

## Bronze Clay Shrinkage Tests

### Pat Waddington

Manufacturers of metal clays give a figure for the amount of shrinkage their product will undergo during firing. If you search for the small print you may find that the shrinkage percentage stated is qualified by statements such as "5gm sample", "30 minutes at 650°C" or 'by volume'. In the case of silver clay they also conspicuously fail to mention that hotter firing results in more shrinkage.

I had used bronze metal clay before, starting with Metal Adventure BRONZclay when it was first released in July 2009. I'd got the shrinkage more or less worked out if I was making bracelet components but I was getting fed up with the long firing time and wanted to try the other bronze clays that are now available.

I bought Metal Adventures Fastfire Bronze and Prometheus Bronze which are ready-mixed clays and Météor Bronze which is a powder clay that needs to be mixed with water. Waldo Iłowiecki kindly let me have some Goldie Hard Bronze and Goldie Soft Bronze powder clays for testing.

At the time of testing I was unable to include Hadar's bronze clays but I hope to do so in the future.

### FIRING TESTS

The first step was to establish a firing schedule for each of the clays. For these I used strips measuring 1cm x 3cm in thicknesses of 1mm, 1.5mm and 2mm. Starting with the manufacturers' directions I tried many different firing times, temperatures and methods usually with abject failure as test piece after test piece snapped or cracked, sometimes at the slightest provocation.

Only when I was able to bend each of the firing test strips through a 180° angle without any sign of cracking or blistering was I satisfied with the firing schedule.

I fired all the successful firing test strips and the subsequent test pieces in a single layer in a steel container with a lid using coal-based carbon. The schedule I used is:

	Stage 1 – Open shelf firin			Stage 2 – in carbon		
	Ramp deg C	Temp deg C	Hold - hours	Ramp deg C	Temp deg C	Hold - hours
BRONZclay				139	825	4
Fastfire				862	862	2
Goldie Hard	Full	280	1	862	862	2
Goldie Soft	Full	280	1	862	862	2
Meteor	Full	280	1	862	862	2
Prometheus	Full	280	1	862	862	2

This works for me. It probably won't work for anyone else and it bears little relation to the manufacturers' schedules except in passing.

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### LINEAR SHRINKAGE TEST

For the linear shrinkage tests I cut identical pieces from each type of clay and allowed them to dry naturally. These were 22mm squares, 2mm thick and the only pre-finishing I did was to remove the burrs left by the cutter as they would have interfered with taking the post-firing measurements.

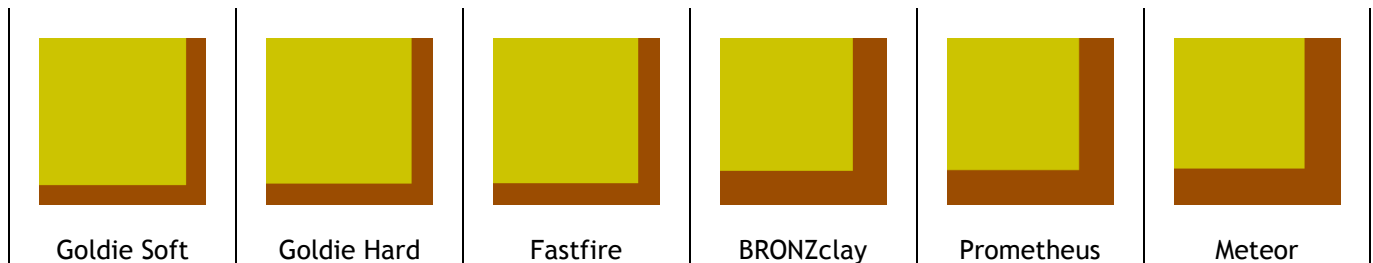
These were the results after firing

	BRONZclay	Fastfire	Goldie Hard	Goldie Soft	Meteor	Prometheus
Thickness before firing mm	2	2	2	2	2	2
Length of sides before firing mm	22	22	22	22	22	22
Volume before firing mm <sup>3</sup>	968	968	968	968	968	968
Thickness after firing mm	2	2	2	2	1.75	1.7
Length of sides after firing mm	17.5	19.125	19.175	19.375	17.2	17.4
Volume after firing mm <sup>3</sup>	612.5	731.25	735.26	750.78	517.51	514.69
<b>Average shrinkage in the length of the sides %</b>	<b>20.45%</b>	<b>13.07%</b>	<b>12.84%</b>	<b>11.93%</b>	<b>21.82%</b>	<b>20.91%</b>
<b>Volumetric shrinkage %</b>	<b>36.73%</b>	<b>24.46%</b>	<b>24.04%</b>	<b>22.44%</b>	<b>46.54%</b>	<b>46.83%</b>
Weight in grams	3.7	5.2	5.1	4.6	3.6	3.8
Density g/cm <sup>3</sup>	6.04	7.11	6.94	6.13	6.96	7.38

To summarise, for a flat piece like this:

**Goldie Soft** shrank in size the least (11.93%) followed by Goldie Hard (12.84%), Fastfire (13.07%), BRONZclay (20.45%), Prometheus (20.91%) and Meteor (21.82%).

