilization because they had superior technology, not a superior civilization. Well, but that's a historical anthropological discussion that could be called, “On how the lesser can overcome the greater in certain circumstances.”...

But the people of bronze shouldn't get cocky because they trounced the people of copper, too. And those of copper shouldn't get cocky because they defeated the ones around there who hunted with sticks and bones. Each one went on defeating the other. That's the art called, “the art of screwing the other.” And there they all go. You can't do anything with these people! It never ends! You turn around and they screw you, they throw something at your head. They always have a pretext for throwing something in your face. Look, look... and you look and they throw something at you. What is this? That’s no longer the nature of metals. No. So one has to take materials seriously, not people, because people always create problems. They're always creating problems, it's all incalculable. They always have surprises for you, whereas metals, more or less, have laws, constants. And then they want to trick you with their people laws. People's laws! Everyone makes the laws as they like them. People are the worst of the material, the most unpredictable.

You say: if we mix this with this we'll get this, and it works. If you give it a certain temperature, this comes out. And you take a person, and something unexpected comes out. They’re unpredictable. In general, where there's life there are problems. The behaviour of life is erratic. There are no guarantees with life. Anything can come out: a martian, a dwarf, anything. A microbe screws you up. You were expecting a mammoth and a microbe screws you up, and you were getting ready to defend yourself against lions and spears, and along comes a plague, the Black plague. Life... life is so ecological! You're all relaxed on the grass, having a picnic, and along comes an ant and bites you. And a bee comes and stings you in the eye. And then the mosquitoes...

...We have to avoid problems here, taking certain precautions so that the propane tank doesn't explode, a piece of steel lands in your eye, a kiln blows up. Many things can be foreseen. It's like that with these materials, with ceramic and with things related to fire. But before ceramic we have slip. Slip. To use slip you would make plaster molds, because slip works very well in plaster and not in other molds. If you do it with glass molds or in molds of other substances it doesn't work very well, whereas with plaster you can fill it with slip and the plaster has the property of absorbing the water. It draws water in, and so in a short time, in 5 minutes, you touch it and it begins to harden, and when it starts to harden you pour the slip out. But you haven't poured it all out, a layer remains. Leave it to dry a little while longer, and you open the two parts of the mold and you have a hollow space left according to the mold that you've used. You leave it to dry, and then you put it in the kiln. It's interesting. It's baked mud. Slip. And with that you can work a lot. It comes out thin. If you wait longer and then pour it, it's thicker. If you wait a long time and then pour it out, nothing comes out. This is something you get a feel for. According to what you see, if you want it to be thicker or thinner, you leave it in for longer and then you pour it out.

Glass

Here we're not talking about artistic ability, and raku is simultaneous to the work of ceramic. And so if you have more or less, or some ability with this technology, you'll have to move on to glass. You don't make glass to start, you get some window glass, borate glass, you get your neighbor's window, you go, you throw a rock at it, you take a piece, you take the pieces of the window glass, you grind it up well, inside of a cloth, and you grind away until it's a powder.... A well-dried plaster mold that is sufficiently thick and solid can sustain a casting of glass for a small object. We're not talking about big things, to make big things you have to coat the plaster with a covering mixed with plaster, it's crap, and this gives it some solidity, and then you cover it with wire, chicken-wire, and then you do it all again, and in the end you've got this giant hunk, all to make a small object. If you do a casting with too much material it'll break on you.

As it cools, glass contracts. You do this whole operation very calmly, walking step by step, and in the end it cracks, “crack-crack,” and at the end it ends up all broken. When you get to 400ºC, “crack.” It's better to leave it in the kiln and lower the temperature slowly, being especially careful between 500ºC and 400ºC. When it gets to 350ºC then you can take it out in the open air. The general breaking point is between 400ºC and 500ºC. You can do these experiments: you make the first glass figure and you leave it in the open air and see how it cracks. Those tests are done in Prague, in Murano, in different places. They make little horses and they show them to you and they crack, they break when they reach 400ºC. Not to mention if someone leaves a door open... "close that door..." Those air currents break everything.

And so sometimes they use vermiculite, any old can filled with vermiculite, sand, or perlite, and so you have this glass object still red-hot and you make a little hole, you put it in there and you cover it up and then the temperature decreases slowly. That thing of perlite helps you, sand could help too, but perlite serves to lower the temperature without needing to put it in the kiln. It avoids breakage. It's the lowering of temperature with glass that's the problem, it's critical, it's the big issue. Not the raising, the lowering.

And so with glass you make all those molds, different things, until you get a certain refractory material that is very good for making molds. But until you manage to get that refractory material, it's better that you try it out with plaster, with the demolding agents, and then you get to what they call "dental plaster" which, funny enough, has everything but plaster in it. It's what dental technicians use to make molds. Those materials are a composite of more or less seven elements. They are very good. Dental technicians use that. And they melt chromium and cadmium. And platinum, too, which is 1700 degrees C. My friends, we're talking about serious temperatures. 1700 degrees C, that's a mold. It's not plaster which breaks at 1000 degrees C.

You can also use graphite for molds. And when they're heated they impede the production of a compromising thermal difference. But when you start putting in certain metals, in plaster that has a lot of sulphur, what happens? When you add the iron, it releases the sulphur, which is a lot of gas and so you get a lot of bubbles. Ah, so then you say, it's because the plaster was wet. You add iron and you get iron sulfide. Iron sulfide produces tremendous gas emissions that create bubbles, and you're always thinking that the bubbles are produced because of the water. It's not the water, it's the sulphur from the plaster. And so you can't use plaster for those sulphur-forming metals, but you can for glass. That's why for metals you have to find other molds that are not plaster-based. But plaster will work for slip, it will work for cold substances, for slip and for glass. Up to a certain point, but beyond that plaster won't work. Plaster works up to there. Of course there are a lot of things that can absorb those gases. Like the charcoal of vegetable carbon which, if you mix it at 3% with the plaster, when the gases are created this allows them to combine with the vegetable carbon charcoal and the gas emissions aren't produced.

That charcoal is also used in sand molds. You put 3-4% charcoal in and it absorbs the gas which otherwise would form, bubbles in the metal. And that thing of the dampness is relative. Because in metals, if we're talking about heavy metals, iron, the molds have to be very compressed so that they don't break and all that. Then there's a very ancient technique and mold, the "green" mold. "Green" not because it's the color green but because green things haven't ripened completely, they are damp molds. And they put molten iron into these damp molds...

We suppose that if we pour some molten material into something damp, the water is going to bubble and even break the mold. So what about the green mold? It doesn't bubble up. And so you have to revise your suppositions. You put metal in there and you end up with an incredible piece. In other cases you put metal into a mold that is damp and there's a tremendous bubbling... You can try it out with metals with low melting-point temperatures. Pewter, 400 degrees C. You pour it onto the damp plaster or any other damp thing and you get this horrible, bubbly thing. It's low temperature. How about iron? With such a high temperature, the surface water that is nearest to the metal that is poured there, the molten metal dissipates it and only the dampness on the sides remains, and there's a little dampness there but that's because of excess temperature. When the temperature is lower, the bubbling is incredible because it doesn't manage to evaporate it. The green mold is a great invention and a very old one, but it's for metals with high melting points.

When we talk about window glass and beer bottle glass and different kinds of glass, we can talk about molds and different kinds of molds. We're not talking about glassblowing, we're talking about casting glass into molds. When you're finished doing all that, you need to make glass. There you have to go with different formulas to make glass, you prepare it with powders, those powders are silicas, sands, and certain salts. There was a lake in Egypt that was called “Natron,” and that's where Natrium came from, sodium, whose chemical letters are “Na.” That lake had salt and they'd take great amounts of it out, they'd put it on their camels and they'd take it to the Eygptian capital or to Heliopolis and so on, where the bald guys were, those guys who were in charge of the administration and who were the priestly caste. They'd take these big quantities of natron to them as payment, and in homage. With that natron they'd manage the production of glass, they had craftspeople for that and preparatory craftspeople and body embalmers who would start their work by eviscerating the cadaver and dehydrating everything using natron. They did many things with this salt. It wasn't sea salt, sodium chloride and many other marine elements besides natrium, also NaCl with other elements, and it was very good for them to mix with the silicates of the sand, to make glass.

And so, ceramics which have as a compositive element an earth rich in silica and other elements, including a few other organic elements, would sometimes give them enough consistency so as to make a thick and workable mud, but that mud couldn't be used to make glass, because its condition was that it didn't have organic substances, clayey substances, but instead pure sand, let's say, rich in silicates in small crystals. With those salts, with calcium carbonate... it's all opposed to the type of earth used for ceramic. And so, there was nothing better than desert sand to make glass. Without organic material, roots or plants. Sand of the desert, pure silica. So, in the desert, and searching for those substances, natrium, they produced glass with those elements and, going towards the Nile, to the shores of the rivers they'd take the clay and yes, there they'd produce ceramic.

Ceramic over here, glass over there, and the bald priests doing business. Everything was good until Akhenaton comes along, but of course the bald guys came back.

So we're talking about glass and of the clay for ceramic. But for glass, sand.

But for the most primitive glass you put borax in to lower the melting point and produce glass, but it's a poor quality glass, borate glass. It's not going to be transparent. But in the end it's glass. And you make it and you're delighted that you've done it. It's like a baby that you just keep looking at for hours. With borax you can do it at about 800 degrees C. You end up making glass at 800 or 900 degrees. That's already something. To make this glass, it's always done with direct heat, not by ambient heat. It's not like ceramic. You don’t need to be careful raising the temperature as in ceramics; afterwards you will have to watch how the temperature drops. And it is done in the muffle, which is perfect for that. Neither in the kiln nor the forge, but in the muffle.

And then it’s necessary to resolve how to lower the temperature. It must be lowered slowly because if you lower it too quickly, it cracks. The muffle must have very good insulation, because otherwise the T drops too quickly and it cracks. But if the muffle is well insulated, you lower the T in several hours, and once at 300 to 400 degrees C you’re there...

Wood molds are also used. These are wetted, very damp, very hard. They open the mold, put the blob inside, and close it up. It smokes and all sorts of things. Wood, they put it in water and like that, wet, they press the blob. Steam comes out. You press tightly and shape it.

Later you have to be careful with how the temperature drops. And for blowing, the glass must flow well; as they say, it must “flow.” You have to make the blowpipe – a tube – blow well, then you put it in the crucible and pick up a fat blob, and using gravity you rotate it until a well-rounded bubble forms. As you blow, it swells and forms the ball. Then you take tweezers and pull from one side and the other to shape it.

Be careful with mixing glasses of different melting points, because they do not join well together. It has to always be the same type of glass. So then, they have a few little green lines, a few yellow ones, red ones, which are already prepared; they make the blob, heat it, and join it together. It must be the same glass and the same melting point. It is the same glass with different coloring. It is a principle that must be respected. Perhaps by chance you can join two different types of glass, but that is not the principle. This has been a very well-kept secret in glass work...

By 1780 the last secret trial took place to suppress those who had transgressed the industrial secret – they were like atomic spies that escaped from Murano to Austria, taking the secrets. The Doge met with the Venetian Council and secretly put the two fugitives on trial in their absence, and condemned them to death. The two individuals were already in Austria, but the long arm of the Doge reached them there with his hired assassins, and on one of those nights they were executed by stabbing. Within two days they had been killed. The assassins returned, were paid their doubloons, and everything was fine. The secret was well kept.

Regarding the issue of the color of the glass there is a lot of folklore, a whole series of legends. For example, blood-red is one of the favorites in these stories. Not blue, it's cobalt oxide and that's it. But with blood-red, on the other hand, you need to know the secrets of the trade to make it. With certain colored earth you need to put first one and then others. If you put them in the wrong order you get a different color. There is an order. Not only the proportions, but you must follow the order, or you get pink or yellow. There are about six or seven variables. The key to the formula is the order.

The difference between glass and crystal is that crystal is much finer, more sonorous. The sonority of crystal is typical. The sonority of crystal is not the same as the sonority of bottle glass. A champagne glass, well crafted, is quite something. Filling some with more liquid, others with less, you can play the entire scale: do, re, mi... We have all those themes in our archives and they are available.

