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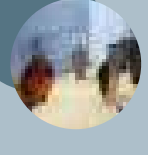
Glass Museum
Murano

WHAT IS GLASS?



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WHAT IS GLASS?

Glass is obtained from the gradual solidification of a viscous paste which is made by fusing together various crystalline minerals at veryhigh temperature.

Depending upon the ingredients and the temperature of fusion, the glass made can be transparent, translucent or opaque, coloured or colourless.

At room temperature, glass is a fragile but also very hard material that is non-porous and refracts light.
The viscosity of the paste itself changes according to temperature: when white hot, it is actually liquid; when red hot, it is more like a malleable putty.

It is when in this latter state that the glass can be moulded and modelled.

Murano glass today

1

THE RAW MATERIALS

— Sand: *silica*;
— Soda: *sodium carbonate*
— Marble: *calcium carbonate*
— Chile saltpetre: *sodium nitrate*

THE FUSION PROCESS

The raw materials are mixed together in a heat-resistant crucible and then fused in a kiln that can reach up to 1,400 °C. This produces the viscous glass paste.

WORKING PROCESSES

The temperature of the fused paste is reduced from 1,400°C to 1,100°C. At this temperature the paste is 'solid' enough to be taken from the kiln and worked before the glass sets (at around 500°C). If it is to be worked by hand, as at Murano, then this process of solidification must take place slowly (the speed at which glass sets depends upon the percentages of the raw materials in the initial mix). At the end of the working process, the glass is still at a temperature of 500-600°C. It must then be cooled slowly: glass is a poor conductor of heat and therefore the inner and outer surfaces can cool at different rates, creating tensions within the material that might lead it to crack (perhaps some time after it has cooled completely). This slow cooling process takes place in what are known as 'annealing ovens'.

Kiln

THE KILN

The kilns used nowadays on Murano have a large crucible of maximum capacity between 20-25 quintals. There are also kilns – known in Italian as *fornaci* rather than *forni* - which are made up of a number of smaller crucibles (of a capacity varying from 10 kilos to 2 quintals), the smaller crucibles being used for coloured and opalescent glass.
Modern-day kilns on Murano are equipped with heat retainers and with equipment that makes it possible to control temperature and the rate of fuel combustion.

Annealing oven

FURTHER INFORMATION

ON RAW MATERIALS

The basic raw materials of glass are described as either 'constituents' or 'modifiers'; the latter category itself is divided into 'fluxes', 'stabilisers' and 'refiners'.
The main *constituent* or vitrifying agent is silica, which accounts for some 70% of the weight of the finished glass. For Murano glass, this silica must be particularly pure, containing less than 0.01% iron (it is this metal which gives glass its yellowish-blue colour). However, the silica must not be 100% pure because the resultant glass would fuse at too high a temperature and would not be workable by hand. Soda (sodium carbonate) is an important 'flux; it lowers the temperature at which the mix fuses and lengthens the time necessary for it to cool, thus making it easier to work the glass by hand. Too much soda, however, would mean that over time the glass would become opaque, as sodium carbonate reacts with the humidity and carbon dioxide in the air. Calcium carbonate is a 'stabilizing' agent. It makes the glass more resistant, lowers the temperature of fusion and stabilises the appearance of the glass (preventing it from becoming opaque). However, it does have the disadvantage of shortening the time necessary for cooling, thus making it more difficult to work the glass by hand. Amongst the various 'refining' agents, sodium nitrate facilitates the escape of air bubbles from the fused paste. It used to be employed along with arsenic dioxide, but given this compound is poisonous its use has been prohibited.

Other ingredients might be added to achieve particular qualities in the glass.

