Luigi Ferdinando Marsigli and the *Mappa Metallographica*: Graphic Creativity and Scientific Measurement

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The *Mappa Metallographica* (45.5 x 70.5 cm) is part of *La Hongrie et le Danube*, a collection of twenty-seven cartographic tables drafted over a period of fifteen years to illustrate the orography, hydrography and metallurgy of the Hungarian stretch of the Danube [1]. The map drawn by the soldier, scientist and naturalist from Bologna, Luigi Ferdinando Marsigli (1658-1730), [2] is one of the drawings he published in 1726 to illustrate his much more extensive printed work [Ceregato 2015, p. 59]: the *Danubius Pannonico-Mysicus* [Marsigli 1726] [3]. This six-volume book [4] provides a detailed description of the Danube territory, including all major orographic, landscape, naturalistic and faunistic features, as well as its mineralography and metallurgy; it presents them in a comprehensive textual treatise, but above all, in an exceptionally high-quality and very modern illustration [5] undoubtedly invented by Marsigli in close collaboration with his assistant and cartographer Johann Christoph Müller (1673-1721) [6].

Marsigli was passionately interested in many subjects, in particular cartography, which he practiced at length and for which he also developed innovative acquisition and graphic restitution systems, probably assisted by Müller's extensive expertise.

The territorial measurement systems that had boomed in the seventeenth century continued to be developed in the eighteenth century. This was due to increased interest in geography, prompted by issues of military and political control and simultaneous improvements in surveying instruments and methods [Edney 1993, p. 63; Török 2012, p. 420]. In the early decades of the eighteenth century improvements in large-scale mor-

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phological and dimensional control as well as renewed requirements regarding the reproduction of the orographic and hydrographical characteristics of the territory appeared to converge in an effort to produce new images. Although the projective basis used to create these representations does not always appear to be scientifically sound, certain graphic models seem to have been produced prior to a trend which, during that century, was to lead not only to greater mastery of surveying operations and the attempt to unify measurement units and systems, but was also to have a strong influence over the definition of descriptive geometry and the science of representation.
Marsigli studied in Bologna and matured in the wake of the naturalistic approach adopted by Ulisse Aldrovandi and Marcello Malpighi; he believed drawings should not simply accompany a scientific text, but be part of it [Olmi 2000]. The reciprocal support between the text and illustration benefited both the draftsman and reader: the former because this combination was an additional communication tool, the latter because he understood the message thanks to the unitary nature of such a complete and comprehensive description.
One particular feature of the Bolognese approach inspired Marsigli with the idea that representation should be flexible, versatile and adapted to the requirements of communication. Ever since his first military expeditions to the Bosporus where he put into practice his naturalistic ideas he quickly realized that, apart from working intensely on a tactical approach so that cartography be considered as its first graphic interpretation, the section was an important and irreplaceable means to achieve a unitary survey in which the outer part of the organism could be understood only thanks to the functions made possible by its internal structure and arrangement. He also realized that this could only be illustrated by making several appropriate cut outs which, he noted, was similar to the method used to represent the human body [Déak 2014, p. 99].
Several successful attempts to extend this section concept to orography and the study of the territory are present in the works of seventeenth-century authors such as Athanasius Kircher (1602-1680) or Agostino Scilla (1629-1700). Kircher appears to cut away parts of mountains to show what happens inside, how rivers start in the heart of the earth or how whirlpools are created at sea due to the presence of rivers and the way they flow through the land. Scilla, born and educated in Sicily, sectioned Mount Etna to show how lava and heat flow from the depths of the earth, its terminal ramifications, and the craters where the magma exits.
Marsigli seems to have visually remembered these and other previous experiences when he had to solve the problem of how to describe a territory with important metallurgic veins and a multifaceted and diffuse arrangement of the vertical underground shafts (wells going deep into the earth) and horizontal underground passages (linking the wells or collection areas) which he visited personally [Déak 2014, pp. 99, 100]. The marvellous internal machine made by man to exploit natural resources to the full (in this case silver and gold veins) was studied by Marsigli as an integral part of the landscape, just like the vegetation and orography. This was the objective behind his rather unique graphic arrangement of the *Mappa Metallographica*.
Faced with the problem of describing what happens on the surface–position of the huts where the materials exits the vertical shafts and is initially processed, protection of the wells, transportation of the materials–and the internal network of production activities–with places for pit stops and collection as well as passages for the distribution, collection and hoisting of the waters and precious materials–Marsigli had to invent a system to explain the correlation between above and below ground so as to clarify the unitary nature of the process between the surface and underground space. Elsewhere he had cut out the sides of mountains, taking away segments to see inside, as Kircher and Scilla had done before him, and not unlike the method used many years earlier by Leonardo da Vinci when he wanted to show the position of a foetus in the womb. However, in the case of the metallurgical area, Marsigli needed a truly innovative drawing combining the effectiveness of a perspective drawing (to show the superficial environment of the Hungarian mountains and woodlands) and the precision of an accurate scalar scientific drawing showing the workings of the perfect underground machine made by man.
So Marsigli came up with a unique representation system for the *Mappa Metallographica* in which a broken horizontal line divides the upper part of the drawing, the outdoors, represented in perspective (occupying a little over a third of the drawing height), from the section in the lower part; the latter takes on the role