And the tints – many of the tints are available. Blood-red is not available. So then primitive glass, the first glass is interesting to make. Then, the Murano formula – which the Murano masters gave our Italian friends – produces a translucent glass. On the basis of translucent glass you can make a colored glass, but you can't make another color with glass that comes already colored. The translucent glass must be divided, and then you give the translucent glass different colors. So with the Murano formula you obtain translucent glass – a first interesting condition – which allows you to go from there on to something else. It is a condition of importance.

If you work with translucent glass you can see from one end to the other. It is a glass without bubbles and it flows well when blowing. We know the bubbles go to the surface, and you need to bring them to a certain temperature. The same as in metals where you add glass so that the slag and impurities can adhere to it – you extract the slag which detracts from the bronze, you take everything. In the case of glass, centuries ago, they used potato.

You take a potato, you throw it in and you have no bubbles. The potato is calcinated, in the glass it burns completely, but it gathers up the bubbles and removes them. You could spend years trying to get rid of the bubbles, testing other systems, but with a phenomenon as simple as the potato you produce an interesting case.

Nowadays there are chemical substances that replace the starch, the potato. But a certain temperature is required for the bubbles to rise to the surface. And when they rise to the surface, the potato takes charge. But you must bring them to the surface, all interspersed there, the potato will take one part and the rest will remain. It must be brought above the melting temperature. So you reach the melting point and you keep going, more heat for the bubbling to rise to the surface. You put the potato in and it carbonizes and produces that collection which you extract with a spoon, the bubbles and other things. So when the bubbles rise to the surface you need something that acts like a glue, just as glass does in the case of bronze. The “waste” that you are extracting is the bubbles, the slag of the glass.

We were saying that the Murano formula has two properties in the formulation: you obtain translucent glass that you can make into other colors – that is very remarkable – and also you have glass that flows, that runs... because there are glasses that do not flow, they are like jelly. Whereas this flowing glass has a density that allows you to take it and work with it. When blowing it, it's extremely elastic – the elasticity of that glass is not the elasticity of other glass.

Take bottle glass and you will see something disgusting... you blow it and it comes out of your ears. I recommend working with the Murano formula. After doing that we can see how to color the glass. You have the little pots, with the oxides, and so then you take the blob, you blow it, you gently put it into the pot, and there is the first rough coloring. When everything is molten you roll it over a pot, swab it in certain parts and it takes on the color. But it doesn't just stay on the surface, you have to bring it up to a certain temperature, it touches the oxide particle and it spreads. This coloring is done by the diffusion of the oxide particles. It is diffused into the glass molecules. So, glass and oxide and glass and oxide and glass are diffused. That is glass coloring, by diffusion and not by staining.

Unlike that monstrosity of the false vitraux (or stained glass) that can be seen painted with glazing; that is inadmissible. The coloring we are speaking of changes the glass and the glass becomes colored. And if you break the glass it is colored everywhere, inside and out, everywhere. In every interstice – like in Raku. You break it open and it is black everywhere.

Glass coloring is magical. That is what they called projection powder. With a touch of a small amount, everything was colored and everyone was astonished. Then, wherever it was broken open it was the same. And so they took that, they ground it, they took another glass, they re-colored it, from that they obtained another piece... what was that? They projected it. It was not stained glass; it was a strange glass. Then with that one you took another little bit and did something else, and like that they'd try it out. And then another and another, never ending. So the legend went, that it was projection powder.

...pewter is already an alloy but one that you can manage with 400 degrees C, unlike the 232 degrees for tin and 327° for lead. With a temperature of only 400 degrees C – that is, on a kitchen stove – you place a pot on the flame and put the tin inside, you add the lead and the zinc, and you make pewter at 400 degrees.

And from there you move on to aluminum, but the oven will no longer be sufficient for aluminum. Seven hundred degrees are required and this is a problem; the kitchen stove is no longer enough. Aluminum does not copy well. It is a disagreeable element. It is all right for a window-frame, for aluminum foil, to make a strange paella, or a light wing for an aircraft, with rivets that always fall out...

Lead, though, is very interesting for many things. There's also tin. Well, and then comes copper, 1000ºC, and other alloys. 1200ºC, bronze, nothing like aluminum. Pewter does not copy well, but can be worked very well. There are great masters in pewter – the Bolivians are masters in pewter. Of course, the tin mines, and that Patiño who monopolized the tin mines and went to Europe. There's also silver, which is 900º, before copper. But bronze copies marvelously well. And bronze can be worked very well. There's cannon bronze, which is bronze with a lot of lead and which has a lot of elasticity so it can absorb the shock. For example, in a cannon you throw in a cannon ball, you load it with powder and all that, and then with such an explosion, if it doesn't have enough lead, the cannon cracks.

For example, the Russians made the largest cannon in the world. A cannon which still stands in Red Square, broken in two. They wanted to use it against Napoleon, and with the first shot it broke... what a disgrace. It is not a matter of how to make hard bronze – like the bronze for a bugle, which is very hard, not elastic. The bronze for bells which not only has the shape of a tuning-fork, necessary to move the mass of air in a certain way, and which makes a very special sound. It has a consistency, a certain hardness, without much lead. So, careful, the alloys are different.

Sometimes in the same alloy there are different proportions... So, bronze at 1200 degrees C. Forge, muffle, no kiln. Direct flame. And already at 1300 degrees C, cast iron, which is not the iron called "steel." That is 1500 degrees. At 1,300 degrees, a little more than bronze, you already have cast iron, but it's a brittle iron. The railings used to protect houses and all that are cast iron. You go with a sledge-hammer and swing and you break the railing. It breaks, but nobody does that – imagine, going around with a sledge hammer breaking the railings of houses... but you could do it because it's cast iron and it is brittle.

We melt iron. You go to the scrapyards – as some people call the waste depots that are full of old things, scrap, and at a very low price you can buy chunks of railings. You give them a few blows with the hammer, you put them inside a crucible, and it's all ready. This proves it is very fragile. But you put that same iron in a mold and then you can work with it, perforating it, welding it, you can do nice jobs, but you cannot heat it in the forge to hammer it because it breaks. This iron does not accept hammering; it is no good for forging.

And long before working with iron, you have to extract the iron from the ground. You have to go to the mountains and find siderite. Some iron-rich ores. When you find those chunks of ore you put them in a crucible and heat it up and that mixture that comes with it – it is like volcanic magma – it more or less gets cleaned up and has a great amount of impurities, quartz, aluminum, all mixed up. And so all of that is molten, and you stir, you look at it, and if you are intelligent and imaginative you think things.

Then you begin to separate the pieces of quartz, the strange clays that have melted, you take out that 40% which could contain iron – it depends on the grade, siderite in our surrounding mountain areas has a grade of 40 to 50% – so, imagine, in 100 kilograms you get 50 kilograms of iron. It's true, it is very interesting to work it and separate it. You go on separating it and now it responds to the magnet.

That iron which you have obtained still needs a lot of work, and needs to be cleaned, but now it starts responding to the magnet. It's nice iron, you can do things, little works, and you begin purifying it. You can recognize siderite with hydrochloric acid that begins to bubble; it has a certain brownish-black color. These are bits of rock that afterwards you need to grind very well to put them in a crucible.

Well, once again we are back to the crucibles. It is necessary to make two types of crucibles. Some light ones, for low temperatures, and other heavier ones, for higher temperatures. Those are the graphite ones. The thing is how you are going to work with the powdered graphite – 200 mesh, no other mesh.

You need something to bind the graphite, otherwise it does not stick together. You need that to make a mold, and you leave it to dry, and there is a whole procedure. In some notes that are going around you will see how to make a graphite crucible. You make it in a stainless steel mold. You leave it to dry and you get the typical shape.

That preparation is cold, and you can even do it with a potter's wheel. You go on widening the opening and shaping it, without worrying about what the wise-guys say about the tremendous pressure that you should apply for the crucible to work. They say that because they are the only ones who have those machines that apply those great pressures. With the wheel and a little permanence they turn out very well.

Experience will advise you when you wonder if the cherry-red crucible should be submerged in water to withstand the thermal shock. Of course, they must be very well dried, like ceramics. From room temperature you bring it up to 400 degrees C and from there, lower it. We are at 0, and again you bring it up to 600 degrees C. You lower it, and let it cool. That is known as the "curing of the crucible." It is being cured, as though it were a pipe.

Then you reach 800 degrees C and you give it that constant temperature for about 5 to 6 hours. And then you bring it up to 1000 degrees. There you have it very nicely prepared at 1000 degrees C. Then you give it a few coats inside and out with some substances – for example, sodium silicate gel on the outside and inside – and you put it back in the kiln at 1200 degrees.

So, it glazes on the outside and on the inside. It's glazed, shiny, and that shows the crucible is protected. Immediately you put in the bronze and other things, and with time you will see that the walls of the crucible become thinner, until in the end you need to do away with it. Well-made crucibles are very noble, but their walls thin to such a point that a slight blow cracks them. So, each casting takes away a little bit.

When you reach 800 degrees C you plateau, and from there bring it up to 1000. From there you lower it and you begin working it with a coat of silica gel, for it to glaze well on the inside and out, until it is shiny. This is the graphite crucible that we are interested in, to work with bronze, for iron, for forges, for kilns, for whatever you like.

The silicon carbide crucible is appropriate for glass because glass does not get it dirty, like graphite does. Whenever you do a casting, it's advisable to empty the crucible completely. When you're working with bronze, the crucible must be only for bronze. When you work with iron, only for iron. But if you begin mixing, then this produces alloys and you won't know what happened. Because there are always residues left in the crucible. And if you are going to make glass, then only for glass.

It is necessary to have a good number of crucibles, large, small, generous. Not Victorian, generous. Work with solvency. Then you can exercise the theme of the kilns. Of course, they are directly related to the theme of crucibles and the theme of hot materials, ceramics, glass, and metals.

And there you encounter a whole mess with the molds, for each type of thing in a different mold. A whole mess with the molds for glass and the molds for metal. You reach the conclusion that everything always turns out badly. It is very interesting.

For example, the old guys who go about in the foundries already foresee a percentage of molds that will be needed when they want to produce something. They use five molds that are the same, and they cast the five molds, of which three turn out well and two badly. They always work with five molds when casting, knowing that three will turn out well and two badly. That is a good percentage, of course. If five out of five turn out badly, that is a bad percentage. Those old guys at the foundries know that and they pay attention to that. And there's no problem, they have accepted it and know that several will be lost.

And you also go with that in mind, knowing that several will be lost. If you come to this with a penny-pinching and excessively thrifty mind, everything will turn out badly. There must also be a perfect form in the forges, in the muffles, and in the kilns, for everything to turn out well. But one of the most unstable things, most complicated, it seems to me, is glass. Take the small variations in the environment. Because if you go to an environment where you have been firing ceramics, for example, and the glaze which you put on the ceramic, and if you put glass in a crucible in that environment, you take out the glass and it comes out colored, because that glaze is impregnating the environment, the walls of the kiln, and when you heat it again the glass absorbs it. Glass is a problem. You can't use the kilns that you used for something else for glass. Glass feels itself exclusive, it is fussy.

...During the Neolithic they made bowls and tools with bone, hard wood, and stone. And then work also begins with hammered metals – hammered with bones, hammered with stone hammers, and they go on working metals, metal sheets. They made marvelous productions, because artistic notions and creative ability were very high. Marvelous productions, without having melted metal. That's another stage.

...At an invitation, Negro gets up to see how the fire swirls in the mud kiln known as “the dervish.”

The Theme of Safety

There are other works, such as with lead or with mercury, that are extremely dangerous. Because mercury cannot be smelled, and it attacks the nervous system directly. Fortunately, none of that happens here.

Sometimes you work with iron and there is an incredible smell of sulfur. Sometimes you put the coke in the forge and a lot of sulfur comes out because it is a byproduct of oil, and that oil in turn has many sulfides. So then you add coke and the smell of sulfur comes out. And sulfur, the sulfide attacks the lungs, it makes you cough. But [at a small scale and concentration], nothing else happens. And so you’re careful with the smell of sulfur because you think it is very toxic, and it’s not so toxic.

Lead, on the other hand, has its things. And Mercury has no odor, and is neurotoxic. In these works that we are talking about here, fortunately we do not have those additional hazards. Those who work with that type of thing have additional hazards due to the toxicity of the metals that they work with. So, they need extractors, air extractors, and all that sort of thing. They are creatures of the laboratory, those who are involved in that whole mess; but not here. Here we must be careful with burns and explosions, bursting gas tanks, but not so much with toxicity. It is not that serious.

