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A Blast Furnace Painting by Jan Brueghel the Elder (1568-1625): a New Interpretation

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Abstract

A small painting by Jan Brueghel the Elder, portraying a blast furnace, is to be found at Galleria Doria - Pamphilj in Rome. The authors discuss this painting while considering the contemporary Flemish paintings of ironworks. From the peculiarity of this painting, from the scene it portrayed and from news about Jan Brueghel´s stay in Italy, the authors conclude that this painting may represent a Bergamasque blast furnace built in Latium.

Introduction

A small (23 x 35 cm) oil on copper painting portraying a blast furnace by Jan Brueghel the Elder (1568-1625) is to be found at the Doria - Pamphilj Arts Collection in Rome (Figure 1). Unfortunately, nothing is known about when and how it was included into this collection. We only know that it was in the Pamphilj's palace in Piazza Navona in 1666 and that it belonged to Cardinal Camillo Francesco Maria Pamphilj (1622-1666). Concerning

Figure 1. Jan Bruegel's painting of a blast furnace (*Paesaggio con fonderia*, Fc 449, Trust Doria Pamphilj. Roma, Galleria Doria Pamphilj©2020 Amministrazione Doria Pamphilj s.r.l.).

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the history of the Doria-Pamphilj Collection and of this painting, the reader may be referred to Bedoni (1983, pp.67-74).

The first art historian who studied and published this painting was Ertz, who confirmed its attribution to Jan Brueghel the Elder (Ertz, 1979; Ertz and Nitze-Ertz, 2008-2010). These authors met some difficulties with classifying this oil painting in Jan Brueghel's production. It cannot be called a landscape painting, and its dating is uncertain. On the one hand, its copper panel shows the same measures as Brueghel's *Paradise*, which was painted while the artist was living in Rome (1592-1595). On the other hand, the style of the horses and of the two gentlemen dates it to around 1602. These authors observe that this subject is unique in Brueghel's production (Ertz and Nitze-Ertz, 2008-2010, p.1247-1248).

In 1988 a black and white photograph of this oil painting was published without any comments by Belhoste, André and Bertrand (1988, p.13, Fig.3).

Some of the technological aspects of Brueghel's painting have been briefly discussed by Arribet-Deroin in her paper about forges and blast furnaces depicted in landscape paintings of the 16th century (Arribet-Deroin, 2012, p.37-40, 42).

For this reason, we shall try to answer to the following questions in this paper:

- Why is this painting so unusual among Jan Brueghel's art production?
- Why is its sole subject a blast furnace?
- Which kind of furnace is portrayed?
- Why is it completely different from the other Flemish paintings of ironworks?
- Why is its setting not the rugged Meuse valley, but a low, hilly landscape?
- What could be the location?
- Why the Bergamasque documents help with understand the scene of the painting?
- Why was the scene of the painting considered to be so important to be painted by Brueghel, and what is its meaning?
- Why is this painting in Rome?

The painter and his painting

In the foreground of this small-scale painting there is an imposing building, which is a blast furnace during a smelting process. It is a tower-like, quadrangular structure.

Three quarters of the furnace are depicted, its masonry is typical of the period, there are two vertical cracks, running vertically down its façade, and one of them is quite large (Figure 2). They suggest the stress and the degree of dilatation the building had to undergo during the smelting. We can achieve a fair estimate of the height of the building by using the master standing near the two gentlemen and the brown horse. Unfortunately, the horse keeps its neck down and is not in the correct position to be measured according to the rules. Anyway, it can be estimated to be about 170 cm tall, which is the median height at the withers of a horse. The master cannot have had a frail body and he looks taller than the withers of the

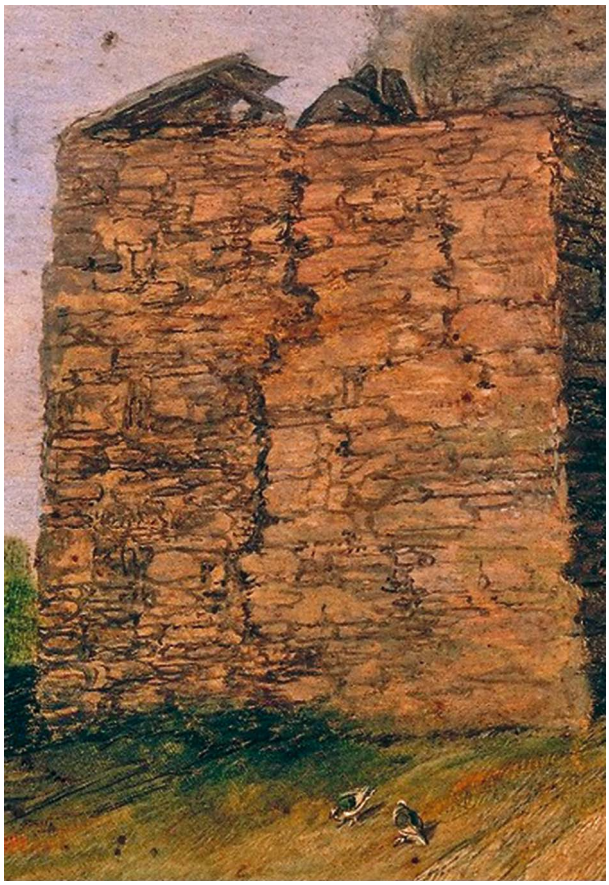

Figure 2. Detail of the blast furnace.