— To produce brighter or more luminous glass, one adds:
- Potash (potassium hydroxide)
- Barium carbonate
- Minium (lead oxide)

— To obtain coloured or opalescent glass, small quantities of various substances are added:
- For YELLOWS: cadmium sulphate, sulphur-carbon, uranium oxide or cerium oxide.
- For REDS: gold, selenium, copper oxide or cadmium sulphate
- For BLUES: cobalt oxide or copper oxide
- For ATHEIST: manganese oxide
- For GREEN: chromium oxide or copper oxide
- For MILKY-WHITE OPALESCENCE: fluorite compounds
- For SO-CALLED 'ANISE' OPALESCENCE: arsenic dioxide or lead oxide
- For SO-CALLED 'SILK' OPALESCENCE: sodium sulphate

ON FUSING PROCESS

The fusing process comprises four stages:

1. **The raw materials are loaded into the crucible.** This process itself is divided into two or three stages: the first loading takes place when the kiln is at a temperature of 1,250 °C, the last when it has reached 1,350° C.
2. **Fusion** proper, which is judged to have taken place when all the silica has melted.
3. **Purification** – that is, the removal of all the bubbles of gas released during fusion. This can take up to several hours. Throughout this phase, the kiln is at 1,400°C.
4. **The fused glass is left to sit in the kiln**, the temperature being lowered to around 1,100°C. The remaining gas bubbles are reabsorbed and the glass paste takes on the viscous consistency it must have before it can be worked by hand. Now the complex process of modeling and forming the glass can begin.

Murano glass up to the end of the nineteenth century

2

2.1. RAW MATERIALS

— Sand (*silica*), extracted either from quarries or *cogoli* (river-bed pebbles)
— Soda (*sodium carbonate*), obtained from plant ash
— Lead or *lead monoxide* (litharge) "Grepola" (*potassium tartrate*)
— *Manganese*
— *Arsenic*

2.2. THE FUSION PROCESS

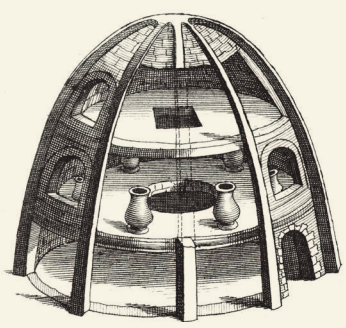
The technology then available meant that kilns could not achieve temperatures higher than 1,200 °C. Thus the fusion process was rather different to nowadays, with an initial stage in which the raw materials combined into a solid mass (known as the *fritta*). This was then combined with manganese to obtain fusion proper.

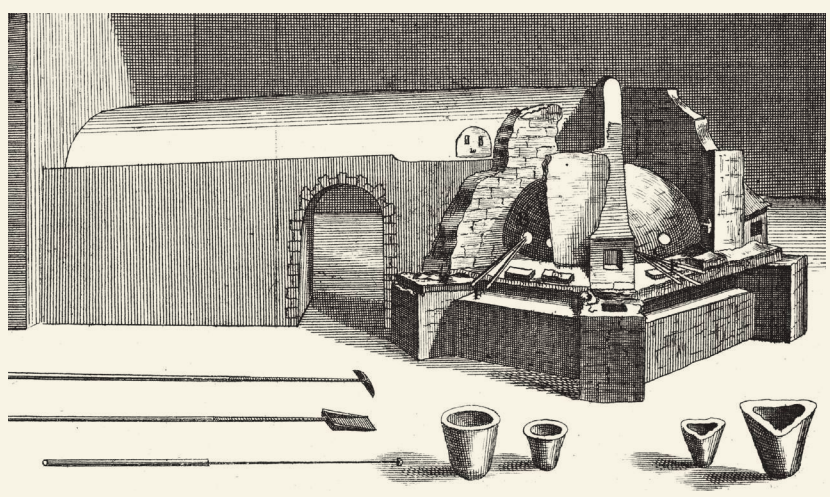
2.3. TYPES OF GLASS

There was glass crystal, common glass and lead glass. Made from a mix of silica and sodium oxide, glass crystal and common glass were used in producing a wide range of objects. The purer glass crystal was obtained by purifying the sodium ashes to achieve what was known as 'crystal salt'. Made of a basic mix of silica and lead oxide, lead glass was more malleable and was used for particular product ranges such as enamels and glass-bead rods (canne per conterie).