These are life-size representations of the shrinkage results.



**Fastfire** was the heaviest piece (5.2g) followed by Goldie Hard (5.1g), Goldie Soft (4.6g), Prometheus (3.8g), BRONZclay (3.7g) and Meteor (3.6g).

**Prometheus** was the densest piece (7.38g/cm<sup>3</sup>) followed by Fastfire (7.11g/cm<sup>3</sup>), Meteor (6.96g/cm<sup>3</sup>), Goldie Hard (6.94g/cm<sup>3</sup>), Goldie Soft (6.13g/cm<sup>3</sup>) and BRONZclay (6.04g/cm<sup>3</sup>).

It was interesting to note than only the Prometheus and Meteor clays were measurably thinner after firing.

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### CIRCULAR SHRINKAGE TEST



For the circular shrinkage test I made bangles which were all identical in size and shape before firing. I extruded the clay through a hexagonal die and twisted it before forming it into a bangle around a circular cutter. The bangles were left to dry naturally and the only pre-finishing done was the neatening of the seam.

BRONZclay was omitted from this test.

These were the results after firing:

	<b>Fastfire</b>	<b>Goldie Hard</b>	<b>Goldie Soft</b>	<b>Meteor</b>	<b>Prometheus</b>
Internal diameter before firing	70	70	70	70	70
Diameter of band before firing	6	6	6	6	6
Volume before firing mm <sup>3</sup>	6472.32	6472.32	6472.32	6472.32	6472.32
Internal diameter after firing mm	65.4	63.75	64.5	59	59.25
Diameter of band after firing mm	5	5	5	4.3	4.1
Volume after firing mm <sup>3</sup>	4181.46	4079.68	4125.95	2785.38	2538.71
<b>Internal diameter shrinkage %</b>	<b>6.57%</b>	<b>8.93%</b>	<b>7.86%</b>	<b>15.71%</b>	<b>15.36%</b>
<b>Diameter of band shrinkage %</b>	<b>16.67%</b>	<b>16.67%</b>	<b>16.67%</b>	<b>28.33%</b>	<b>31.67%</b>
<b>Volumetric shrinkage %</b>	<b>6.97%</b>	<b>9.23%</b>	<b>8.20%</b>	<b>16.21%</b>	<b>16.00%</b>
<b>Weight in grams</b>	<b>29.1</b>	<b>29</b>	<b>25.8</b>	<b>18.7</b>	<b>18.9</b>
Density g/cm <sup>3</sup>	6.96	7.11	6.25	6.71	7.44

To summarise, for a twisted bangle like this:

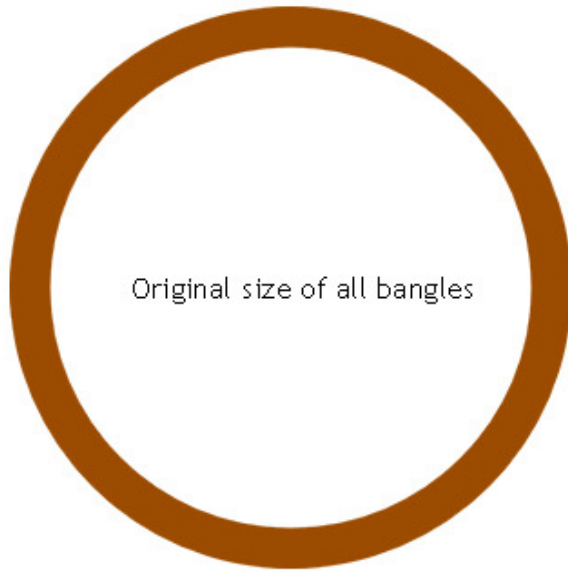
**Fastfire** shrank the least in terms of the bangle size (6.57%) followed by **Goldie Soft** (7.86%), **Goldie Hard** (8.93%), **Prometheus** (15.36%) and **Meteor** (15.71%).

**Fastfire**, **Goldie Hard** and **Goldie Soft** all shrank the least, and by the same amount, in terms of the thickness of the bangle (16.67%) while **Meteor** and **Prometheus** thinned noticeably (28.33% and 31.67% respectively).

**Prometheus** was the densest piece (7.44g/cm<sup>3</sup>) followed by **Goldie Hard** (7.11g/cm<sup>3</sup>), **Fastfire** (6.96g/cm<sup>3</sup>), **Meteor** (6.71g/cm<sup>3</sup>) and **Goldie Soft** (6.25g/cm<sup>3</sup>).