Figure 3. The workers resting and eating.

Figure 4. The man at the blast furnace, to his left a small forge and the bellows.

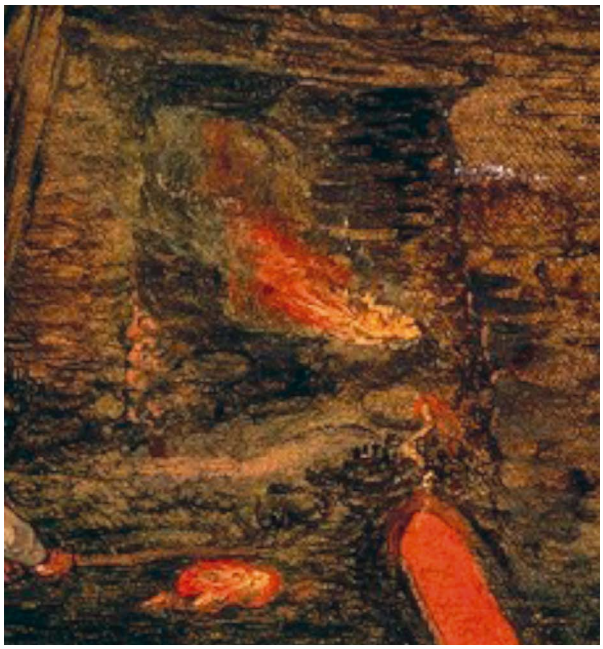

Figure 5. Detail of the cast iron flowing out of the furnace.

horse, so we believe that he must have been about 180 cm tall. In proportion to these two measures, the height of the furnace can be estimated to be just above 6 m.

To the left three workers are resting, two are sitting and having some food and drink near a mound of ore (?)[1], while a white and black dog is eagerly waiting for a bit of food, a third worker is standing and seems to be looking at the furnace (Figure 3). Nearby, parts of some crude iron bars can be seen on the ground. They can be compared to those at plates VIII, IX and X of the Encyclopédie (Proust, 1983, pp. 434-435). To the right two other workers are filling baskets with ore, while another basket is ready on a low, wooden table nearby. They too can be compared to those of the Encyclopédie at plate VII (Proust, 1983, p.434). This ore is reddish, possibly suggesting roasted hematite. Between the two groups there is a wheelbarrow with a shovel on the top and a forked piece of wood below it. At the bottom right-hand corner of the painting there are other elongated bars of crude iron placed on some squared wooden beams. One man is holding an iron rod near the furnace opening. Unfortunately, this detail is not very clear. He seems to be doing something with what could be a lump of slag that he has pulled away from the rill of molten cast iron pouring out of the furnace (Figure 4), while to his right molten cast iron is being poured into a mould (Figure 5). According to Arribet-Deroin (Arribet-Deroin, 2012, p.42), this worker is pulling the slag out of the "ante-crucible" (*tirant à lui le laitier qui coule de l'avant-creuset*).

Cast iron could be cast in different kinds of ingots, not only in the usual bar-shaped ones, but also in large rectangular (137 x 59 cm) and a few centimetres thick ingots (an example is to be seen at Gromo Museum, Bergamo), in smallish elliptical (34 x 23 cm) and thick ingots (Museo delle Miniere at Schilpario, Bergamo).

A blast furnace had in general two tapping holes: one for slag tapping and the other for pouring cast iron. Here we can see just one opening. Perhaps the fire and the smoke hide the other, or it is in the dark corner to the left. Since the molten slag was lighter that the liquid cast iron, it floated freely on it and was tapped at intervals by the master who opened a small hole in the front of the furnace. After tapping the slag, when there was enough molten cast iron in the furnace, the master opened the other hole to drain the metal. These two holes were prepared in the walls when the furnace was built and plugged with a mixture of fire-resistant clay before the

Figure 6. The master and the two gentlemen.

smelting. In this way, the master could open them easily, using an iron rod during the smelting (Brocchi, 1808, p.69; Audibert, 1842, p.626).

Nearby there is the master himself, who holds his hat in his left hand and in a humble attitude is having a talk with two bearded gentlemen who have just dismounted from their horses. The master is shaved and rather pale in complexion (Figure 6).