...Seeing things that way and with a slightly historical review of procedures, and going from one thing to another, I believe we should not intend to obtain very artistic items. Of course, that is something that comes after, and in addition, for people who have the talent for that. The aim is not so much to produce beautiful objects from different materials, but simply to learn how to handle these things. What happens with the kilns, what happens with the materials, what happens with hot materials, in contrast to a whole array of cold things, and in those three major varieties of ceramics, glass, and metals. About how all that is possible. But without aiming to make great productions. Make the attempts. We are always attempting to make something pretty.

...When someone starts making the dome of their kiln, how different it is from that primitive oven. It is the reverse. You begin with a pit, and later, when you want to conserve the fire, how can you keep it in the earth? And how do you carry the fire when it’s raining and then a violent wind blows over you?

...Unless you have it in your cave – but in fact you have protected it because the cave is acting like an umbrella.

...Some anthropologists, because they've never made fire except with matches, believed that fire was produced first and conserved later. Well, no, it wasn't like that. First it was conserved, and later it was produced. Of course, because fire was already in Nature. So then, the point was to have it at one's disposal. It was already produced. People did not know how to produce it themselves. But it was produced in Nature. So then that fire was like a gift, coming from the volcanoes, from the fire in the forest, coming from the fire in different places; but it was not at one's disposal.

But before it could be considered a "gift" it was recognized as threatening and dangerous. There is the first difference between hominids and other animals. And this problem has not been given enough attention. There's a great difference. The fire is there already. And the hominids – what kind of creatures are these that dare go towards that dangerous thing and do not run away like the other animals? All of them flee before fire, but the hominids move closer to the fire. That is something that marks a historical difference.

Because in these guys' circuitry there is sufficient capacity to oppose their own reflexes. Nature says "escape"; but they go against this and say, "move closer." This fact is extraordinary and alarming. How do they do it? You say that to someone and they say, "yeah, of course." What do you mean "of course"! That fact is so extraordinary yet it seems natural and unimportant to everyone.

The fact we are pointing out marks a fundamental difference between hominids and other species. That thing of moving closer. You move too close and you get burned. How can we do it? You take a branch or a cane, grab the fire, and there we can conserve it briefly. The cane burns, our hand burns, and we run off terrified.

Let's see, how do we get the fire out of that forest that's burning, from that lava that burns everything as it flows, from that lightning that set the bush on fire. How do we take that fire before it goes out, take it, conserve it one way or another while it goes out on you... and it goes out on you, and it always goes out on you, and so you go to get more, when you can.

It went out, and until you can find more 20 years go by – and you only had 30 years to live, or 20, if a bear didn't eat you first. Move closer to the fire! No animal did that. But those who did that, they used it to keep others at a distance. If they are all frightened of the fire – and we are, too – let's try to manage the fire and frighten everything else. And so the fun started.

As usual, they began to impose themselves upon others. That's the difference. We have to ask ourselves what was the mechanism for this creature to go against their instinct of self-preservation? That's the question. How was their mental conformation for them to go against the instinct of preservation? It's a very interesting question. It affects anthropology, it affects historiology, it affects psychology; the answer to that question affects many things.

...Like all animals, hominids also suffered from an insurmountable fear of fire. That's what is admirable and interesting. They didn't go strolling over. They went with a sacred fear of fire. That is the interesting thing. It’s necessary to put yourself in the head of those hairy beings, with that enormous jawbone, short in stature, with a little head with the cubic capacity of an orange.

Terrible. Imagine, with that jawbone, they grab your arm and eat it. Imagine those strange anthropoids that see fire, and wonder. They wonder and they dare, against that fear... Sinanthropus, Cro-Magnon, Homo sapiens, all approaching the fire. What a family!

How must the mental circuitry be for you to go against what is dictated by the unconditioned reflex? They are all automatons. They are all machines that respond by reflex to stimuli. They hit him, and he responds. He feels fear, and flees. How is this? His curiosity goes against his instincts. It’s the same as what will happen later with deferred responses. A stimulus arrives, and the individual doesn’t respond. He responds later. The deferred response is proper to this hominid.

Just like going against their instinct of preservation and their choosing to investigate in the face of danger. All of these things are outside the natural order of living beings. Neither the deferred response, nor going against their mechanical instinct of preservation is shared by other species.

Morphologically, physiologically, genetically, it’s all there mixed up. They all have the same history. They all have mimesis: in the face of danger they all hide. They camouflage themselves, like certain creatures that even change color and turn into “branches” and you can’t see them. Like these guys who go fishing or hunting and wear camouflage. And those other ones who wear branches, they cover up, mimic, they mimic the environment. Like any creature. They mimic. They have tropisms. That is also in hominids. Many characteristics. They reproduce. All those things are in everyone. All that is shared in common.

The only problem is that “something more.” That “something more” is not in any other creature. It is in that monstrous hominid species. That “something more” of the deferred responses and going against the flight reflex. That “something more” is the theme to understand what happens with this one.

Because then the explanations come... that the thumb opposes who knows what, and so the monkey hangs from the trees... all that is marvelous... the gregarious instinct, groups of creatures, far more gregarious than hominids. What else? What other things do animals have? Language? Dolphins, lots. What’s so great about that? That's common.

But none of those animals does that experiment of going towards the fire. Conserve and later produce it. Many centuries pass and always the tiger is the first tiger. Always the same. What is so great about that? The tiger comes and has another tiger, and the other tiger has another tiger. So what? It’s the same. It’s like the projection powder. From this we get this one and another one, and always the same thing. And with that, what?

On the other hand, these others are born into a social environment, and a baby appears and everyone takes care of it. A child has been found who-knows-where and they take the baby to a hospital, and all of society is concerned... They are born into a social environment, and a short while later they're writing and reading, making use of historical memory, passing on those historical imponderables, of language, knowledge, technology, and so on. Not genetically. Genetics is very slow. Millions of years for a small horse to become a large horse. Millions of years... such antiquity! And all that is accumulated, and the knowledge left behind by some serves as the basis for the knowledge used by others. It serves as the basis for the next generation.

And the thing goes on opening up. It is not the same as the tiger, which is always the first tiger, which always learns the same things. So then, learning does not happen at a genetic level. It is through writing, through gestures, through all kinds of gestures, gestures of the hand, gestures of the body, gestures of the face, and gestures of the vocal apparatus, which is sound.

One sound is not the same as the other. Let's learn from this. Child, you need to know that "UU" means "let's escape." And "UI" means "let's go." On the other hand, others have language, too. Ants have chemical language; many cetaceans have more particular languages; some monkeys understand gestures, and always within that field. And these go on accumulating and being perfected.

The first cuneiform writing, placed in a kiln to give those writings permanence; from the Assyrian Babylons to the electronic writing of today, quite some time has passed. But this has accumulated. So look at the transmission of information, not as genetic, but through an imponderable, non-material, "substance."

There has been transmission, through sensations and perceptions, not through chemical or genetic transmission. It is the imponderables that form cultures, civilizations; what is transmitted by gestures, by indirect learning, without being in contact with the other.

And as for tools and the like, there are anthropoids, there are creatures that make levers, that have clubs, that beat each other, that make holes and things. They have certain technical rudiments. They fix the places where they lay, where they lay down in their caves. But with fire, no other animals.

It's a matter of circuitry. It's a matter of how the circuitry is put together. It is a different arrangement. The cockroach is 50 million years old, 47 million more than hominids. And the cockroach is the same: solid, stable, it does not change. There it is, perfectly well adapted. The hominid is a misfit. That instability produces interesting things. The hominid is not stable. The hominid is not in any way adapted to all environments. The hominid must transform the environment to be able to adapt. The hominid must wear skins from other animals to combat the cold. Because it does not adapt. It's a misfit. Exactly, it's the other way around from the theory of adaptation. It's because of inadaptation that humans have done so many things. It is by anti-system – although you may not like it, you who receive a grant from the University. No, these guys are misfits. They are anti-system, unstable, creators of new forms, anti-natural. They do not obey the dictates established by Nature.

...The centuries passed, and when they learned to produce fire, history accelerated. A little time longer, a little time less... and they went to bother other planets. Having produced fire, we can expect them on Mars, the moons of Jupiter, in distant places. It's a matter of time.

But, how were they able to produce fire? Having produced it, they will go constructing and accumulating. Now, having something on which to support themselves, a platform for support, they were able to advance. Because in the case of this species, the historical experience is cumulative. If it weren't cumulative, like in other species, they could have stayed at having produced fire and that's it. And each one producing it again. And with that, what?

Their anthropology does not explain anything. It's from the 19th century. It doesn't explain anything. They may say things: that civilizations appear between rivers... warm places... cold places. Yes, yes, they play guitar, depending on where each one comes from. So then, in Europe everything is explained in one way, and if you are Asian, in another. The point is how are the mechanisms that permit those kinds of changes? How are those mental mechanisms? That is the theme, not how is the geography, how is the climate. How are the mental mechanisms that permit one species to not flee but to move closer to the fire.

Those mental mechanisms – regardless of whether they are in Africa, in northern Europe, in Asia, or in Oceania. How is that damn mental mechanism? It's tremendously difficult to understand that the problem lies in the mental mechanisms. It is incredible. Immediately they revert to geography, to the external, always to the outside. It is necessary to go inwards, get inside the mechanism.

Intuition

...It is that "something more" that calls our attention. Human beings have always had signals, intuitions of that "something more," and you can see it in how they care for the dead. The human being has always cared for its dead, contrary to other animals. Intuition is at the basis of all scientific development.

For example, August Kekule created the theory of the quadrivalence of carbon and determined the hexagonal formula for benzene (in 1865). He didn't reach his happy representation until it presented itself to him in a dream – so his biography says – after pursuing the idea for years. He was looking for the way carbon and hydrogen entwined, and the allegory of entwined snakes in his dream showed him the mechanism he was looking for.

It's clear that if there is a direction, intuition can come. Intuition is at the basis of thought. For reason to function, we need intuition; it is "pre-rational." What is rational is mounted on intuition, which is the framework of the organization. We already have the mechanism of the deferred response, and the division of time and space. We have the mechanism of going against the instinct of preservation by moving towards the danger of fire, and we also have the mechanism of intuition, which is pre-rational and directs searches. Myths are the intuitions of a pre-civilization, they are the basis of future rational explanations. The rational is based on intuition.

From Where the Religious Arises

...One of the tribe dies, and the care for his body that follows, at times with pomp and reverence, shows us the intuition of the “something more” of life. They didn't eat that body, except in exceptional cases. Sometimes they ate it when a great man or a great person died, to take his attributes, or sometimes they ate an enemy that they thought was honorable and whose qualities could be transmitted. But in general terms they buried their dead, or burned them, and they were not left abandoned in a junk pile. There were honors for the dead and their memory.

They encountered the finitude of life and the inevitable fate of every human being. It’s not like animals who have no past, present, or future, and do not know if they are dreaming or living something. We can find this in sacred writings when they say that a seed which falls on stone bears no fruit, but does when it falls on fertile ground. We are by now in the full stage of the domestication of plants, and the first settlements begin.

By observing the agricultural cycle, the conservation of plants begins, which serve not only for eating but begin to be stored, conserved. They begin domesticating plants, and not eating just anything. Nor was it a matter of eating everything, but of eating just a bit and conserving the rest in bowls, in caves. They conserved what they had gathered. We need to eat something and conserve something.

So we will also conserve the animals we have. We'll eat half and keep the others and reproduce them. We’d better get a whole lot of animals, put them in a pen, breed them, they'll reproduce, we'll eat the offspring, and there are also some that we can load up and make them work for us. That is the enslavement of animals, making them carry things, “beasts of burden” they were decently termed.

Then they began extracting the milk from some creatures, and the skins were used to make garments. So, beginning to have animals was very interesting for all the benefits brought by the conservation of cattle. And for this they had to change their transhumant, migrating habits into settled habits. They somehow thought of settling; the first settlements appeared. And so then, of course, they did not walk all over the place sowing; they needed to locate a place to have animals and plants.