KILN INNOVATIONS FROM THE FOURTEENTH TO TWENTIETH CENTURY

Up to the sixteenth century, most kilns on Murano will have been of this 'three level' type. At the lower level the wood itself was burnt; at the second level were placed the crucibles with the glass mix; on the third level, the finished objects were left to cool slowly. We do not have any illustrations of such kilns on Murano, but they probably had six openings, so that they produced enough glass for 24 hours of work. In the seventeenth century, the shelf where the glass was left to anneal was extended, ultimately becoming a space outside the kiln proper. Through a hood in iron or another heat resistant material, the air from the kiln was now fed into the separate space of the 'annealing oven', thus improving the quality of the finished product. The kilns would then remain practically unchanged until, towards the middle of the nineteenth century, Murano glass-makers began to use grills to improve the efficiency of fuel combustion. Substantial changes would be made in the twentieth century: the kiln and annealing oven were entirely separated from each other; oil and then methane were used as fuels; there was widespread adoption of crucible kilns equipped with temperature control and heat recovery equipment.





FURTHER INFORMATION

ON RAW MATERIALS

The main vitrifying agent used by ancient glass-makers was again silica, which was obtained from quarries. From the mid-fourteenth to the end of the seventeenth century, however, the sole source of this material was *cogoli* (riverbed pebbles); these were heated in a kiln, thrown into water so they would crack and then ground down into fine powder within a machine known on Murano as a *pestrin*. In the eighteenth century the island's glassmakers began to use sand from quarries in Dalmatia and Istria. The flux was soda (sodium carbonate); of varying degrees of purity, this was obtained from incinerated plant material. Depending upon the type of plant, the ash was potassium- or sodium-based. Murano glass has always been a sodium based glass. Thus the ash used was that of plants of the Chenopodiaceous family (glasswort, salsola). Most of the ash came from the East – in particular, from Syria or from Alexandria; material from the former source was more highly-prized, being known as 'Syrian alum'. There were also sources of supply in Spain (ash of plants of the barilla species) and Sicily (so-called 'Catania ash'). The ash was milled and then sieved. If put through lixiviation – which involved it being boiled, decanted, filtered and undergoing a final evaporation process – the ash produced so-called 'crystal salt' or 'glass salt'. This highly-purified flux was, from the midfifteenth century inwards, used in making glass crystal, the most highly-prized of all Murano glass. In the nineteenth century, glass factories began to use industrially produced soda (Leblanc, Solvay).

Other Raw Materials:

— The lead used in lead glass was in fact a lead oxide (litharge).This was obtained by heating metallic lead, hence it was also referred to as *piombo brusado* [burnt lead].
— *Grepola* was potassium tartrate. It was used in small quantities to make the glass more resistant; it might also be calcined before use.
— *Manganese* was used to clarify the glass; its use on Murano is recorded as early as 1290. The most highly-prized manganese came from Piedmont.
— Arsenic recorded in the production of glass crystal and *lattimo* [milky white glass] from the seventeenth century onwards.
— *Colouring Agents*
  - For YELLOW: silver
  - For GREENISH-YELLOW: crocco [iron oxide]
  - For AMBER-YELLOW: sulphur
  - For BLUE-GREEN and RED: ramina rossa and ramina nera (two types of copper oxide)
  - For VIOLET: manganese
  - For BLUE-AQUAMARINE: zaffera (a product containing cobalt)
  - For PINK: silver and gold
  - For RUBY RED: gold
— *Opalescent Agents:*
  - *Calcina* (obtained from lead-tin, leadarsenic, lead-antinomy)
  - *Calcined animal bones* (use recorded from sixteenth century onwards).

ON FUSION PROCESS

The process was rather different to nowadays because the kilns could not achieve Temperatures above 1200°C. It involved two phases:

a. The preparation of the *fritta*

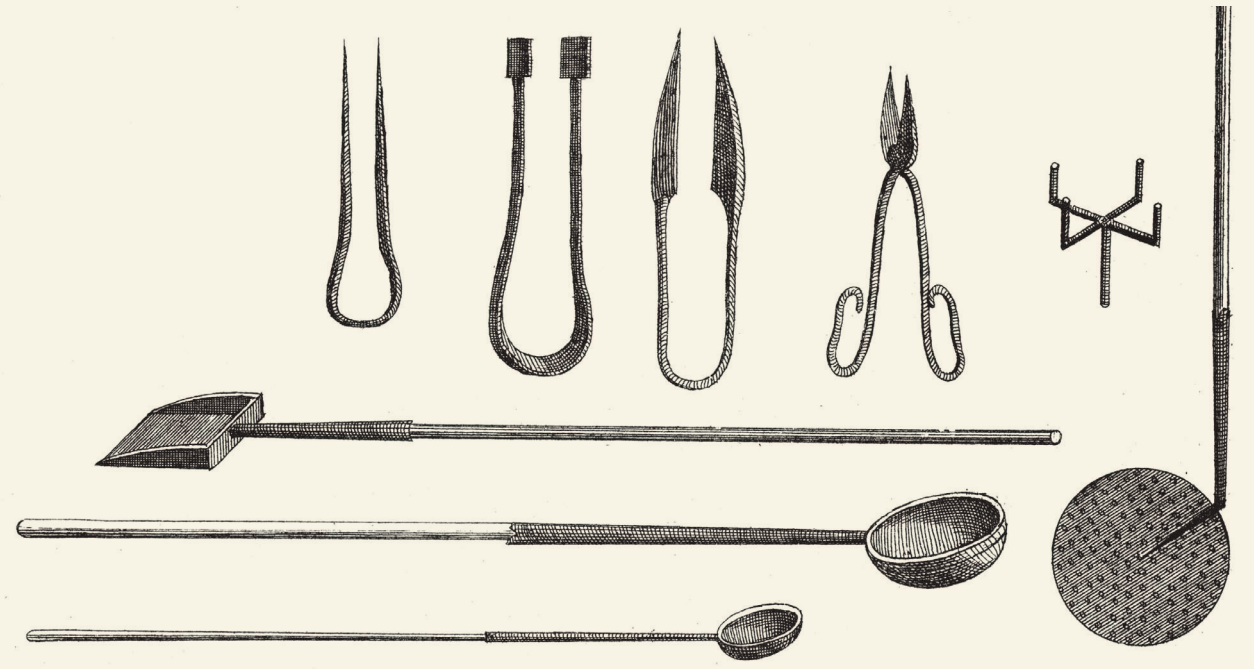
The silica and ash were mixed together then placed on a shelf in a kiln known as the chalcera. This reached a temperature of around 700°c, and after 6-12 hours the ingredients had formed a solid mass known as the *fritta*. The first recorded mention of this term comes in 1347; in a statute of the Guild of Glass-Makers dating from 1271 the solid mass is referred to as the *maxia vitrei*.

b. Fusion proper

Manganese was added to the fritta, which was then placed in crucibles within the kiln, where fusion took place. During this process, the glass was removed from the crucible one or more times and poured into water. This stage – known as the *traghettar in acqua* [passage through water] – purified the mix and made it more homogeneous. The resultant glass, which obviously had to be melted again, was known as the cotizzo.

The vocabulary of Murano glass-making

3



BARDELLA
A short, wooden rod strapped to the glass-maker's thigh; there Might also be one strapped to each thigh. This was used to support the weight of the iron rod during the working of the glass. Subsequently, such support was provided by the arms of the craftsman's workstool or *scragno* (see)

BALOTON
A mould lined with small, square-based pyramidal points; it was used to produce a lozenge-like decorative pattern on the surface of the glass.

BOLO
The mass of molten glass at the end of the blow rod, which would be blown and worked to produce the finished object.

BORSELLA
Pincers of various sizes and shapes used in modelling, squeezing, cutting and decorating the bolo.

BRONZIN
A slab of iron (once of marble of bronze) on which the glass-maker rolled the bolo to give it a round or cylindrical form.Because of the material once used to make the slab, the process was also referred to as *marmorizar* [to marble](see)

CANNA DA SOFFIO
A hollow iron tube which has a slightly conical opening at one end. This 'blow rod' is used to remove from the crucible a bolo which is blown, freeformed by hand or shaped using a mould.

CAZZA DA INFORNARE
(from a document of 1347):
A shovel used to tip the *fritta* (see) and *cotizzo* (see) back into the crucible

CAZZA DA MISSIAR
An implement with a long handle ending in a spoon; this was used to move the fused glass from one crucible to another.

CAZZA DA TRAGHETTAR
(from a document of 1348)**:**
A spoon-bladed shovel used to left the fused glass from the crucible and pour it into water-filled tubs.