To the left of the furnace opening some tools (iron rods, a broom and a shovel) are propped up against its wall. Other iron rods used by the masters are cooling in a water pool in front of the furnace. Close by, in a dark corner under the lean-to roof, there are the bellows and what seems to be a small forge. This roof is part of a larger lean-to roof, running all along the front of the building. It is covered with straw and some pigeons have landed upon it. A wattle fence, made of willow (?) branches and straw, isolates the small forge from the water wheel which is fed from above by a wooden channel (Figure 7) (Reynolds, 1983, p.12). Possibly this forge was used for repairing the tools used by the smelters. It is certainly not the big forge used for cast iron decarburizing. On the other side of the furnace there are some iron rods near a wattle structure which connects the building to the tree trunk supporting the corner of the roof.

In the background and to the right there is a worker carrying a basket of ore toward the stairs leading to the furnace top where there is another worker grey with charcoal and ore dust. In addition, another worker carrying a basket full of charcoal is approaching the furnace from another direction, while on the right edge of the painting there is a man doing something while bending over near a wheelbarrow (?) and a building with a straw roof, possibly the workers hut.

To the back of the furnace we can see the parapet of the stairs leading to its top. There is also some wooden scaffolding. It must be part of the temporary protection used in order to avoid rain and dampness getting into the furnace when it was not in use. Part of this cover can be seen on the edge of the furnace chimney behind the man on its top. A pigeon is perched on the scaffolding, while six others are approaching.

To the left of the furnace the background is quite different. A small stream separates the iron works from the green and quiet landscape, a sort of hilly parkland. There is a small bridge, formed by a wooden plank over the stream. Two people (a woman and a child?) are approaching it or are just standing near it without crossing it. At the edge of the painting, beyond an open valley a hill rises abruptly, showing a rocky face and some isolated rock formations (or a quarry?). In the sky, a couple of magpies are flying (Figure 7). Finally, there is the wood

Figure 7. The landscape to the left of the furnace.

itself. It is not possible to determine the plant species there, all we can say is that it is formed by broadleaved deciduous trees and bushes. This brings us to the time of the year. According to the 16th and 17th century documents about the hiring of the iron masters, furnaces were used in the colder months of the year, from autumn until late spring only. Some documents state that the furnace campaign will end on St. Peter's Day (June the 29th). Out of more than one hundred documents about the hiring of iron masters there is not a single document referring to smelting campaigns in the summer months. This is not a wood in autumn, winter, or early spring, since it is fully green. Both the people standing by the stream and the two gentlemen are not wearing winter clothes or cloaks. Accordingly, it must have been late spring-early summer.

Why did Brueghel deem this scene worth of being painted? Brueghel painted this scene at the very end of the smelting campaign. This explains both the deep cracks in the furnace, worn out after months of smelting, and the two visitors. The inside of the furnaces was relined at the beginning of each campaign. On this occasion, the cracks in the external walls were closed, but here they are gaping in order to show a long campaign. The two visitors are indeed the furnace owners or their agents, and they have come to gather information from the master about the smelting campaign results. The master is waiting for the final payment of his generous wages and perhaps hoping for an efficiency bonus, which fully explains his attitude.

There are eleven workers in this painting. From the Bergamasque hiring documents (Cucini and Tizzoni, 2022, pp.50-60) we know that the basic working crew of a blast furnace consisted of five people. Alongside

the five there were the charcoal burners and an undefined number of unspecialized assistants, which may well bring the group to eleven people. Seven workers are dressed in the same way: a grey felt hat with a wide brim, a whitish overcoat, and trousers of various colours, leg protections and shoes. Quite a different attire from that of the two gentlemen. We know that often the ironwork owners provided their workers with clothing; this may explain why they are all dressed in the same way. Not much can be said about the man at the top of the furnace, because he is soiled with ore and charcoal dust, just like the other worker carrying the basket of charcoal. One single worker stands out from the group because both his hat and his coat are quite different. He is in front of the furnace helping with the filling baskets with ore. There could be many different simple and casual reasons for this, e.g. the owners of the ironworks had run out of a certain type of clothing. Nevertheless, we would like to suggest also another reason. Some documents (ibid.) state that some workers could be moved from one furnace to another, according to need. Since, as we wrote, we are in the final days of the smelting campaign, this worker could have been called in from another furnace to give a much-needed hand at the end of the work.

Symbolism, philosophy and nature

Ironworks are a rather common subject of Flemish painting of the 16th and 17th centuries. Making a complete list of them is beyond the purpose of this paper, so we shall list just a few:

Henri Blès (or Herri met de Bles) (c. 1450-1550), Lucas van Valckenborch (c. 1530-1597), Marten van Valckenborch (c. 1535-1622), Marten Ryckaert (or Maerten Rijckaert) (c. 1587-1631). The main difference between all these paintings and the one we are discussing is that they are all "landscapes with ironworks". Often they are set in the rugged landscape of the Meuse Valley (Stiennon, 1954). Sometimes they are portrayed instead as details of a large painting of a different subject, such as a village "kermesse", a robbery, or "The Tower of Babel".

Contrary to the above pictures, Jan Brueghel's small painting is descriptive and has a "miniaturistic approach" (Faber Kolb, 2005, pp.8, 39, 41). It faithfully portrays the real events as well as the iron furnace and its surroundings.