Protect each other mutually, and form the first social organization. Stop being transhumant. So, the domestication of plants and animals was a precondition for settlements. It is not that first they settled and later said, “Let’s see, how can we fill this with piglets...” No, it’s not like that. It is not an urban planner's drawing, with everything empty and then we see how to fill it. First we make the city and then we see how we drop the chicken-eggs from an airplane. No, it’s the other way around.

From the gatherer stage, hunters and fishermen, until the time of the first settlements, a long time has passed. It is no longer a tribe that lives in a cave and then when the winter comes they follow the other animals in their movements, eating fruits, eating other animals, everyone in the same story. When they begin conserving animals and fruits, History starts.

That is opposite of conservation, always forward, always doing things that surpass what was before. But conserving things at the same time, and all that goes on making memory. Perception is ephemeral, but what is kept of perception and that which opposes perception, is what permits projection. That destructive force of perception, thanks to the work of the image, that thing which is worked on by memory, which is the conservation of perception.

For example, dogs also have memory. They bark at some people and wag their tails at others. That’s fine; there is memory there. While they sleep you can see them twitch their paws – they are dreaming something. There is imagination, there are images. They expect certain things, that someone gives them food... and that is done by everyone from Lapps to South Africans... futurization... but people always stay in what is peripheral; it is very hard for them to move inwards.

To comprehend from the inside. To comprehend the world of what is done by hominids is to move inwards, and not only from the skin outwards. It is very hard. In the paroxysm of decadence you end up thinking only about clothes. People disappear and only the clothes are left. Everything is periphery. The different civilizations end up being differentiated by their garments and not by their contents. Consequently, nobody knows the content of the other’s civilization. They dress in a certain way, they eat certain things, and they dance. They dance, eat, and wear other garments; that’s it.

They beat each other to death because they wear these clothes and others wear another. But what is that? Well, we’re not doing well, but we will learn. Well, I think we will learn, because on the other hand, a certain direction is being formed, as though a phenomenal intuition were pushing us from behind and forwards, always pushing the stone. That is why this conversation has been called “the stone.” Let’s hope it does not fall once again towards its origin, the heavy stone of civilization, as happened each time in the Greek myth of Sisyphus.

In this small space where we are we can reconstruct history – in broad terms, of course. Imagine, reconstructing three million years. This is a marvelous little place. It's called, “The Pyramid.” Pyramid is what the Greeks called those geometric figures. It’s very strange, calling a geometric figure, “pyramid.” It means: that which has fire inside. How did it occur to them to say it has fire inside? Here we are, in the middle of the pyramid. We’re in the middle of the fire. They gave it that name “paranormally.” “What will we call this place? The Delights? No, no, we'll call it the Pyramid.” How can you call it “the pyramid”? Call it “the pyramid,” I know what I am saying! And there the namer, like a zombie, like a medium, got it right. He did not know that something from the future whispered the word “pyramid” in his ear, a word that, while doing geometry, speaks nonetheless of the fire.

Very well ladies and gentlemen, we'll say goodbye.

DESCRIPTION OF TECHNIQUES

(in alphabetical order)

SOME CONDITIONS FOR CARRYING OUT THE CRAFT OF FIRE

In the Workshops of the Parks of Study and Reflection we recommend having:

- Kilns (forge, drum kiln, electric kiln able to reach 600ºC, pyrometer with a K-type thermocouple for ceramic work)
- Workshop table, shelves, etc.
- Dedicated, ventilated workshop place, with electricity and water.
- Necessary tools, including those made by us.
- Safety equipment (fire extinguisher, gloves, closed shoes, safety goggles, leather apron, first aid kit, etc.)

Safety

Each stage of work in the craft of fire requires paying attention to different safety measures.

With the cold materials, when using resin, care should be taken when using resin to have adequate ventilation to avoid intoxication.

When using gas kilns, always test gas connectors with soap foam, never with fire. Gas tanks should be 4 or 5 meters away from the kilns, in a ventilated area. Regularly check the electrical connections for electric kilns, and have a power-breaker in the installation.

Learn to appropriately regulate the flame of the burners used and make sure that they are secured firmly to the kiln. Carefully clear the area around the kilns to avoid tripping and accidents.

When working with high temperatures – for example when doing Raku (opening the kiln door at 1000ºC), or molten metal casting into a mold – rehearse the operations and movements to be made with everything at room temperature beforehand, and have ready the appropriate tools and tongs for each crucible or piece to be taken out of the kiln. Clearly define the roles of those who will participate in the process, and recommend that observers, if any, keep a safe distance away. In these works it is highly advisable to maintain a calm, attentive, and orderly attitude, without hurrying or improvising.

NOTES ON KILNS, BURNERS, AND MOLDS
5-10 October 2004, La Cazadora.

Founding Furnace

Construction: L-shaped brackets are welded to the metal ring of an iron garden-table, to make the frame which will support a steel sheet on which to place the kiln. The sheet is painted with sodium silicate and then the refractory blanket, cut to the same size as the sheet, is stuck to it.

A support is welded to one of the table legs (6- or 8-inch construction iron) to support the burner.

A floor of refractory bricks (1200ºC) is laid on the blanket, with a little refractory cement in the joints. Ten bricks were used in this case.

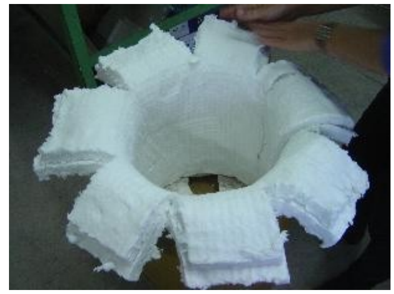
When using the kiln, the crucible (containing the metal to be melted) will be placed on the floor of the kiln, on top of a refractory brick and on a piece of newspaper (the ash from the burned paper will prevent the crucible from sticking).

On top of this base, two rows of curved high alumina refractory bricks (1600ºC, composition: silica and high alumina aluminates, 58% aluminate content) are placed in the form of a circle. Make sure that the seams of the two layers do not coincide.

The size of the circle will be adapted to the size of the drum that rests on top.

An opening where the burner will be placed is left in the first row of curved refractory bricks.

The inside of the empty drum (40-50 liters) is lined with two layers of refractory blanket, leaving an extra 15 to 20 cm at the top to fold out and back, and then tighten with a metal-strip clamp and two wing nuts. The bottom of the drum is also lined with a layer of refractory blanket.



At the bottom of the drum and towards the side, a square 8-10 cm opening which will serve as a chimney is cut (through both the metal and blanket). A handle is made of nichrome wire (nickel-chromium, to prevent it from melting with the heat) to allow the drum to be handled and lifted without getting burned. The wire is threaded through two small openings on both sides of the overhanging edge at the base of the drum, and fastened.

A small opening is made through the side of the drum and blanket, half-way up, for the place to put the pyrometer.

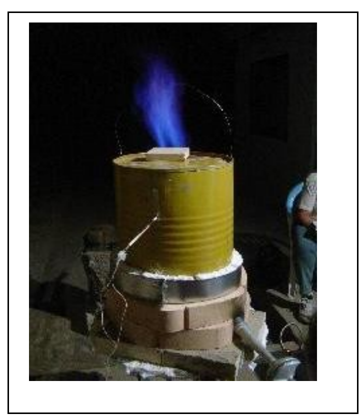
Burner

Butane gas mixes at the mouth of the burner with the oxygen that enters when the flywheel is opened. This is the *Venturi* effect. The cone widens or accelerates the effect of the gas mix. It's the same principle as a Bunsen burner. The flywheel regulates the flow of oxygen in.

First test of the kiln

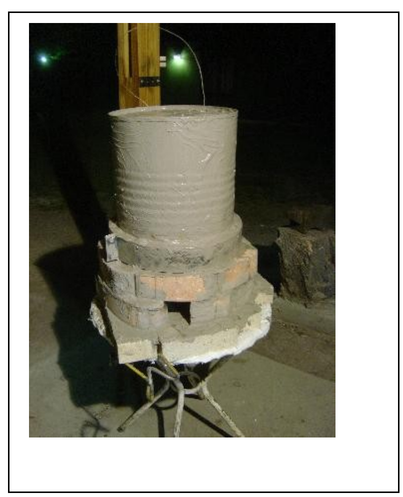
Before lighting the burner, check for possible gas leaks in the connections (from the tank to the hose, from the hose to the burner and the burner thread) with a sponge soaked in detergent, to see if bubbles appear due to a gas leak.

The burner is lit outside the kiln, not too high, and then placed in the opening of the kiln. The temperature rises quickly to 500ºC, but it is necessary to heat the entire system and the crucible along with it. The temperature rises by closing the outlet. When it is opened, the temperature drops. A red-orange-blue flame is what we're after, not yellow.



750ºC are reached in 15 minutes. It rises to 900ºC in the following 15 minutes (silver melting point) and flames come out of all the cracks. (960ºC, close to gold and copper, which melts at 1000ºC). Test for heat loss.

The kiln can be improved by placing refractory cement between the bricks to close up the leaks, making it possible to reach 1200ºC to melt bronze (1150º to 1200º C). Also consider fixing the blanket so that it sits better, and fill-in the cracks with sodium silicate to avoid heat loss. It is not a kiln for conservation, but for this reason the temperature should not drop too quickly either.



Sand molds

Mix fine damp sand homogeneously with 8% sodium silicate. The sodium silicate is liquefied beforehand by adding 50% water to obtain a liquid gel. Do not exceed this percentage of silicate, since no interstices would be left for the material to breathe. Also add 4% fine coal dust (ground vegetable charcoal passed through a fine mesh screen). The coal dust prevents the metal (e.g. iron) from leaving bubbles, because it absorbs the gas released by the molten metal. This mixture is kneaded well so that it is thoroughly and evenly mixed.

For the proportions, we go by volume rather than weight.

To make the mold, construct a frame with 1½ to 2 inch by 0.5 cm-wide slats of pine or other soft wood. Place the item to be copied inside the frame. In this case, the symbol of the School.

The item is covered with a transparent plastic wrap, then covered with the sand as described above, up to the height of the frame, and well pressed.

Next, place cardboard on top to turn the entire frame over and remove the original item (as it is covered with plastic wrap, it separates easily).

Resting on the cardboard, the mold with the filled frame is then placed inside the open chamber (which in turn is supported to prevent it from moving).

Next, the chamber is covered and secured with the clamp. The gas hose is attached to the inflating nozzle. Inflate until the cover swells (open and close the gas).

Wait about 10 minutes before opening the chamber. Check if the mold has hardened (it can be tested with a fingernail) and repeat the step if necessary.

The chamber: This is a container for olives (originally from Mendoza) or something similar. It is a plastic container of approximately 40-50 liters, with a clamp for sealing it hermetically. A valve like the kind used to inflate car tires is placed in the middle of the container; this will be used to inflate it with carbon dioxide.

Note: *It's possible to replace the use of sodium silicate with Bentonite, and not use the gas chamber. In this case, the mold is allowed to dry for 5 hours.*

The sand mold can also be hardened in a kiln. If no kiln is available, it can be scorched on all sides with a blowtorch – but this is complicated because the core does not harden properly.

It is also possible to make the mold with a wax object. The wax is placed inside a can for preserves, for example. The sand is pressed well around the wax, as described above. The kiln hardens the sand and at the same time melts the wax. If any wax remains, it can be removed with the blowtorch.

The molds are heated before being used for the thermal shock to be as low as possible. For example, the mold is heated to 800ºC and then molten iron at 1500º C is added. This helps the mold resist the strain and not break.

Molds for ceramics (using parts and slip): If you want to copy a cup, vase, or any container, you must make a 2-part mold (shell mold). In this case it was a coffee cup. The cup was placed on a small lump of wax inside the plastic container to prevent it from moving when the plaster is poured in.

The plaster is poured until it covers half the cup. After it has set – but while the plaster is still fresh – two indentations are made (these will be the negative part of the locking key, for the next piece of plaster to fit perfectly). The keys for each part must be large and fit well.

Once the plaster has hardened, proceed to prepare the plaster for the other half – that is, the upper half. Before pouring the plaster, cover the first part very loosely with plastic wrap, in order to separate the two plaster parts later.

When the last plaster sets and hardens, the two parts (separated by the plastic wrap) are carefully taken out, separating them from the original item. The negative key that was made in the first part matches the positive key in the second.

