Density Testing of Glass Paperweights

A Workshop at the 2005 PCA, Inc. Convention, Appleton, WI

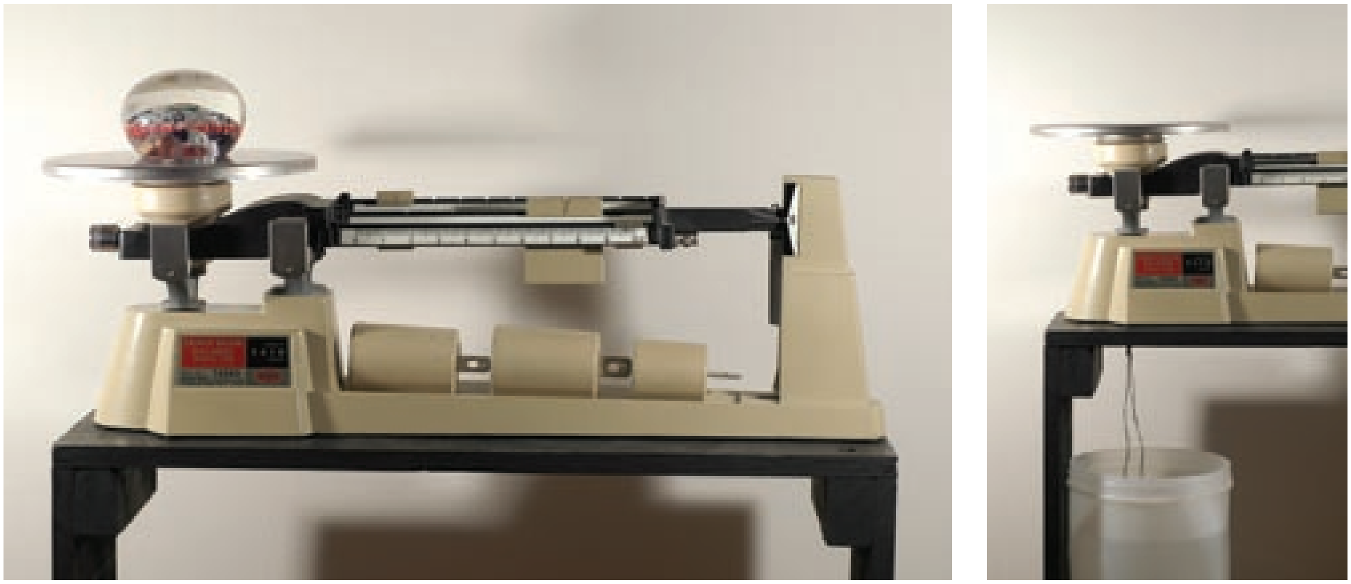
Presented by: John D. Hawley

The attribution of an antique glass paperweight can be a simple task if it contains a signature or millefiori cane that is known to be characteristic of a certain factory. However, a different approach is needed when one is confronted by a mystery weight that offers no obvious clue to the observing eye or by one that could have been made by one of several possible factories.

Density testing is a technique that can quite often be useful in suggesting which factory or factories might (or might not) have manufactured a paperweight. The density of a material is defined as its mass per unit volume and is usually expressed in metric units of grams per cubic centimeter (g/cc). One often sees the terms density and specific gravity used interchangeably, but this is incorrect. The specific gravity of a material is a ratio of its density to the density of water and is dimensionless. Considering that we are measuring the *average* density of the formulations of the clear and colored glasses in a typical paperweight, it is practical to assign a value of 1 g/cc for the density of water (we will ignore the slight variation with temperature). Thus, for our purposes, the specific gravity of the glass in a paperweight is numerically the same as its density.

Glass is a mixture of sand, potash, and "other ingredients," the type and quantity of which was usually held secret by the factory. The formulation of the glass thus varied from factory to factory. This difference is a good thing because it is the reason we see different density values for the paperweights made by each glasshouse. Sometimes this difference is slight; for example, the average density of Baccarat weights is 3.368 g/cc and that of St. Louis is 3.307 g/cc. If a mystery weight had a measured density of 3.34 g/cc, we'd be hard pressed to decide which of the two factories it belonged to if all we had to go on was the density value. On the other hand, many Bohemian factories used a lime-potash glass instead of the lead glass preferred by the French, and they have an average density of 2.51 g/cc. We would thus know without a doubt that our mystery weight did not come from this area, and that is helpful information to have.