Prosperetti (2009, pp.68-74) in her masterly study of Jan Brueghel also discusses the symbolic meaning of mining and metallurgic scenes in Flemish paintings. For a more complete discussion of this subject, the reader may be referred to her text.

She observes that mining and metallurgical scenes are not different in their meaning from The Tower of Babel. Their aim is the accurate description of human activities: with the result of a represented continuous maximum effort with minimum or even without output. In the 16th century the mining technology had improved, even if gunpowder was not yet used in mines. Agricola's *De Re Metallica* was first published in 1556. Mining activities were then used in order to illustrate the change of ethical thought: human knowledge was nothing if compared to divine wisdom.

The allegoric encyclopaedic paintings of this period not only represent the complexity of *scientia* and *sapientia* but also the path from human knowledge to larger, enlightening wisdom.

Typical examples of this are the two paintings Allegory of Fire / Venus at the Forge of Vulcan, at the Pinacoteca Ambrosiana in Milan, and the other (painted by Jan Brueghel and Hendrick van Balen) at the Doria Pamphilj Collection in Rome. The forges in these paintings are very accurate and represent a reliable source for the metallurgy of the period. Surprisingly, there are no blast furnaces depicted in either of the paintings.

Prosperetti (2009, pp.73-74) discusses some observations of the painting we studied. She thinks that it is an Allegory of Fire set into a mining landscape, but there are no mines in this painting, just mounds of ore. The only iron making operation here is the smelting of cast iron, and there is nothing else in common with the other paintings of ironworks.

"*The alignment of two wheels, that of a wheelbarrow and a water wheel, divides the picture into triangular segments, the left one of which leads sight out of the site of production along a spatial alley into a forest clearing. The traditional allegory has been transformed into an existential picture that invites a meditation on how to live one's life through the lens of a carefully observed reportage on a forge deep in the forest along the Meuse.*" (Prosperetti, 2009, p.74).

If this was Brueghel's aim, it can explain why the water wheel position is not correct (see below), but locating this site along the Meuse, although there is no river in sight, looks rather doubtful.

By contrast, we can observe that it is the very water from this peaceful valley that makes the wheel turning and allows the ore to be reduced.

Evrard (1955) has discussed the technological inconsistencies in Flemish paintings of ironworks. A common feature of these paintings is that they tend to portray the complete iron making sequence, from the mine to the forge. Therefore, the mines are close, sometimes too close, to the furnaces and to the forges. According to

Evrard (1955, p.58), most of the furnaces portrayed by the van Valckenborch brothers were painted based on the same original drawing.

There are some inconsistencies in Jan Breughel's oil painting too, but far less than those of the other painters. Bearing in mind that this painting was made from memory and possibly by help of a sketch made on the site, they are not too many after all. First of the inconsistencies is the possible single opening of the furnace, as we have quoted above. In addition, the iron tie-rods of the furnace are missing. The position of the water wheel is at an angle by which its camshaft could not operate the bellows. The bellows themselves look too close to the furnace, and they seem to blow their air into the side of the furnace. Nevertheless, we must remember that Brueghel was not an engineer but a painter, so he may have not appreciated some technical details of the ironworks.

In the metallurgical literature of the 19th century various names are used for this type of furnaces: *Hauts-fourneax construits à la bergamasque* (Gueymard, 1831, p.153), *hauts-fournaux de Lombardie* (Audibert, 1842, p.623-625), *forno bergamasco* (Zoppetti, 1873, p.168), *forni reali* (Curioni, 1860, p.71) etc. We used the name "Bergamasque blast furnace" in order to designate a kind of blast furnace developed in the valleys of the provinces of Bergamo and Brescia and then spread to other parts of Italy and Europe by migrating iron masters.

From the descriptions of Bergamasque blast furnaces we know that there were three holes in the front of the furnace. On one side of the façade there was the hole for slag tapping, on the other side the hole for cast iron tapping and in the middle the one for the blast of air (Brocchi, 1808, p.69; Audibert, 1842, p.626). Even if this position of the tuyere may seem uncomfortable for the workers, it had its own logic. According to Audibert (1842, p.636-637), the Bergamasque furnaces did not reach very high temperatures because of their internal structure. The air blast in these furnaces did not strike directly the charcoal but spread in all directions. Therefore, the temperature inside the furnace was less intense, but more uniform and fit to produce lamellar cast iron from the local ores. To what Audibert and Brocchi wrote we may add that because of the position of the tuyere the blast of air, having crossed the whole furnace, hit the back wall. Then it went up the chimney heating the implemented charge. Its heat and its CO content would have started the reduction of the ore. On the other hand, if the bellows were blowing into the furnace side, part of the blast could escape through the unplugged tapping holes in its front. We must bear in mind that until the height of blast furnaces was not raised above 8 m, thus becoming "real" blast furnaces, the ascending draft through the chimney was not strong enough to pull out proficiently all the fumes. Was Breughel correct with this detail, or was it just another slip of memory? It is difficult to answer to this question. Moreover, the rocker arms of the bellows seem to be missing too.