After drying both plaster shells, they are bound together with rubber bands and the slip is poured into the mold (liquid clay and something else).


Leave it to set for approximately one or two hours (depending on the room temperature and how dry the plaster is) and then pour out the remaining slip, leaving behind a clay film about ½ cm thick stuck to the plaster.


This is the object that will become ceramic when placed in the kiln (it must first be allowed to dry well).


Note: *The device with parallel wheels can be used to clean the emery stone.*

Ceramic is in a way similar to glass, but while glass is molded hot like metals, ceramic is molded cold.

It is understood that the empty form and the form are complements. An empty form has a context that sustains it. It is almost a miracle that a whole body comes out of that empty form. Many things are understood about dynamics, moving tensions, the production of images, in short, many things are understood. A mold comes out of a body. The body was of iron and the empty mold allows you to make a object of resin, it is fantastic!

NOTES ON MATERIALS, KILNS, AND MOLDS

Mendoza, March 2004

Materials:	**Kilns:**	**Molds:**
Marble, plaster, and cement	For bronze – with gas burner	Expanded polyurethane
Resin	For iron – cupola-type with coke and crucible.	Silicone rubber
Pewter	Forges	Plaster
Aluminum	Crucibles	Sand and quartz
Nickel Silver		Perlite
Bronze		Wax
Iron		
Glass		

MATERIALS

In the photo, various objects in “cold” materials. Bonded marble in epoxy, plaster-cement and epoxy resin.

Pewter

A metal or alloy composed (by weight) of 70% tin, 20% zinc, and 10% lead. Melts between 450º to 480º Centigrade.

Aluminum

Pewter and aluminum reaching melting point at the kiln opening. Bars with factory-made alloys were used. Approximate melting temperature, 800ºC.

Nickel Silver

Bars with factory-made alloys (copper and zinc) were used. Melts at 1200ºC.

Bronze

Pewter and bronze objects

Different qualities of bronze were used - the exact alloys were not known. Melts at 1200º to 1280ºC. The first meltings were done in the kiln with ceramic fiber insulation and a butane gas burner. A silicon carbide crucible was used with an approximate capacity of 15 kg. Melting continued later in the charcoal coke kiln and in the forge.

Iron

Iron objects.

Melting was first attempted with gas and later with coke and oxygen. It was possible to melt steel at 1500ºC (forged iron for bolts). A test was performed in a small cupola-type kiln where the iron and coke were mixed in layers. The iron flowed when oxygen was injected. Then a large kiln was constructed with refractory bricks and forced air intake with a blower. Tests were made with cast iron (car engine block scrap iron) which melts at 1300ºC. A good flow and inertia with the temperature was achieved. Work was done combining silicate and calcium carbonate. Some very good items were made after several experiences. Faults were due to the molds, the type of iron used, or to insufficient temperature and a lack of fluidity in the metal.

Glass

Different quartzes were tested (200 mesh), in sand from the Parana river, common fine sand, and perlite. Different formulas were used with borax, calcium carbonate, kaolin, feldspar, Solvay soda ash.

Resin

Epoxy resins of various qualities were used and "loaded" with different materials (marble, coloring, talcum, etc.).

Expanded polyurethane

Bust in various materials. From left to right: 1. wax; 2. polyurethane; 3. cement; 4. bronze; and 5. marble.

A foamy commercial polyurethane that hardens in contact with air was used. A silicone rubber mold was filled and when dry was given a patina effect with acrylic paint, achieving a rather stony appearance.

KILNS

Covered kiln for bronze with oxybutane input.

Kiln for melting iron in an open crucible. Compressed air and coke.

A kiln to melt bronze was constructed using refractory bricks (with a side entrance for the gas burner). The outside was covered with ceramic fiber and steel.

By adjusting the draft and intensity of the flame it was possible to melt bronze in 4 hours, in a silicon carbide crucible. Tongs were forged to take the crucible out and pour the molten metal into the mold. This kiln was not suitable for iron.

The same base from the previous kiln was used for the first attempts to melt iron, but instead of the ceramic fiber cylinder, a high-alumina refractory brick was used for the walls, leaving an opening in the lower part to the side. From there it was possible to inject oxygen under pressure. The kiln was then loaded with residual coking coal and oxygen was injected. Like this, the temperature for melting steel bolts (in a ¼ liter crucible) was reached. We also tried a small cupola-type kiln (without a crucible). Although we were able to melt it, we were not able to work with the molten iron. At this stage we started using a graphite crucible, because we noticed that at high temperatures the silicon carbide crucible would soften.

After the experiences above, a larger kiln was built. First, a stone base. On top of this, and where the cylinder was to be placed, a mortar made of cement, sand and grog, to thermally insulate the kiln from the floor. A cylinder of sheet iron (22) outside, with the inside of curved high alumina refractory bricks and perlite filling between the brick wall and the sheet metal. Two openings were left in the base, one for air and the other for a gas burner (which was later closed when lit directly with firewood and charcoal). Air was supplied by a 3-cubic meter/minute blower with a flow regulator.

In this type of kiln, the air enters below the perforated grid (made with refractory cement) which supports the coking coal and the crucible. The approximate height is 60 cm with an interior diameter of 30 cm and an exterior diameter of 70 cm. Two 30x30cm refractory tiles are used as a cover for the kiln. Another pair of tongs was made to take the crucible out of the kiln. Bronze, cast iron, and steel were melted in this type of kiln.

Forge working with blower and coke, capable of melting iron in an open crucible.

Crucibles

Graphite crucibles made on the wheel. They are not compressed.

Graphite crucible:

Graphite	500 grs.	50 %
Silicon carbide	100 grs.	10 %
Kaolin grog	100 grs.	10 %
Kaolin	300 grs.	30 %
Feldspar	50 grs.	

It is fired at 800ºC in a sawdust box and then directly in the forge with coke. After firing at 800ºC an engobe of sodium silicate dissolved in water is applied. It works very well with a thick wall (more or less ½ cm).

How to make kaolin grog: a fine kaolin (200 mesh) is mixed with water and kneaded; thin noodles are made and left to dry. Once dry they are ground and fired at 1000ºC.

Silicon carbide crucible (by volume): 1 kaolin
1 graphite
1 silicon carbide

This formula was used for melting bronze and the result was satisfactory. It should be tested with larger size pieces.

Graphite crucibles must be fired the first time in a reduction atmosphere and then have an engobe applied.

Clay crucible:	refractory clay	50
	quartz (kaolin)	10
	kaolin	10
	grog (kaolin)	30

Refractory clay formula (by weight)

AL 2 O3	30 %	Equivalent temperature 170 degrees C
SI O2	51 %	
FE 2 O3	2,5 %	

Metal melting and casting in molds

Molten iron flowing into the ladle to carry the metal to the molds.

We worked with pewter, aluminum, nickel silver, bronze, and iron. Plaster molds can be used directly for pewter, given its low melting point. It is important to make sure the mold is well-dried. The pewter can be melted in a stainless steel pot on a kitchen stove.

The melting point for nickel silver is similar to bronze. It is melted with a gas burner.

When melting bronze, ground glass can be used to extract the slag, since the glass gathers the impurities to it and these can then be taken out of the crucible using an iron tool.

MOLDS

Preparing the mold in a half shell, before compacting the sand.

Mold on a wax bust. Then, silicone rubber, and plaster covering everything.

We could define these as the elements which allow us to transfer a form to different materials. We work with the following molds:

Plaster: for ceramic, silicone rubber, and wax.
Silicone rubber: for wax and expanded polyurethane.

Plaster and quartz: for pewter, aluminum, nickel silver, bronze, and iron.
Shells of sodium silicate and refractory materials: for bronze.
Sand: for bronze and iron (compacted sand can be used for cast iron; it also works better if the originals are first painted with graphite or charcoal paint, using shellac as a vehicle).

Plaster molds

Plaster mold used to make wax and pewter positives.

The matrix or object to be copied must be waterproofed and a mold release agent (Vaseline, grease, oil) applied and carefully spread over it. Then, a container is made and the plaster is prepared (2 parts plaster and 1 part water). If the plaster will be used to cast wax, it is waterproofed with oil and wet with water before casting the wax. A plaster mold is suitable for pewter as long as it is perfectly dry. For nickel silver (with lost wax), the wax item must be covered (painted) with a mixture made of plaster and quartz (1 part plaster, 2 parts quartz, by volume). To contain this first coat of quartz-plaster, tests were made with sand and 8% sodium silicate. This was then scorched with the burner to give it the necessary hardness. Plaster was used, perlite and quartz (1 part quartz, 1 part perlite, and 1 part plaster) to make the mold. To obtain a good copy of the piece it is recommended to coat it beforehand with the quartz-plaster paint, 200 mesh.

Sand

Sand can be compacted with bentonite and sodium silicate at approximately 8%. Charcoal at 4% is also added for iron.

Perlite

With this material – and in molds of a certain thickness – there is a problem in burning out the wax because a temperature of 800ºC is required, and it takes a long time for that temperature to reach the core of the item. In small and medium-sized items, replacing the grog or sand works well. It also works for casting glass, acting as a thermal insulator that slows the cooling.

Procedures for making molds

The dimensions and the form determine the method used for making the lost wax mold. If a solid item is to be copied, the sand is pressed over the item, selecting containers that are appropriate for compacting the sand. The material used to cast the object determines the mold to be made.

- Original or matrix
- Silicone rubber or plaster mold
- Wax copy
- Wax mold: plaster, quartz, and sand
- Burn the wax out. Empty the mold.
- Melt the metal and cast into the molds.

Original or matrix

The original or matrix can be of any material. If several reproductions are desired, the mold must be silicone rubber or plaster, if the shape allows.

Silicone rubber or plaster mold

Wax can be cast in these molds.

Wax formula (by weight).

Virgin wax	70 %
Solid paraffin	20 %
Plant resin	10 %

Mix everything at 100ºC and then wait for it to cool to the point that a film begins forming on the surface.

Wax copies

If the item is to be hollow inside (a hollow space between the walls of the object), wait until it thickens and then empty the mold, leaving a coating 0.5 to 1 cm thick.

Wait until the wax cools within the mold. Then extract it. Make the castings and gas vents with the wax piece extracted from the mold .

Note the necessary gas vents for when the molten metal is cast. This wax matrix will be painted and compacted in sand. Then the “lost wax” work is carried out, leaving the negative (empty space) in the sand. Once dry, the metal is cast into it.

Preparing the wax matrix

For metal casting: paint the wax molds with shellac and then apply a coat of quartz-plaster.

Coatings tested:
Plaster and quartz (2 parts quarts, 1 part plaster). Suitable for bronze.
Plaster and graphite (2 parts graphite, 1 part plaster). Suitable for iron in sand.
Refractory cement (works well when dried well after applying).

Other attempts:
Sand mixed with 8% sodium silicate (works well when well-compacted). Coat the wax with plaster and quartz, and then compact the sand and scorch it (improves surface copying).

For iron:
Compacted sand with 4% ground charcoal and 12% bentonite.
Plaster is not recommended.
Different coatings were also tried and this worked well with small items, with quartz, kaolin grog, and 15% sodium silicate, leaving each layer to dry for several hours (6 to 8 hours).

Burning out the Wax

Blowtorch removal of wax in the mold.

The plaster molds should be put in the kiln while damp and the wax burned out at 800ºC, keeping them at this temperature for several hours.

It is important to make sure all the wax is removed from inside the mold. It must be completely burned out. An indicator is seeing that the mold is white in color and there are no dark stains in the casting space.

FORGE

Punta de Vacas Park workshop, 2008.

An important item for managing fire in the workshops is the forge. The forge has several applications – including melting metal in crucibles – but essentially it enables you to heat metal at high temperatures for the processes of tempering (to harden and soften), and shaping. Its construction is very simple, although it is advisable to use the right good-quality materials, since it operates at high temperatures.

Construction of the Forge at the Punta de Vacas workshop

For our forge we used the rim of a truck wheel; two-inch rods of 3-mm steel, round 12-mm iron bars; also refractory cement and split refractory brick lengths to protect and concentrate the heat at the center of the forge.

Making the dumping ashgate and the tuyere

Welding the legs to the rim of the truck wheel

Welding the dumping ashgate, which is the lower tube through which the air enters and prevents the ash from obstructing the opening.