In order to measure the density of a paperweight, one needs a triple beam balance such as an Ohaus model 750-SO and its accompanying model 707-00 attachment weight set (both available from Edmund Scientific at http://scientificsonline.com), a wire sling, a two quart container, and distilled water.



Weighing paperweight in air (left) and while submerged in distilled water (right)

The procedure for determining the density of a paperweight is straightforward. One weighs the paperweight first in air and then suspended under water in the sling. The below formula is then used to calculate the specific gravity and density of the glass in the paperweight. For the NEGC patterned millefiori shown above,

$$\text{Specific Gravity} = \frac{\text{Air Weight}}{\text{Air Weight - Water Weight}} = \frac{419.8}{419.8 - 288.2} = 3.19$$

$$\text{Density} = \text{Specific Gravity X density of water (1 g/cc)} = 3.19 \text{ X } 1 \text{ g/cc} = 3.19 \text{ g/cc}$$

Unfortunately, many factories either changed formulations over time or did not have very good quality control over their process. Economics was an important factor - Sandwich in particular was known for reusing scrap glass (cullet) in their melt. If a factory changed formulations and/or had poor quality control, we see a wide range of measured densities in their paperweights. The wider the range, the more it overlaps the density ranges of other factories, and this obviously complicates the attribution process. The big three French factories (Baccarat, Clichy, and St. Louis) had the best quality control as evidenced by their tight density ranges. The American factories have wider ranges; for instance, that of the New England Glass Company is almost three times that of the French. The Boston & Sandwich Glass Company is the worst with a range almost five times that of the French, a range so wide it encompasses the ranges of most of the other factories for which I have density data. Aside from their liberal use of cullet in the melt, I am convinced that we are seeing one or more significant formulation changes on the part of this company during the period of time it manufactured paperweights.

The below table provides an overview of density data compiled for thirteen glass factories, and the accompanying charts illustrate it in graph form. Given a large sample size and good data, one can use statistics to calculate the density range within which 99% of that factory's paperweights will fall.