The pool where the iron rods are left to cool is too close to the furnace, and this could lead to infiltrations of water and dampness. Even if pigeons are rather fearless birds, their landing on the thatched roof, crossed by the hot gases rising from the furnace mouth, may be a touch of poetry by Brueghel. The shadow provided by the lean-to roof was necessary for the master in order to estimate the stage of the smelting by its colour.

Jan Brueghel and his patrons

The period of Brueghel's lifetime was characterized by violent strife between Catholics and Protestants. One of the few subjects on which the two groups agreed was that the study of nature brings man closer to God. Cardinal Paleotti, who was a friend of Cardinal Federico Borromeo, was a supporter of the great Bolognese naturalist Ulisse Aldovrandi (1522-1605), the creator of the word "*Geologia*" (for this subject and the religious and philosophic ideology shared by Jan and Federico see: Jones, 1997, pp.65-75; Faber Kolb, 2005, pp.34, 50, 56, 75).

As it was common for the artists of his time, Brueghel went to Italy. Bedoni (1983, pp.19-48, 89-103) carefully discussed his Italian stay in her still essential book about Brueghel. In 1590 he was in Naples and from 1592 to 1594 in Rome. Here he met other Flemish artists; among them there was Paul Bril who introduced the young Brueghel to the upper echelons of the clergy (Woollett, 2006, p.6). Two cardinals became his patrons, Ascanio Colonna (1560-1608) and above all the Milanese Federico Borromeo (1564-1631), a discerning and able art collector. Between the artist and the young cardinal, just four years older than Brueghel, there developed a real friendship, sparked by their shared interest in art, natural history, spirituality and philosophy. After a while he was invited to live at the Cardinal's palace in Rome, and in August 1595, when Borromeo became Archbishop of Milan, he took him with to Lombardy. Some months later Brueghel decided to go back to Antwerp, and in June 1596 Federico Borromeo wrote a letter of introduction to the Archbishop of that city: "*Joannes Brugelus, qui hasce tibi litteras reddidit est mihi cum ob pingendi peritiam, tum ob animi morumque candorem carissimus. Fuit aliquot menses e numero meorum domesticorum.*" (Crivelli, 1868, p.7) (Jan Brueghel, the bearer of this letter of mine, is most dear to me because of his painting competence,

Figure 8. Detail from Mercator's Latium map. "Ferriera" - upper third righ.

his honest soul and morality. He was for some months among the intimate members of my household).

During his Roman period Brueghel travelled through the Papal States, as testified by his drawings of Tivoli (Bedoni, 1983, pp.30-38; Woollett, 2006, p.7). In order to go to Tivoli, he travelled along the valley of the river Aniene (then called Teverone) and visited the imposing remains of Hadrian's Villa, the temple of Vesta and its waterfalls, which were a must for artists of the time. Later he used his Roman drawings to paint details of his oils, for example the Vesta temple can be seen in the Allegory of Fire / Venus at the forge of Vulcan at Pinacoteca Ambrosiana, Milan (inv. 68).

On the 1589 map of Latium by Gerardus Mercator we can read the word "*Ferriera*" (ironworks) immediately to the South of Hadrian's Villa (Figure 8).

The same site is on Seutter's map, dating about one century later. In Brueghel's times the area south of Tivoli belonged to the Patrimonio di San Pietro. The Patrimonio was the real estate and land belonging to the Roman Church. Because of its location close to Rome, this furnace can be identified as "*Il forno di Roma*" or "*Il forno nuovo di Roma*" as referenced in the Bergamasque documents (Cucini and Tizzoni, 2022, p.50).

The archival documents, as far as they have been published, show that in the Papal States there was no strong iron working tradition. Possibly this was because there was only one mine of good iron ore in Umbria at Monteleone di Spoleto that was exploited only since the 17th century (Barbieri, 1940, p.81). There is iron ore in Latium in the Tolfa hills only, but it was not deemed fit for reduction (Mariani and Mazzantini, 2001, p.71), possibly because of its high content of arsenic and sulfur. Around the mid-16th century, the Brescian entrepreneur Clemente Bucelleni and the Milanese merchant Gerolamo Varesio created a company for ironworks in the Papal States. The ore had to be shipped there from the island of Elba (Mariani and Mazzantini, 2001). Of course, Bucelleni and Varesio used the only iron making technique they knew and called the Lombard masters (Mariani and Mazzantini, 2001, p. 69). In 1577-1578, in order to increase the iron production, the Pope rented the blast furnace at Follonica (Grosseto), which was a point of contention between the Duke of Tuscany and the Prince of Piombino. These iron works were also built and run by masters from Bergamo and Brescia (Cardarelli, 1926, pp.1-16). We will remember that the ore in Brueghel´s painting looks like roasted hematite.

The Lombard iron masters and their crews could provide an integrated approach to iron production: from the mine to the forge. They could mine the ore, build blast furnaces and forges and run the entire iron plants. Because of the services they provided they were sought after by many states (Cucini and Tizzoni, 2022).