Split refractory brick lengths bound to the inside of the forge with special cement. Note the steel bars at the center to allow air intake and prevent the ash from obstructing the ashgate.

Our finished forge. The blower on the left (made with a kitchen air extractor).

The air flow control mechanism can be seen, which is achieved by opening and closing the lower flap of the ashgate.

Coke coal is placed inside, with some twigs for lighting. The air from the blower feeds the fire, which can reach more than 1200ºC.

MELTING OF IRON

La Cazadora, November 2005.

1. Kaolin crucible

This is an attempt to reproduce “archaic” clay crucibles:
White clay, 10% (TinCal or similar type)
Kaolin, 50%
Quartz, 10% (200 mesh)
Kaolin grog (2-3mm mesh), 30%

Preparation of grog: kaolin and water to make thick “noodles” that are dried and later ground up. This powder is fired at 800ºC in the drum kiln.

2. Graphite crucibles (pressed)

Graphite (+/-400 mesh), 60%
White clay, 30%
Quartz or silicon carbide, 10%
Add clay for greater plasticity

(The crucibles were shaped inside a double plaster mold, reinforced with a metal mesh. The smaller crucibles were molded like a normal bowl.)

3. Kaolin molds

With the same proportions as for the kaolin crucible, using the material in the Babylonian way, around the wax, melting the wax and letting it run out, drying and firing at 1100ºC. Finally, it is placed in a box and covered with sand, leaving the pouring hole and gas vents uncovered.

4. Greenware mold

Bentonite, 12%
Sodium silicate, ?
Charcoal powder, 4% (Prepared by grinding and then sifting)
Sand, 84%

The bentonite and water is mixed one day before, obtaining a sort of damp clay. The three elements are mixed in the necessary amounts for the mold. The rest of the box is filled with sand. The box is made, the sand is placed inside and the mixture on top, then well compacted. Then, by applying pressure, the empty shape is left in the sand.

5. Firing the crucibles

The crucibles were fired the first time at 1000ºC. Engobe (sodium silicate diluted in water) was applied to the crucibles.

Note: In our attempts with engobe, the kaolin crucible became damp and was not left to dry sufficiently afterwards. This resulted in cracks during the second firing. So, it could be fired the second time without engobe. The crucibles were fired again to 1200ºC.

6. Preparing the iron

Select cast iron without carbon and without steel (from an engine block which you can get already split up, or from railings, drain-pipes or stove-pipes). It’s best to use the same type of iron and not mix them. Clean the iron to remove as many impurities as possible. Break it up into smaller pieces with a hammer so it fits better and fill the crucible to the top.

7. Melting the iron

Before pouring the molten iron, rehearse the movements required as many times as necessary to memorize everything well (with the crucible full of iron chunks to know how much effort will be needed to lift it).

Place the empty crucible or crucibles in the forge, within a wall of refractory bricks and covered up to the top. Light the forge and heat the crucibles until red-hot. Then the crucible is filled to the top with iron, covered with a refractory brick, and everything is covered with coke coal and brought to iron-melting temperature. The possible layer of slag is broken with a pointed rod, being careful not to break the crucible (close to the wall and parallel to the inclination). Cast the iron into the molds.

8. Finishing the production

After taking the items out of the molds, they can be polished and tempered.

The items are tempered by placing them directly in the forge fire until cherry-red (800ºC). Then they are put in water, alcohol, grease or oil, and returned again to the fire until reaching brown-black (450°C). Then the iron pieces are hammered on an anvil to adjust the molecules and left on sand to rest.

DRUM KILN

Workshop at the Center of Studies, Punta de Vacas Park – 30 January 2010

Interest

To make a drum kiln for working with ceramics.

The kiln may also be used to melt certain metals in crucibles and for doing some glass blowing.

Materials

- A 200 liter galvanized drum. (Common iron could have been used, but galvanized is more resistant to wear).
- 40 insulating refractory bricks (porous), able to withstand 1400ºC.
- Iron strip or sheet 6 meters long by 4 or 5 cm wide and 2 mm thick. Used for lower clamp, handles and supports. Nuts and bolts.
- One box of ceramic fiber blanket with zirconium, 128 k density for 1400ºC, approx. 4 m^2
- 15 Kg of kaolin powder, water
- 2 Kg sodium silicate, silica gel
- A few meters of Kanthal type wire; small perforated refractory plates or buttons. These will be used to attach the blanket to the drum.

Instruments and accessories

- A 1¼" Venturi atmospheric burner for gas in tanks and one Bunsen or Fisher type burner. Hoses for gas and appropriate couplings. 2 or 3 tanks of gas.
- A pyrometer with "K"-type thermocouple for measuring up to 1200º centigrade, or "S"-type for over 1500ºC when working with glass.
- Refractory supports for the kiln floor, made with cordierite plates.

Tools

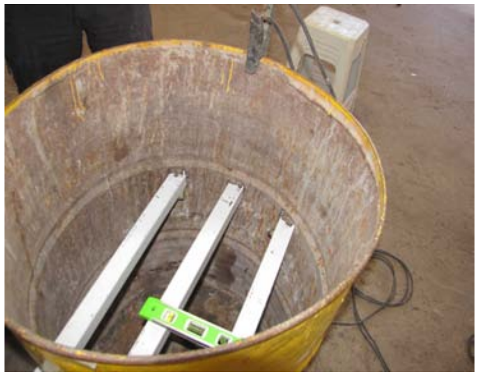
Saws, rasp or coarse file, electric welder, grinder with metal cutter, drill, cutters, pliers, screwdrivers, spatulas, level, setsquare, pencil, measuring tape, etc.

Procedure

The base

Three iron bars and a circular sheet were placed about half-way up inside a 200-liter drum to form a base for the insulation bricks.

A 10 x 10 cm square was marked on the side of the drum at the height of the brick base. The two sides and the upper part of this square were cut. The lower part of the square was bent outwards and down, making a shelf to support the burners.



Joining the bricks

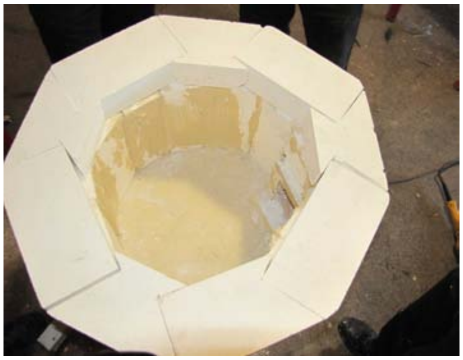
All joints were cemented with kaolin mixed with water to form a thick cream, which was applied over the bricks that were previously wet with water. A 1 or 2 mm layer achieved a good fit with no cracks. We avoided using refractory cement because kaolin works very well in this type of kiln – it allows you to make corrections and makes maintenance easier in the future.

The floor of the kiln was assembled by laying down the porous bricks, cutting some of them to complete the circular shape, with a depth of 12 cm. The opening for the burner is placed at this level, reinforced with a few 1500ºC refractory tiles.

Another 10 bricks were placed vertically on top of this refractory base to form a faceted wall, separated about 5 cm from the drum plate. This space was later filled with ceramic blanket (2 inches thick). In this way the base is not so heavy and the thermal insulation is better.

On top of the vertical bricks and after filling the space between the bricks and the galvanized plate with ceramic blanket, an upper ring was formed by overlapping horizontal bricks, slightly exceeding the diameter of the drum for the upper part of the kiln to sit well.

An iron strip was placed on the sides of the upper ring and bent to follow the exact shape of the bricks, acting as a clamp and adjusted with a screw. This clamp was joined to the drum base with 4 iron plates, securing everything firmly. The iron joints were electric-welded.




The entrance for the fire was made totally out of bricks, placed diagonally towards the left, for the fire to circulate inside the kiln.

This completed the base of the kiln. Three 8 cm high refractory supports are then placed inside as the base for a cordierite tray that holds the items to be fired.

The upper part

The galvanized drum was cut in half. A 12 x 12 cm opening was made in the top for the chimney.

Several small holes were made to secure the ceramic blanket using Kanthal wire, some near the base, others at about 15 cm from the top, and another 4 pairs at the top. Two more 1 cm diameter holes for the pyrometer were made at different heights.

Then three layers of ceramic blanket were glued with sodium silicate (silica gel). The first two layers were placed right up to the edge of the drum, and the third layer overlapped about 11 cm, in order to be folded back and over the outside, and then secured with the clamp.

Lengths of Kanthal wire were passed through the first holes and through the blanket, secured with the ceramic buttons and then tightened without tearing the blanet.

After firmly adjusting the blanket, a few layers of kaolin mixed with water were applied to form a protective ceramic crust.

Once the kaolin dried an opening was cut in the upper part of the blanket to coincide with the chimney.

Finishing

The kiln was put on top of bricks in the most appropriate place in the workshop.

Three pulleys were fixed with iron supports and a counterweight similar to the weight of the upper part of the kiln. This balances the weight of the kiln, making it easier to use. One person alone can raise and lower the kiln cover.

Operation

To fire ceramics, one or two trays with supports can be placed inside the kiln. The usable space inside for placing items is: in the lower part, 30 cm diameter by 20 cm high; and in the upper part, 40 cm diameter by 40 cm high.

After arranging the items to be fired, the temperature can be raised using a Fisher burner. With this burner you can regulate the fire well, and reach 800º to 900ºC. Then the Venturi burner is used to reach the final temperature.

CERAMIC MOLDS
La Cazadora, September 2004

1. From the rubber mold we made hollow wax figures. We filled the mold with wax heated to the melting point. When the wax walls are more or less 3 mm thick, the rest is emptied, the wax is allowed to cool, and then taken out of the rubber mold.




2. The clay is prepared with grog (semi coarse). A large handful of grog for 800 grams of clay, mixed well until there are no traces of grog on the surface.

3. Closed mold. The wax is covered little by little with small amounts of clay (like little balls), always in the same direction. We press and spread the clay towards the sides, leaving thicker layers on the edges; more pieces of clay are applied and spread until a thickness of approximately 5 mm is achieved evenly over the entire object. A clay funnel for pouring is molded onto the base, wide enough for the molten metal to pour in while allowing the air to come out. In other cases the clay funnel for pouring and the air vent is molded previously into the wax and later covered with clay.

3 b. Two-part or shell mold: the wax object is coated with a demolding agent (Vaseline) and the step described above is repeated, covering the object with clay. Then the clay (the mummy) is cut in half and the clay is separated from the wax. Two holes are made in one shell (one 1 cm diameter and the other smaller, 0.5 cm). The funnel is added for pouring the metal into the larger hole, and the other hole is for the air vent. They are both made of clay.

4. Lost wax: the wax is extracted from the clay mummy, using small blowtorches and a kitchen oven at about 70 degrees C.

The clay molds are left to dry overnight by the fireplace.

5. Cracks in the molds are repaired with a mixture of clay and vinegar.

6. Firing the ceramic: the first 2 hours were with firewood up to 150ºC to dry the objects well. Then we raised the temperature 100ºC every half hour with the gas burner until reaching 800ºC. And then we increased it 100ºC every 40 minutes until reaching 1000ºC.

The gas is turned off, the door opened, and the ceramic is left to cool until warm.

7. All the objects are lubricated on the inside with car oil, so the ceramic does not stick to the metal.

8. New cracks are filled with wax to prevent sand from getting in; the shells are also joined with wax and tied.

9. Preparation of wood boxes with well-compacted sand inside, where the objects are placed to pour the metal.

10. In the forge, with a refractory crucible, first we melted aluminum (at 600ºC), and poured it into the molds. Then we melted bronze (at 1200ºC) and poured it into the molds.

11. Wait a while and then fully submerge the objects in a bucket of water until they are cooled. Break the ceramic shell with a hammer.

12. Finish the objects with a file, sandpaper, Dremel, and so on.

AFRICAN RAKU

Grotte di Santo Stefano – September 2005

We have red pyrophile clay (25 Kg, of which we used half).

We need to make grog, medium fine grind. For this we take bricks and break them up with a hammer until the appropriate grain-size is achieved (putting it through a sieve with a couple of millimeter sized mesh at the most) and in sufficient quantity to mix with the clay at 50%.

The two components are sufficiently mixed and then, a little bit more! Finish kneading by hitting the lumps of clay to get rid of the air bubbles.