COTIZZO
Fused glass removed from the crucible and poured into water to purify it before melting it again.

CROGIOLO
A crucible in heat-resistant material in which the raw materials are fused within the kiln. It was also called *padella*. Old documents refer to the heat-resistant material of which it was made as either *tera* [earth] or *creda* [clay].

FRITTA
Partially vitrified aggregate obtained by rehating ashes and sand mixture at about 700°C, used in the old fusion process

INGHIER
(from a document of 1770):
An iron hook used to open and shut the iron door to the kiln.

LEVADA
The 'lifting' of a bolo of molten glass from the crucible using a blow rod.

L'ERA
The annealing area. This is the origin of the English term 'leer' or 'lehr' for such annealing ovens.

MANARETTA O MANERETTA
A comb-like implement used to obtain decorative effects, for example in *vetro a piume* or *vetro fenicio* [feather glass or Phoenician glass (see)].

MARMORIZAR
Rolling the *bolo* (see) on the *bronzin* (see) to give it a round or cylindrical form

PADELLA
see *Crogiolo*.

PALETTA DE METALLO
A long-handled implement used to move a small object that has yet to be finished.

PEA OR POSTA
see *Bolo*.

PETTINE
see *Manaretta*.

PONTELLO
A solid iron rod which is used to support the glass bolo when one is working on the part that initially was attached to the end of the blow rod.

SCANNO OR SCAGNO
(from a document of 1313)**:**
A three-legged stool on which the master craftsmen sits. It is a characteristic feature of glass kilns throughout the Mediterranean area. In Northern Europe, the master glass-maker stood to work the glass

SERAURO
The mouth of the kiln, through which the glass is removed.

SPEO
A small iron rod used to collect small blobs of molten glass that will be used to form decoration.

SPINADOR DE FORNAZA OR SPINANAUR DA MESSEDAR VERI
(from documents of 1439 and 1512)**:** An iron rod used to mix the glass in the crucible. It was also used to mix in colorants with already-fused glass. The procedure nowadays is referred to as *dar a spignauro*.

SPIGNAURO
see *Spinador*

STIZADOR
An assistant at the kiln and annealing oven. He gradually moves objects around, from the hotter areas of the kiln to the cooler areas near the opening.

SUPIETO
A short, hollow iron rod which ends in a cone-shaped opening; the glass-maker uses this to blow on the surface of the glass to make sure its thickness is uniform.

TAGIANTI
Shears of various forms used to cut away excess material when working the hot glass.

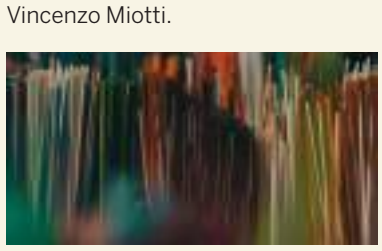
MAKING BLOWN GLASS

The process begins with the *levada*, when the master glass-maker removes from the crucible the lump of molten glass (*bolo* o *pea*) that he will work.
This is then rolled on an iron slab (*bronzin*) before the craftsman sits at his stool (*scagno*), supporting the blow rod on the stool arms (*bardelle*). Continually rotating the glass back and forth, the craftsman then begins to pull the bolo into shape using special shears (*tagianti*). Then, while an assistant (*servente*) begins to blow the glass, the master craftsman models it using one of a variety of tongs (*pinza*). He measures size using a pair of compasses, then supports the glass using the *pontello* while he works on the part which before had been attached to the blow rod. Using the *supieto*, he blows onto the surface of object to make its thickness uniform. Then, using the *borselle* again, he makes any final changes before the object is put back in the annealing oven.

Types of glass and decorative procedures: a glossary

4

AVVENTURINA, VENTURINA, STELLARIA
Cinnamon-yellow vitreous past, distinguished by the presence within it of gleaming specks, obtained when minute crystals of copper precipitate during the cooling of the fused mixture. The name comes from the fact that the success of the process is to a certain extent adventitious. Lost at the end of the seventeenth century, the secret of this process was apparently rediscovered by Vincenzo Miotti.