Brueghel's letters to Federico Borromeo provide much information about his life and relationship with his patrons. From Antwerp the painter used to send Borromeo small presents and exotic objects (Crivelli, 1868, pp.7, 96, 131, 148) as well as paintings (which were purchased by the Cardinal). Sometimes we know the subjects of these paintings, but at times they are simply called "small pictures" (*quadretti*) (Crivelli, 1868, pp.99, 107). In three letters he alludes to an "unhappy event" that happened to him during his Roman period and from which he was rescued by Cardinal Borromeo himself. Two of them were sent to Borromeo on June the 17th 1606 (Crivelli, 1868, pp.70-71) and on September the 26th 1608 (Crivelli, 1868, p.123): "*In tempo del mio disgratcio, venive in casa mia a consolarme et servire: quanda tute il mondo me abandonave*" (At the time of my unhappy event, when everybody else had abandoned me, you came to my home, comforting and helping me). A third one was sent to the Milanese art collector Ercole Bianchi on September the 26th 1608 (Bedoni, 1983, p.39).

Brueghel was born in Brussels; he became an orphan when still a child. Because of this he moved to Antwerp with his brother and sister. There he lived with his grandmother, who was herself a painter. In 1585 Antwerp had become "*a Catholic bastion of the Habsburg Southern Netherlands*" (Woollett, 2006, p.5). Jan was Catholic and he practised his art in line with the Catholic canon, so he had no religious problems during his stay in Rome.

The Flemish community in Rome was known for its rather excessive banquets where wine was flowing a bit too freely. According to Bedoni (1983, pp.39-41), he may have been involved in one of the frequent pub brawls. If so, he would have been taken into custody in the jail of San Nicola in Carcere and not in the more severe jail of Santo Uffizio. In the years 1591-1593 Federico Borromeo was the Cardinal of San Nicola in Carcere, so it was no real problem for him to release the young painter.

This idea of Brueghel having been involved in a pub brawl does not fit with his personality as described by Borromeo himself in his letter (see above).

Bosca (1632-1699) in his history of Biblioteca Ambrosiana (Bosca, 1672, p.123) wrote about the Allegory of Fire: "*Haec tabula aut commendat, aut accusat artificem; tanto enim studio elaboratam fuisse tulit fama, quod cum tunica molesta foret puniendus Brueghel, iam que tortor parasset fasciculos, ereptus flammis a Federico, flammas apprime reddiderit.*" (This painting praises or indicts its author. He painted the fire with such perfection because rumour has it that Brueghel had the opportunity to study it closely. Once he was already wearing the pitched tunic and the executioner was preparing the faggots, when Federico grabbed him from the flames).

Now, being burned alive was not of the common punishment for a pub brawl, even if it was a bloody one. Usually this sort of punishment was for crimes deemed more "serious", according to the legal and moral standards of the period. Moreover, Bosca states that this was a rumour (*tulit fama*). He did not know it from any direct source, so it could have been the dramatization of a far less serious event.

To this hypothesis about a brawl, as suggested by Bedoni, we would like to add another, new, one.

This "event" oddly reminds us of what happened on September the 14th, 1786 to poor Johann Wolfgang von Goethe while drawing the scenic castle of Malcesine on

Lake Garda. A wandering foreigner drawing sensitive sites in a politically tense period could be taken for a spy, and this was a serious crime indeed. Moreover, what sensitive subject could Brueghel have dawn near Tivoli if not a blast furnace?

Finally, we may remember that Cardinal Ascanio Colonna, the other patron of Jan Brueghel, was the son of Marcantonio, commander of the Papal fleet at Lepanto and the man who reorganised iron production in the Papal States. The blast furnace of Nettuno (Rome) in the fiefdom of the Colonna family was built by Bergamasque masters in 1586 (Cucini and Tizzoni, 2022, p.48-49). In addition, Federico Borromeo came from a family of mine and ironwork owners in their fiefdom in Val d'Ossola (Piedmont) (Frigerio and Pisoni, 1983). From a letter by Jan Brueghel to Borromeo we know that still in 1610 and possibly even later Jan was in contact with Paul Bril (died in Rome in 1626) and with his Roman patron. Towards them he was behaving in the same way he was behaving towards Borromeo, i.e. he sent them paintings and various presents (Crivelli, 1868, p.162). It may well be that amongst the small pictures sent to Rome there was the one with the blast furnace near Tivoli.

Some notes about furnaces in Flemish paintings

In the 1508 map of the forest of Belloy in Normandy there is the drawing of a tower-like building with a water wheel and flames rising from it. Unfortunately, it is a very poor drawing and we cannot gather any useful information from it (Belhoste, André and Bertrand, 1991, p.36).

In 1540 Biringuccio (1540, p.17 r) wrote that he was impressed by the blast furnaces he had seen in his youth. He does not state their height, but he says that their extended bellows were tall "*dalle sei alle otto braccia*" (from six to eight arms, i.e. about 3.5–4.7 m according to Tuscan measures) (Zupko, 1981, pp.46-47). This means that these furnaces must have been much higher.