Trick: if the grog (which is very dry) absorbs too much moisture from the clay, making the mixing and handling difficult, moisten it a little before mixing it with the clay.

Primitive bowls are made (instead of other shapes).

A lot of firewood is gathered for the firing bonfire.

A drum with a lid and sawdust.

A bucket with water.

The bonfire is lit (for about 20 objects, a bonfire of 1.5 meters in diameter).



The objects are spread around the bonfire about 80 cm apart, arranging them on bricks so they do not absorb any humidity from the ground (some objects are more dry than others).



The bonfire is kept alive while each object is turned so they all dry evenly. The pieces can be brought closer to the hot coals in the measure that they dry.

When the objects have dried well, use a shovel or tongs to place them right on top of the coals.

All the objects are covered with sticks and kindling so as to not crush them. As the firewood burns, go on adding more (always being careful with the weight on the objects) until a big bonfire is made.



When the objects get as red as the coals, they are left a little longer so that they all reach the same temperature.

Using tongs and gloves, one or more objects (depending on the width of the drum) are carefully removed and placed in the drum with sawdust. The drum is covered and after five minutes, using tongs and gloves, the black objects are taken out of the sawdust and carefully placed in the water. In the meantime, make sure the objects still in the fire remain covered with coals.

When the objects submerged in water have cooled sufficiently to be taken out by hand, they are cleaned and left to dry.

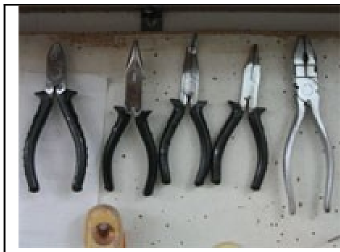
WORKSHOP TECHNIQUES
Madrid, May 2007

Contents

1.- Tools and devices

1.1.- Handtools

Pliers	Screwdrivers
Hammers	Files
Scissors	Chisels
Gouges	Saws for wood or metal

 Pliers	 Blades	 Spatulas
 Awls	 Wrenches, pliers, metal cutters	 Rubber mallet, file, hammer
 Bench vice	 Screwdrivers	 Heavy mallet, saws

Pliers
Bench vice
Stapler
Cutter
Bar clamps
Wrenches
Steel brush
Spatulas

1.2.- Electric tools

Drill and screwdriver bits
Angle grinder
Heat seal gun
Dremel
Circular saw
Sander
Tin soldering iron
Dryer

 Sander	 Polisher	 Dremel

1.3.- Heating devices

- Burner
- Electric oven
- Sawdust kiln
- Ceramic kiln
- Gas stove
- Gas kiln
- Drum kiln
- Forge

 Electric oven	 Gas stove and oven	 Forge
 Sawdust kiln	 Drum kiln	 Ceramic or electric kiln

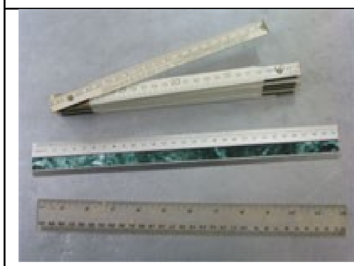
1.4.- Measuring tools

- Measuring tape
- Compass
- Measuring cups
- Folding ruler
- Calipers
- Rulers
- Set Squares/T-squares

Digital caliper

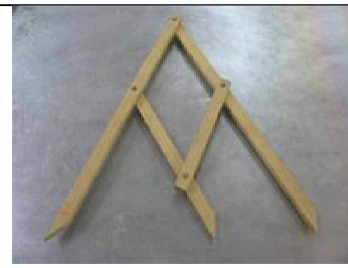
Right angle squares

Measuring tape



Rulers

Metal golden section gauge



Wood golden section gauge

1.5.- Various tools

String
Metal and electric cables
Sandpaper
Containers
Jars
Metal pails
Rollers
Cotton swabs
Tubes
Plastic bottles
Rubber bands
Bandages
Rubber tire
Buckets
Crucibles
Rods
Spoons
Stir sticks
Boxes
Cardboard to make boxes

Tape

String and rubber bands

Glue

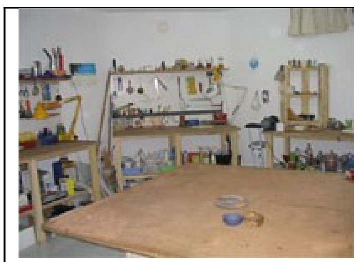
 Knives	 Modeling spatulas	 Paintbrushes

1.6.- Protective gear

Gloves
Masks
Safety goggles
Aprons

1.7.- Furniture

Work benches
Tool boards and panels
High stools
Shelves
Tables
Storage cabinets

 Work tables, tool panels, shelves	 Cupboards	 Work table and shelves
 Shelves	 Shelves for materials	 Shelves for ceramic items

1.8.- Safety items

Fire extinguisher
First aid kit
Air extractor

2.- Materials and products

2.1.- Mud

Mud is formed by the mixture of various types of sand, mineral compounds, and organic remains which have been carried by the current and mixed together by the water.

We collected silt from the banks of the Jarama river (near the Velilla lagoons), the Tietar river, and the Santo Domingo cave in Calzada, La Rioja. The color, consistency, and malleability of the mud varied depending on the place.

Mud is moldable, malleable, giving way to pressure when damp and shrinking when dry, becoming brittle and hard and revealing its sandy texture.

Mud was used above all to make kilns for the conservation of fire. Curiously, the fire contained for several hours in the little kilns makes them harder and more resistant since they get cooked from within.

2.2. Clay

Clay is very malleable, fine, completely water soluble, moldable, elastic, and possesses great plasticity. Because of this plasticity, it is easily deformed through pressure or its own weight. The more wet it is, the more malleable and plastic it is.

The wettest clay is **slip**, which can be obtained by dissolving clay powder in water. It forms as a saturated solution and acts as a dense liquid, serving as a glue between slabs, to attach separate parts, to paint a produced object by layers to give it another finish, or for the creation of new pieces with a mold. In the section on plaster, we will discuss the creation of shell molds to make pieces by working with slip. In any case we can say that slip is very adaptable to any mold that will allow it to dry.

When clay dries, it is hard and brittle, but still allows for the addition of new parts, so long as it has not been subjected to the heat of the kiln, in which case it changes its state and becomes ceramic.

For clay as for mud, the techniques are:

- Balls or lumps (pinching)
- Noodles or sausages (coils)
- Slabs or plates.
- Molds.
- Potter's wheel

And the different works that are done are:

- Kneading.
- Molding.
- Stitching.
- Adding elements, such as sand, straw, grog, etc.

- Smoothing.
- Sanding.
- Polishing.
- Burnishing
- Engobe.

Pinching technique:

After kneading the clay well so it has the consistency and plasticity required to work without being deformed, a ball or mound is formed. Using the thumb and fingers, make an indentation in the ball, and begin to give it shape. This technique is often used to make small and simple rounded vessels. Small bits of clay can also be added to the bowl as you make it, to give it the desired shape. When dried to the hardness of "leather", the surface can be smoothed and decorated.

Slab technique:

Similarly, after kneading the clay well, take pieces from it and place them between two pieces of wood or other hard material of a certain width. A rolling pin is passed over them to form uniform slabs, and then the edges are cut with a miter to give them the desired shape. The various slabs can then be attached with the technique of gluing or stitching, with the help of a clay slurry. This technique is used to create hollow geometric pieces with flat surfaces. Once dry, they can be sanded to give the surface the required smoothness. The slabs should not be too thin because they shrink as they dry, and can break.

Noodle or coil technique.

After kneading, clay coils are formed that can be joined together, or else long coils (noodles or sausages) that can be twisted in a spiral to form the desired vessels. These are then glued or stitched between the seams. The surface can be smoothed afterwards with your fingers, and can be finished with a small, moistened brush. Once it has reached “leather-hardness”, the surface can be finished and decorated. This technique is typically used to create different types of vessels.

Wheel technique

First, cut the piece you want with a thread. Knead on a plaster board or tile that you have prepared. The aim is for the board to absorb some of the moisture of the clay. This board can be made very easily done by pouring plaster on a wooden box and letting it dry for a while. Make sure that the plaster surface is smooth and regular as it will be the basis on which we will knead the clay

.

The kneading is done with both hands acting like two paddles, pressing symmetrically, and creating a form like a "bull's head." This part of the process is very important because it gives the clay consistency and removes the air pockets.

Before putting it on the wheel, the clay is given a conical shape, and a "track" is put on the wheel, upon which the “lump” will be thrown. Then, one hand does the centering while the other pushes downwards. Both hands are occasionally used to pull the mound towards you in order to help center it, keeping your elbows on your knees. The base is also cleaned with your finger. This whole process has to be done with wet hands so that the clay can maintain its plasticity.



The work with the wheel requires some pressure on the clay but not force. Once it is centered, this pressure is used to raise it up and push it down, forming a cylinder.

To push it down, the mound is supported with one hand and pressed with the other. This lifting up and pressing down kneads the clay well and it is advisable to repeat it several times: the clay gets softer and any possible air pockets are removed. The excess clay goes into a bucket kept nearby, and you can wet your hands in a basin kept alongside as well.

Productions and pieces

Different geometric figures have been produced, like the five Platonic solids (tetrahedron, hexahedron, octahedron, dodecahedron, icosahedron), sphere, cone, cylinder, pyramid, and others.

Generally, the figures were made hollow and through different techniques, though mostly through the use of slabs.

Other items produced were kilns or bowls to conserve fire, some modeled figures, others have been made with shell-molds and some pieces were made using slip in plaster casts. With the wheel we have started to make objects such as bowls, plates, vases or vessels of different sizes and shapes.

2.3 .- Gypsum

This mineral is calcium sulfate which is extracted from gypsum rock. It is worked in a way very similar to plaster, but unlike plaster, gypsum is not stirred or moved when put into water so as to not kill it, and there must always be water in the container to prevent it from drying.

2.4 .- Plaster

This is calcined gypsum that has been refined. To work with it, it is mixed with water just like gypsum, and because it hardens quickly some precautions have to be taken. The container used should be very clean, especially free of the remnants of previous mixtures.

It is very important not to use too much water, in order to not to make excessive amounts of plaster that you may not have enough time to use and have to then throw away. It is always preferable to make a small amount and work with it more comfortably.

Plaster is finer than gypsum, it dries faster, takes on a more intense white color, and is less porous.

To make the material, sprinkle it carefully into the container , trying to distribute it evenly throughout the water. Add plaster until the dry powder can be partially seen above the surface of the water, like an island. If there is not enough plaster, the mixture will be too runny and can not be applied until after quite a while. If instead we add too much plaster, it will harden quickly and go to waste because we will not have enough time to use it as it will have lost its plastic properties. Now stir the mixture, which should have a soft and not too thick consistency, like melted chocolate. This point can be recognized once your mouth waters, that is, once you experience an increase in salivary secretion. Mix it evenly, stirring with your hand and searching for any lumps to be dissolved or crushed with your fingers.

Many molds and figures have been made in plaster, for example, fingers, hands, feet and busts, geometric or decorative pieces, copies of Indian art or prehistoric pieces, etc.

A special work, described below, is the creation of plaster molds to make pieces with slip.

Plaster molds for working with Slip

The main difficulty with making objects with slip has to do with the shrinkage of the material. To avoid this you can put sodium perborate in the slip and lower the shrink rate a little.

The consistency of the slip should be like melted chocolate, not too runny, but still wet. If there is a lot of water it will crack quickly and if it is too thick it will not make a good positive of the mold and you'll end up with a bad copy. The pouring is done in successive layers in order to give it enough thickness while it dries, and is stirred and distributed slowly in all directions to cover the entire surface of the mold.

The two parts (shells) of the mold have to be very smooth for them to fit together properly. The product used as a demolding agent has been an important factor in the tests carried out. Vaseline and olive oil can be used with good results, but care must be taken that no drops or streaks are left that could affect the final copy. And in the search for the perfect demolding agent, a lubricant like 3-in-1 has also worked very well.

If the original has undercuts, these have to be filled so that we don't run into problems when it comes to extracting the positive. Edges and contours should not produce concavities in the mold either, although all those details can be carved and shaped with an awl once the piece has dried and been extracted from the negative.

2.5 Resin

Resin is a polyester composite which can be bought in stores that specialize in chemical products. In this case we used polyester resin bought in 1-liter containers.