On the next page are life-size images of the shrinkage for the bangles.

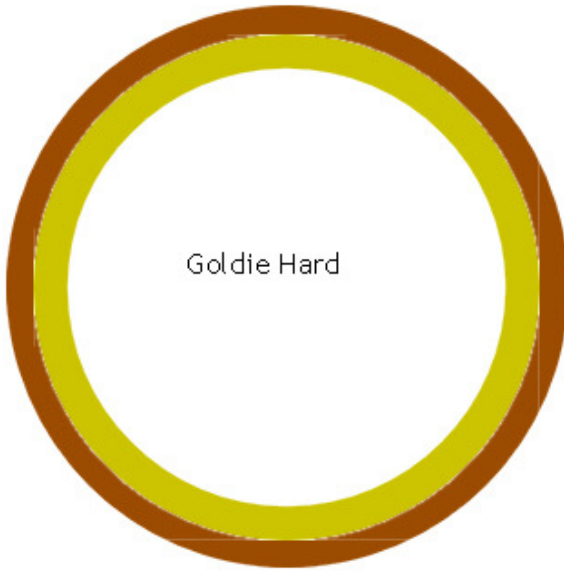
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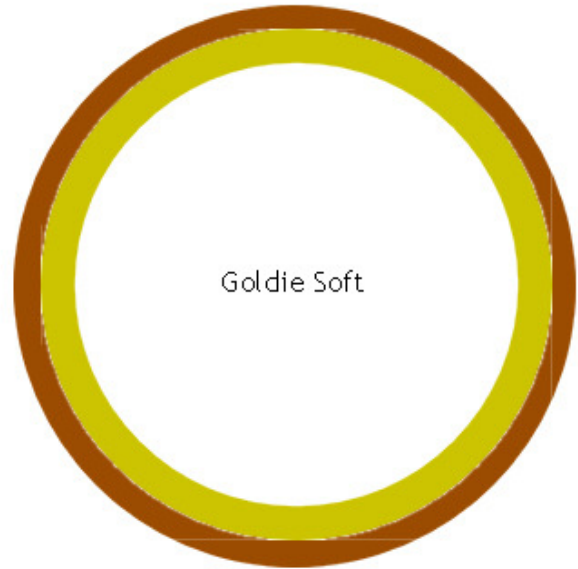
Original size of all bangles



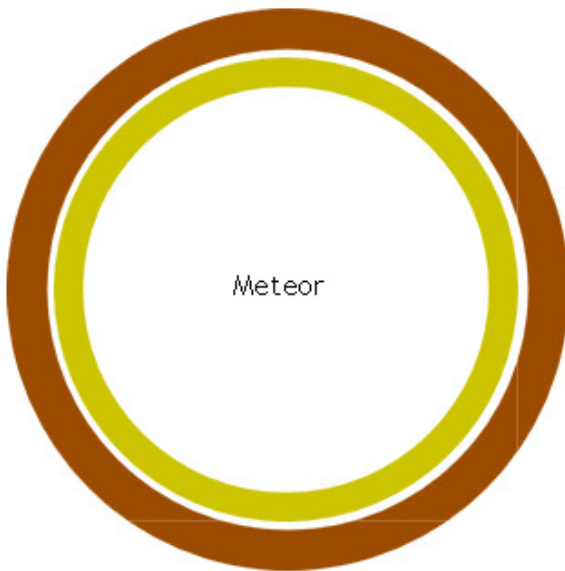
Fastfire Bronze



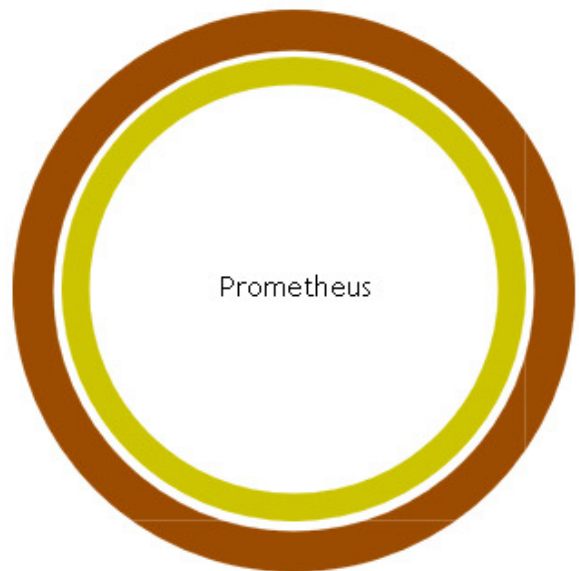
Goldie Hard



Goldie Soft



Meteor



Prometheus