The description of iron reduction was not Agricola's special field. What he wrote about this subject is mainly a summary of Biringuccio's text, as Hoover and Hoover pointed out (Agricola, 1556, p.425, note 55). His iron smelting furnace is a "*high bloomery furnace* (*Stückofen*)" (Agricola, 1556, pp.420-426), and it is by far smaller and shorter than Brueghel's furnace.

The height of the Barden furnace in the Weald in 1646 was 6.1 m (Cleere and Crossley, 1985, p.244).

According to the 1678 metallurgical handbook by della Fratta et Montalbano (1678, pp.84-85), a blast furnace was 20 feet tall. In della Fratta's time scholars used the ancient Roman units of measurement. 1 Roman foot is 29.64 cm; 20 feet is very close to the height of "just above 6 m" we estimated for the furnace in Brueghel's painting. Della Fratta dedicated his book to Ranuccio II Farnese (1630-1694), Duke of Parma and Piacenza. We know that the Farnese family had called Bergamasque masters for the iron works in their state at least since 1547 (Scognamiglio, 1981, pp.224-226), and they were still employing them in 1679 (Cucini and Tizzoni, 2022, p.51).

The heading of one of the pages in the Register for the year 1747 of the ironworks of Locarno Val Sesia (Piedmont), belonging to the Milanese d'Adda family is: "*Regola Bresana per far un forno novo*" (Brescian rule to build a new furnace) (Archivio di Stato di Vercelli, Sez. Varallo Sesia, Archivio d'Adda Salvaterra). This document gives us the measures of the furnace and its main stones. In order to be very accurate, the master (?) who wrote this "rule" uses Brescian ounces as unity of measurement (one Brescian ounce = 0.0397 m) (Zupko, 1981, p.175). The height of the furnace is 144 ounces (5.71 m).

At the beginning of the 19th century the height of the Bergamasque furnaces was always 6.17 m, and it was quadrangular in plan, according to the Brescian metallurgist Brocchi (1808, Tab. at pp.74-75; Frumento, 1971, p.216). The geologist/metallurgist Curioni, who published the first geological map of Lombardy and Canton Ticino in 1872, informs us that these furnaces did not exist anymore in his times, but that they were "*alti non più di sei metri*" (not taller than 6 m) (Curioni, 1860, p.71). According to Audibert (1842, p.625), however, they were 7.20 m tall, but he had seen just one of these furnaces and we are already in a period when some iron work owners were raising the height of their furnaces in order to improve them (Curioni, 1860, pp.71-72).

In all the other Flemish paintings the furnaces are never in the foreground, and sometimes they are not realistic, e.g. the furnace by Marten Rykaert with a forge on its back wall. Because of this it is not so easy to establish both the technological aspects and the precise measures of these buildings. Anyway, when comparing their height to the human figures in the more detailed paintings, these furnaces also appear to be about 6 m high. Arribet-Deroin (2012, p.38) wrote that they are "*de l'ordre de 5 m*". In her paper she correctly observes that all the Flemish paintings do not necessarily show ironworks, but some of them portray non-ferrous metals production (Arribet-Deroin, 2012, p.31). Therefore, we must assume that there was no difference in height between iron and non-ferrous furnaces. This contradicts what Biringuccio and della Fratta (see above) wrote about the height of the blast furnaces.

Blast furnaces of a height of more than 8 m were already in use in many European countries since the beginning of the 18th century, e.g. the blast furnace described by Chambers in 1728 was "*near thirty foot in height*" (about 9 m) (Chambers, 1728, p.406).

The height of the Gloucester furnace in 1734 was 8.6 m (Cleere and Crossley, 1985, p.244).

The Lombard Iron Basin, i.e. the area between Lake Como and Lake Garda, where the iron masters came from, had become an increasingly backward area since the first half of the 17th century. This area was divided into two main parts: the western part, which belonged to the State of Milan (then under the Spanish Habsburg Crown) and the eastern part, with the main iron mines, belonging to the Republic of Venice. The Milanese part was troubled by continuous passages of Spanish troops going from Genoa to the war in the Low Countries and by the assaults of French armies. Moreover, in 1620 a deep manufacturing crisis began in the state (Tizzoni, 2015, pp.100-110). The situation in the Venetian part was better, but the government in Venice was far away and not really interested in these parts of the country. The advice for the improvement of iron production in the district of Brescia, written by the Venetian "*Capitano*" Giovanni da Lezze in his huge report of 1609-1615, did not have any effect in Venice (da Lezze, 1969-1973). The plague of the years 1629-1633 was very severe in the Alps and increased the speed of the crisis. Instead of trying to update their working methods, the local miners and smelters reacted by becoming increasingly conservative. At the beginning of the 19th century the Bergamasque furnace was still in use in Lombardy and in those parts of the Piedmontese and French Alps where the masters had built their ironworks, since these areas had become progressively backward and isolated (the main industrial development was in the towns of the plain). Many 19th century metallurgists who had an almost ethnographic interest in the studying of the different ways of iron making (e.g. J. Percy) noticed this ancient iron production method. The French mineralogist/metallurgist Gueymard (1831, pp.153-155) observed with dismay that the Bergamasque furnace was still in use in the area of Vizille, in Isère, forgetting that part of France had been part of Piedmont.