Resin is usually used with rubber molds, although it perhaps it will accept other mold materials. The condition is that they need to be waterproof or become waterproof, so that the liquid does not filter through the mold and mix with it.

Resin's main quality is that you can copy figures or pieces with a high level of detail. In this sense we can say that the resulting figure will be an exact copy of the original, without the loss of resolution we experience with other materials. It is best to use it for figures that are not very large and for single pieces, not shell-molds – being a liquid, it can leak out of the shell seams easily. For this reason, making a good seal for the mold you are using is very important. Otherwise, the resin leaks out and the work is ruined.

It is mixed with a catalyst (1.5% or follow instruction on product) stirring gently in the same direction for about five minutes, depending on the amount of resin used – it may be more or less. Make sure that there are as few bubbles as possible since they will be difficult to get rid of later. If you are using an accelerator, should the resin not come with it already, never mix it at the same time as the catalyst **since this can cause explosive reactions**. To prepare the resin, first add the required amount of catalyst and once it is well dispersed, add the accelerator. Great care must also be taken not to confuse the resin catalyst with the catalyst for the rubber, which is different and only serves the material it was designed for. This happened once and the result was that the work was ruined. It is best then, to label the catalyst for each material well and store them in different places in the workshop, so as to not produce any confusion.

Resin allows for the addition of any kind of element, such as sawdust, clay powder, metal filings, marble or quartzite. Also, any pigment, be it translucent or opaque, may serve to modify its original clear tone. Colorings have to be added sparingly since they have a lot of coloring power, and must be stirred well until they are evenly dissolved.

 Faux-amber resin sphere	 Resin spheres	 Resin Venus of Willendorf
 Resin buddhas	 Resin hand	 Anthropomorphic face in resin

If you want the figure to not be too plastic on the surface, talcum powder can be sprinkled into the mold cavity, or the mold can be primed with a mixture of something thicker than the resin and whatever additional element it is carrying, before the resin is poured in. This procedure consists of brushing the mold surface so that this primer becomes the outer layer of the piece. That layer has to be left to dry for a while depending on the size of the piece, before the rest of the resin is poured in, because if not the end result may be uneven and not uniform.

When the resin is poured into the mold, the bubbles are removed by tapping on the table next to the mold. As the bubbles rise to the surface, they can be removed with a little stick. Also, if the mold is closed, you have to use a stick or wire to ensure that the resin reaches all the cavities the mold may have and that all the holes are covered.

With resin we have made geometric pieces like the sphere, pyramid or octahedron, and figurative pieces as well, such as copies of the Venus of Willendorf, Egyptian scarabs, medusas, cyclops, etc.

2.6 Rubber

Rubber is a silicone polymer or elastomer which can also be bought in stores that specialize in this field of chemistry. It is elastic but comes in liquid form. Once the catalyst is added it sets and dries at room temperature in approximately one day. There is another process called vulcanization which causes the rubber to set in seconds through the concentrated application of heat, but we haven't experienced this yet.

 Frontal view of rubber casing over a bust …	 … and side-view	 Open rubber mold

It is the ideal material for making negative molds and because it does not have to destroyed to extract the piece, it allows you to make a series of figures. It also supports work of a very detailed resolution, copying even the slightest change in the surface of the piece. That is, it can leave marks on the copies with details of things as fine as a hair or a grain of sand.

The bed or box is made and sealed well, and the piece is put inside it with a little adhesive on the smallest area possible to fix it so that it does not move. The distance between the piece and the walls of the box must be large enough to allow the mold to obtain an appropriate thickness. However, this space should not be too large, because then it will be too thick, more rubber will be used up and it is an expensive material. Try to have the amount of rubber for the mold to be proportionate to the size of the piece. The recommended minimum thickness is about 5 mm.

The volume of rubber to be used can be calculated by pouring sand in the box with the piece inside, and then pouring the sand out into a measuring cup. If this is done, the box and piece must be thoroughly cleaned so that no sand remains. If the box is waterproof and completely sealed, the volume can be measured with water in the same way as sand. Water will always be a neater way of measuring and its volume is easier to measure.

Rubber is mixed with catalyst at 5% in a container. Stir slowly and well in order to not create bubbles, always in the same direction. Then, pour the mixture around the edges or corners, so that all the empty spaces are filled and no bubbles are formed. But even then with all the care taken, it is normal for there to be some bubbles, which then have to be removed by hitting the surface where the box lays with a rubber hammer. A few minutes of constant hammering on the table is enough to help remove the bubbles. We emphasize this because every bubble that remains in the mix will deform the pieces made with that mold.

It is then left to set, and this takes about a day, depending on the size of the mold. Once dry, as small a cut as possible is made lengthwise, but big enough to extract the piece.

We have made shell-molds with rubber although the pieces that came out worked out well only with some materials, like wax or plaster that dry quickly, and clay which is thicker. On the other hand, good results were not achieved with resin since it leaks out easily even if the seams are well-sealed.

The rubber mold, whether closed or open, accepts cold materials such as resin, plaster, clay, or hot materials like wax. However, slip does not work in closed molds because the mold does not absorb the moisture and the piece does not dry.

Another interesting work is the creation of rubber casings for large pieces. The procedure is as follows: the surface of the figure is painted with a brush with rubber which has been left to dry at room temperature for several hours so it thickens and does not run. Coat the figure well, giving it successive layers over time if this is necessary so that it is well-coated, or if a layer is too thin in some places. The recommended approximate thickness of the casing should be a minimum of 3 mm.

Rubber molds were made for many pieces and objects, for example, the Tree of Internal States, the symbol of the School, spheres, pyramids and other geometric shapes, an Egyptian scarab, the Venus of Willendorf, a warrior of Siam, etc.

2.7.- Wax

Wax is made with 70% beeswax, 13% paraffin, and 17% pine resin, also known as colophony. These substances are heated until they dissolve.

Wax can be used to copy almost any object with a mold made previously. Its main application is in making copies of objects with a mold made of silicone rubber. The silicone molds are filled and once the wax cools and becomes hard the wax is taken out in order to make a new mold with plaster. This is called the lost-wax process and is used in casting.

To work with lost wax, first a negative must be made of the model object. This negative is used to make a wax reproduction. After making the silicone negative mold, it is cut open and the model object is taken out. Then the mold is closed once again and secured with rubber bands or adhesive tape. The wax is heated until it becomes liquid and then poured into the silicone rubber mold. This is how the positive reproduction is made. It is allowed to cool for a few minutes at room temperature and can then be put in a freezer to speed-up the hardening process. This is done because the risk of breaking the object during demolding is high if the wax is still too hot when it is put in the freezer. Finally, the object is demolded and prepared to make the empty form in plaster.

2.8- Pewter

We have worked with different proportions in the mixing and melting of metals, and the results in terms of hardness, color, and so on, have depended on the proportion and the metals used. For example, to obtain a more silvery color, no lead is added and the amount of zinc is increased.

The different metals are melted starting first with those that have the highest melting point. In the case of the metals that can be used to make pewter, the melting points that establish the order of the melting process are:

Antimony	630 ºC
Zinc	419 ºC
Lead	327 ºC
Bismuth	271 ºC
Tin	232 ºC

A kitchen stove can produce sufficient heat for the metals with a low melting point, but we had to use a gas blowtorch – the type used in plumbing – to reach the temperature needed to melt antimony. After melting the metals, the mixture is stirred or shaken so that everything is evenly mixed and the impurities that float to the surface are extracted. At this point the alloy is ready for pouring into the mold.

The following must be taken into consideration in the process to make an object:

- The molds used are plaster
- The mold must be very dry so the metal does not bubble, and preferably heated beforehand in the kiln to reduce the thermal shock from the molten metal.
- The mold must have some type of vent or chimney for the smoke in addition to the pouring hole.
- Pouring must be slow but constant to avoid bubbles.

The following are the proportions used for different types of pewter:

The First Pewter tested

Tin	70%
Zinc	18%
Lead	12%

Paris Pewter

Tin	85,44%
Antimony	14.50%
Lead	0.06%

Workshop Pewter

Tin	86,66%
Antimony	6.66%
Lead	6.66%

We used zinc in one case and it produced a very hard and resistant alloy.

The proportons should be calculated by volume to ensure that they are accurate. The calculation is much easier if small metals bars or tablets are prepared first, in plaster molds made for this purpose, and in which each metal has been cast separately.

Leather gloves or construction-worker gloves must be used for handling tools. It is advisable to cover the handles of the pot with leather, cloth, insulating tape, or any ingenious device that we can think of to prevent the heat from reaching our hands in spite of the gloves.

We should also point out that propane or butane gas must be used for melting, and if this is not available, then use “camping gas” like the kind that comes in a blue tank – since natural gas has less heating power and kitchen stoves, be they vitroceramic or not, have even less.

We should also say that the melting must be done in red porcelain pot or iron pot – in both cases with spouts for pouring – and never in an aluminum pot because it deteriorates quickly and that can be dangerous.

Many objects have been made of pewter: geometric figures such as cones, spheres, cubes, tetrahedrons, pyramids, etc. Also parts of the body, such as fingers, hands, face masks, etc. And other figures, such as the tree, the Venus of Willendorf, various etchings, etc.

2.9.- Cooked Mud

Mud objects were fired in metal drums or large cans filled with sawdust, producing objects similar to what is known as Raku.

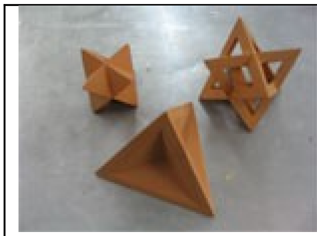
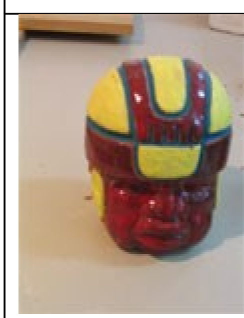
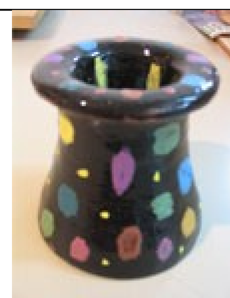
First the bottom and top of the drum are perforated with a chisel and hammer. Then about 4 cm of sawdust is placed inside. The objects are put inside the drum making sure they do not touch. Then they are buried and totally covered in sawdust, making sure that the hollow objects are filled with sawdust. The remaining mud objects can be placed in successive layers until the drum is full.



After the last layer, another 4 cm of sawdust is placed on top and the surface is sprayed with a fuel such as kerosene. The fuel is lit and the drum is covered, producing a slow combustion because of the reduced amount of oxygen. From time to time it must be checked to make sure it is still smoking and that the embers have not gone out. The drum can also be raised on stones so that there is more ventilation and the fire can burn all the sawdust.

2.10.- Ceramic

Different programs with different rates of heating and cooling have been used with the ceramic kiln. These programs are automated and used depending on the type of clay or the glaze being worked with.

 Bisque-fired geometric figures	 Glazed dish with oxide coloring	 Glazed tile
 Oxide painted figures	 Glazed leaves	 Geometric figures
 Mayan head with oxide and glaze	 Oxide and flux vase	 Oxide-colored glazed vase

 Vase with blue oxide over orange	 Glazed vessel	 Glazed and oxide-colored vessel

Glaze is diluted in water and greatly absorbed by the ceramic, so it is necessary to apply 3 or more coats with drying intervals in between.

Oxide permits greater detail and definition than glaze, but do not of themselves add shine to the object. For the object to come out shiny it must be mixed, in different ways, with glaze or flux.

Flux is used to fix the oxide and to make the object shiny.

The results of the application of these colorings to bisqueware has been uneven: applied with a brush, the results have been poor; dipping the object in the liquid has been better; and the best results were obtained by spraying with an airbrush, both in terms of the finished product as well as in terms of not wasting the material.

2.11.- Supplementary products

Sand
Sawdust
Powdered zinc, quartz, marble, graphite, etc.
Grog in various grain-sizes
Kaolin
Borax
Cordierite
Bentonite
Sodium feldspar
Vaseline
Turpentine
Fuel alcohol

VIDEOS

Mud – Conservation of Fire – Conservation (English) – Production of Fire – Potter's wheel

http://www.tallerdevideo.org/Eduardo/