***CANNA DI VETRO* GLASS RODS**
These rods – either monochrome or made of up layers of different coloured glass – are sliced into sections that are then used to make mosaic glass (see). They might also be used in the production of filigree (see) and of glass beads (see). The hollow rods are now the ones most commonly used in making *conteria* beads [seed beads] (see). Up to the last quarter of the fifteenth century, however, all beads were made using solid rods – as is still the case with so called *"a lume"* beads (see).

CANNA MILLEFIORI
MILLEFIORI RODS
These 'thousand flower' rods are made up of concentric layers of different shapes and colours combined together when cold. The resultant bundle is heated to soften it; the interior layers take star-shaped forms thanks to the use of particular moulds and the hot and malleable rod is drawn lengthways to make it longer and thinner. When cold, it is then sliced crossways, producing a number of flat discs whose pattern reflects the same combination. These are the murrine, used to be incorporated into Mosaic glass objects or to produce *rosetta beads* [Chevron beads] (see)

CONTERIE
see Venetian Beads

INCALMO
A technique in which objects are formed from distinct parts added together while the glass is still hot. Developed in the twentieth century.

INCISIONE ALL'ACIDO
ACID ENGRAVING
Surface decoration obtained using hydrofluoric acid to eat into the glass to different depths.

INCISIONE ALLA RUOTA
WHEEL ENGRAVING
Surface decoration obtained by using copper disks coated with an abrasive material. In use since the seventeenth century.

MEZZA STAMPAURA
Developed by the Romans, this technique was 'rediscovered' in Murano in the fifteenth century. It consists of adding a lump of hot glass to the base of an object still attached to the blow rod. Before further blowing, the object is placed in an open ribbed mould, creating a pattern of raised ribbing on the finished piece.

MORISE
A form of decoration typical of Murano. It is obtained by adding a thin thread of hot glass to the object and then nipping it using special *borselle da pissegar* [nipping tongs].

MOSAIC
Known since the days of Classical Antiquity, this type of decoration is created by combining small tesserae together according to a pre-ordained design. These tesserae were either small pieces of glass paste or of glass placed over a base of coloured plaster.

GOLD MOSAIC
The process for the creation of such mosaics is described in Venetian *ricettari* [glassmaking manuals] that date back to the fifteenth century. Onto a thin sheet of glass, gold leaf was attached using egg white as a glue. Then, when already in the kiln, further molten glass was poured on top of the gold. The glass was then pressed within a iron plate that was divided into a number of small squares, each one of which became a gold tessera.

MURRINA, MURRINA IN PIANO
MURRINE, FLAT MURRINE
see Mosaic glass

MURRINE IN CANNA
see Millefiori rods

PERLE
Depending on which technique is used for their production, Venetian beads can be either *conteria [seed beads]*, *rosetta [Chevron beads]* or *a lume [lamp-worked beads]*..

***CONTERIE* SEED BEADS**
Documented in Murano as early as the fourteenth century, seed beads are monochrome, tiny and produced 'industrially' by cutting a hollow glass rod into sections in which length equals diameter. The spherical form is achieved by heating these pieces and placing them – together with sea sand, coal dust and lime – in a container that is then rotated. Once removed from the mix, the round beads are polished using wheat bran. They can be also used for embroidery and different kinds of compositions.

PERLE ROSETTA
CHEVRON BEADS
Invented in the fifteenth century, chevron beads are made from hollow rods made of several multi-coloured layers like the murrine (see).

PERLE "A LUME"
LAMP-WORKED BEADS
Lamp-worked beads go back to the seventeenth century. They are made by heating a rod of solid glass over a naked flame (*lume*). The molten glass drips onto a metal wire (sometimes coated with clay), that is held in one hand and continually rotated. Depending upon the thickness of the glass deposited or the implements used to model it, one can obtain beads of various shapes. The beads themselves can then be decorated by dripping molten glass onto them from very fine glass rods (of 1-2mm in diameter).

PITTURA A FREDDO
COLD ENAMELLING
The procedure is the same as the above, except that the end-result is not fired. This means that the objects might often lose their colour over time. The technique has been in use since the sixteenth century.