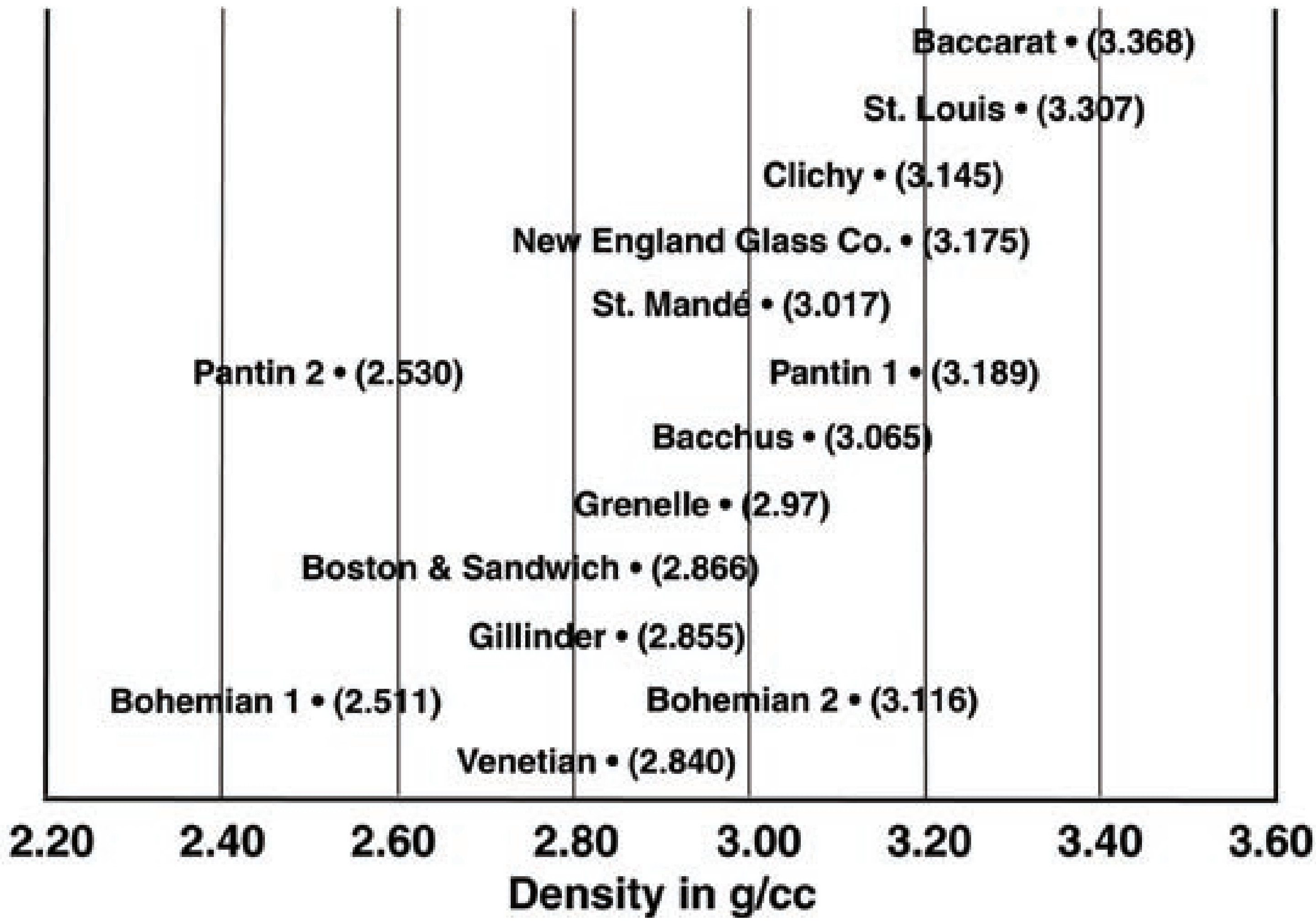
Factory	Sample Size	Average Density	Measured Range	Predicted 99% Range
Baccarat	111	3.368	3.46 - 3.30	3.47 - 3.27
Clichy	104	3.145	3.22 - 3.07	3.25 - 3.04
St. Louis	100	3.307	3.38 - 3.22	3.41 - 3.20
St. Mandé	45	3.017	3.15 - 2.94	3.18 - 2.86
NEGC	158	3.175	3.42 - 2.98	3.44 - 2.91
B&S	63	2.866	3.21 - 2.44	N/A (5)
Pantin (1)	25	3.189	3.24 - 3.12	N/A (6)
Pantin (2)	20	2.530	2.61 - 2.43	N/A (6)
Grenelle	12	2.970	3.10 - 2.82	N/A (6)
Bohemian (3)	9	2.511	2.69 - 2.44	N/A (6)
Bohemian (4)	5	3.116	3.27 - 2.97	N/A (6)
Bacchus	11	3.065	3.20 - 2.96	N/A (6)
Gillinder	4	2.855	2.88 - 2.84	N/A (6)
Venetian	4	2.840	2.91 - 2.81	N/A (6)

Notes:

(1) & (2) Pantin group I weights have a high glass density, those in Pantin group II have a low density.
(3) This group of data represents typical Bohemian weights from the Riesengebirge area.
(4) This group of weights has been tentatively identified as Bohemian.
(5) Data is too scattered for meaningful statistical analysis.
(6) N/A indicates a sample size that is too small for statistical analysis.

Density testing is a valuable tool but is not the ultimate answer to paperweight identification. It is best used in conjunction with other methods to propose or verify the place of manufacture. Unfortunately, in most cases the measured density will fall within the overlapping ranges of several factories and thus provides the collector with a choice of attributions. However, this is not all bad because in this situation at very least one will know what factory or factories *didn't* manufacture the paperweight in question, and that will put you one step closer to finding out which one did.

Average Paperweight Density by Factory



Paperweight Density Range by Factory