Only shortly before the mid-19th century the Lombard iron masters accepted to abandon the Bergamasque furnace. Because of this we have only descriptions of the Bergamasque blast furnace, but not of the Walloon or of the Comptoise ones. The only ancient description of a possible Walloon furnace is in the poem "*Ferraria*" by Nicolas Bourbon (c. 1503- c. 1550) (Bourbon, 1533). We can gather very few technological information from it. The furnace was square in plan, outside it was made of common stone, of fire-resistant siliceous stone inside, and it had bellows. The Walloon furnace had already been abandoned since a long time ago when the 19th century metallurgists began their studies, and so they did not write about it. Since we have no descriptions of a Walloon furnace, but only some pictures, why should we assume that all the furnaces in Flemish paintings are Walloon? Sometimes Flemish painters added also "exotic" details in their paintings, e.g. the Vesta temple in Jan Brueghel's oils.

While there are archive documents of the 17th and 18th centuries and 19th century metallurgy texts describing the Bergamasque furnace, we must exclusively rely on Flemish iconography when it comes to the Walloon furnace, with the *caveat* written above. Thus, when comparing the blast furnaces in Flemish paintings with the descriptions of Bergamasque furnaces, we may ask ourselves if the only real difference between the Walloon and the Bergamasque methods was in the decarburization process and not in the shape and size of the ore reduction furnaces.

Conclusions

This picture by Brueghel is unique not only among his production but among the whole painting of his time. It is neither an allegory nor a landscape, nor a genre painting. Its only purpose was to show a blast furnace. Why did Brueghel consider this scene worthy of one of his paintings? Why did he think that this scene was worth remembering for somebody from the Roman clergy?

This blast furnace must have had some meaning both for the painter and for the recipient/buyer of the painting. This explains why it differs so much from the other Flemish paintings of ironworks, which tend to be standardized. They show a large, rocky river valley with various scenes (shepherds, animals, boats, wayfarers etc.), and often the entire sequence of ironworking from the mine to the forge. Instead, this painting shows in detail a particular moment at the very end of a successful smelting campaign, as shown by the season of the year.

We know from 19th century metallurgy handbooks and from earlier archival documents that smelting campaigns were often marred, or even abruptly stopped, or delayed by accidents, such as problems with the water wheels and the bellows; large lumps of partially molten ore could plug the furnace, fires, quarrels and the like. So, the successful conclusion of a smelting season was not at all guaranteed. This is the painting of a particular event at the furnace, an event worth painting and re-

Figure 9. The remains of the blast furnace of Fiumenero (Bergamo). Photo: M. Tizzoni.

membering. Which other event could it be but the happy conclusion of a smelting campaign?

The setting of this blast furnace is a hilly landscape with a small stream of water, so we believe that the Meuse valley can be ruled out. In his life Jan Brueghel travelled to Italy, passing through Cologne, where his sister lived, but we do not know the itinerary he followed (Woollett, 2006, p.37, note 27). Sometimes he went to Brussels, and in 1604 he was in Prague at the court of Emperor Rudolph II (van Suchtelen and Woollett, 2006, p.69), but once again we do not have any news or drawings that inform us about his travel itineraries. Instead, we know he could have seen the blast furnace near Tivoli. The landscape in the painting does not help us with understanding in which part of temperate Europe we are: it could be Siegerland as well as Latium, or any other place.

This painting has been in Rome at least since 1666; its original owner understood its meaning and most probably belonged to the upper echelons of the Roman clergy. Therefore, he may have appreciated an image of the rising iron production in the Papal States. Since he knew the dealings with the Bergamasque masters, he could understand the scene in the painting and its implication (a successful conclusion of the smelting season as also shown by the crude iron bars near the furnace). Certainly, a painting of a blast furnace outside the Papal States had very little meaning or appeal for a cardinal.

Brueghel portrayed a specific and important event at the end of a successful smelting campaign. It was a happy day, both for the masters and the owners, at the very end of a period of hard and rewarding work. Only the extremities of the crude iron bars are shown on the site, in order to suggest and underline at the same time their large dimensions and number. This painting gives us the atmosphere of that particular day at a working blast furnace, and its technological inconsistencies are irrelevant details.

If we are right, this is the only existing painting of a Bergamasque blast furnace built in Latium at the end of the 16th century.

One final note: the top of the furnace in this painting looks oddly similar to that of the dilapidated blast furnace of Fiumenero in Val Seriana (Bergamo) (Figure 9).

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Notes

1 Actually, this stuff looks like dirt. Being unsure about its nature, we added a question mark.

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