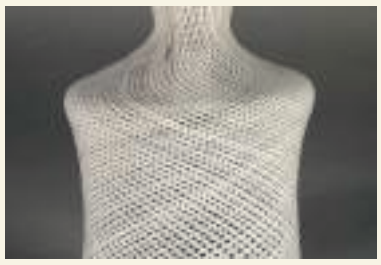
PITTURA A SMALTO
ENAMELLED GLASS
This decoration involved the use of a brush to adorn the surface with a mixture made up from powdered glass, coloured pigments, metal oxides and fats. The decorated was then set by firing the object at 900-1000 °C The technique has been in use since the fifteenth century.

VETRO A PIUME O VETRO FENICIO
FEATHER GLASS OR PHOENICIAN GLASS
This type of decoration was obtained by winding threads of glass or lattimo around the object; these were worked with using a special comb or maneretta to create an undulant pattern. In use since the sixteenth century. Such glass would, in the nineteenth century, also become referred to as vetro fenicio.

***VETRO BATTUTO* MILLED GLASS**
The surface of this vetro battuto [literally, 'beaten glass'] is abraded using a grinding wheel that creates aligned patterns of small irregular 'bubbles'. The process results in a glass surface that looks rather like hammered iron.

VETRO CALCEDONIO
CHALCEDONY GLASS
This opaque glass was made by mixing in salts of silver or other colorant oxides with the fused paste. The aim was to imitate such semi precious stones as agate, chalcedony, onyx, malachite and lapis lazuli. The first certain reference to vetro calcedonio in Murano documents dates back to 1460.

VETRO CRISTALLO
GLASS CRYSTAL
Transparent, colourless glass of great brilliance, obtained from the use of purified raw materials and clarified by the addition of manganese dioxide. From the Middle Ages onwards, this was the most highly-prized type of Murano glass; however, it is different in composition to both English and Bohemian glass crystal.



***VETRO FILIGRANO* FILIGREE**
A refined technique of glass decoration developed in Murano in the first half of the sixteenth century, this filigree work within the glass was obtained by using rods containing fine threads of *lattimo* (see below) or coloured glass. If the threads in the rods are in twists or spirals, the filigree work is known as *filigrana a retortoli*; if the rods themselves overlapped with each other, they form *filigrana a reticello* or *filigrana doppia*.

***VETRO LATTIMO* MILK GLASS**
This opaque white glass takes its name from the word for milk [latte]. Up to the fifteenth century, it was used for mosaics and enamels. Given its similarity to porcelain, it was then used to make blown-glass objects in imitation of the first Chinese porcelain to reach Venice. The opaque effect was usually achieved using a calcined mixture of lead and tin or tin oxide.

***VETRO GHIACCIO*ICE GLASS**
The name reflects the fact that the craquelure on the surface of this glass makes it look like ice [ghiaccio]. The effect is obtained by immersing the half-finished object in cold water whilst still hot, and then putting it back in the kiln. In use since the sixteenth century.

***VETRO MOSAICO* MOSAIC GLASS**
This method of decoration, inspired by Roman glass, made its appearance in Murano work in the fifteenth century. it is created by combining different glass fragments (tesserae and/or sliced sections of glass rods) when cold. Once the desired pattern has been obtained, it is heated in the kiln, so that the glass components soften and bond together with a multi-coloured mosaic effect. The nineteenth-century glass makers used murrine obtained from "millefiori" rods (see). Mosaic glass are worked "in flat" or blown.

VETRO PRIMAVERA
A type of ornamental glass developed by Ercole Barovier for Barovier & Toso. It consists of translucent glass whose entire surface is marked by craquelure; the handles and the edges of lip and base are all in black glass.

VETRO PULEGOSO
This opaque glass was first created by Napoleone Martinuzzi for the VeniniGlass factory. The myriad number of tiny air bubbles (*puleghe*) within the glass give it a pitted surface.

VETRO SCAVO
This rough-surfaced glass has an opaque finish which is largely grey but may have striations of various colours. Its name – literally 'excavation glass' – comes from the fact that it was inspired by Roman glass artefacts.

VETRO SOMMERSO
SUBMERGED GLASS
This glass was obtained by plunging the glass during the working process into crucibles with different colours of glass. The resultant object is made up of transparent, differently-coloured layers, perhaps of great thickness. In use since the twentieth century.