of Piero della Francesca's *rabattement* of the reference plane or plane of construction, around what we now call the 'trace' of the plane itself.
In the *Mappa Metallographica* there is no real *rabattement* of the plane of construction, but the vertical plane of the section starts under the 'trace', as in a perspective section. In Piero's drawings the part under the perspective view describes the real form and real measurement of the represented elements: likewise, in the Map there is a drawing under the 'hinge line' which, due to its very nature, conveys the real form, the real measurement, the real depth and real inclination of the wells, tunnels, passages, excavation systems and ascent/descent into the entrails of the earth.
The surface activities and woodlands are represented above the 'trace': Marsigli's intention was to convey the orographic ensemble and settlement; the image is in fact a bird's-eye perspective view, well-suited to this purpose. He uses a section drawing under the trace, in the lower part of the drawing (63,63% of its height) illustrating the underground area. Here communication has to be effective, scientific and measurable, and the orthogonal view is the only projective mode that can solve the problem. The section looks inside the earth, sectioning the characteristic elements, vertical links (wells and steps) and passages that have to be used to move and push the carts full of minerals. What was important was to describe not only the exact length of the passages and their inclination, but also the magnitude of the whole mining area and convey it in a drawing which is 'flat' and definitely two-dimensional. Therefore the section seems 'flattened' on a single plane: by eliminating the earth and solid areas and indicating only the hollow elements that are of interest, the latter are shown as if they were on the same vertical plane despite the fact that the perspective image shows them to be at differing depths compared to the observer. To link corresponding elements, the sectioned wells in the orthogonal projection are connected by vertical straight lines to the external cones above the mouths of the wells shown in the perspective view; these straight lines are almost 'lines of recall' to facilitate the interpretation of a drawing that is only ostensibly simple.
The two projections are also graphically very different. The perspective part is in chiaroscuro and highlighted, with only slightly shadowed areas but with textured surfaces and recognizable materials, including several trees and plants in the fields. The lower sectioned part appears to have be a line drawing without hatching, not even to distinguish the solid parts from the tunnels; it has graphic conventions to indicate the passages, ladders, ascent steps, work tools and equipment, and letters indicating special points in the network of sloping or vertical horizontal passages, the place where they meet, the corners, and how to find one's way in what looks very much like a labyrinth.
In the perspective part, the only concession to a method slightly more similar to a technical drawing is the fact that some of the conical spaces are drawn in such a way that viewers can see inside. Instead the lower part is described in all respects like a technical scale drawing in which distances and gradients appear measurable; these measurements can make the work of the miners quantifiable and therefore organizable.
On the whole the *Mappa Metallographica* is like a landscape drawing, but also a technical diagram. A drawing based on the reflections and curiosity of a soldier who loved nature, and those of a scientist who strongly believed in drawing and its communicative versatility. His work made cartography [7] flexible so that it could convey precise messages: not surprisingly, Marsigli is recognized as the father of thematic cartography [Török 2012]. Although his maps were drafted for practical reasons and military and political purposes, they nevertheless reflect the intellectual curiosity and broad perspective of a naturalist and man of science [Török 2012, pp. 422, 425]; In Marsigli's ideative imagination, the *Mappa Metallographica* was to combine the meaning of drawing and that of the measurement of represented things, passing from appearances to being accurate and dimensioned, from an airy outdoors to a perfect functioning machine that seems to enjoy its own personal 'breath'.

Notes

[1] The maps were drafted between 1726 and 1741. The collection can be consulted on the website of the Bibliothèque nationale de France: <https://gallica.bnf.fr/ark:/12148/btv1b5971966r> (accessed 2020, November 10). The image of the *Mappa Metallographica* is from Bibliothèque nationale de France: https://gallica.bnf.fr/ark:/12148/btv1b53039391j (accessed 2020, November 10).

[2] Luigi Ferdinando Marsigli is often cited as "Marsili". The question of how his name is written is discussed by Deák who believes that "Marsili" was a latter form and decidedly opts for "Marsigli" [Deák 2006, note 8].

[3] The map is shown at the end of *Tomus III. De Mineralibus Danubium effossis, Necnon Aquâ Abrasis, & in eum deductis*: Marsigli 1726.

[4] In the first version it was drafted in six volumes, in the second version in three: the story of the map is reported in Deák 2014. For more information about the history of Marsigli's monograph, see Deák 2004. The map is included in the attached documentation on a CD and published in Deák 2006.

[5] In the six books of the *Danubius Pannonico-Mysicus* the sprawling area of the Danube was studied from a large to small scale. *Tomus I* focuses on geography, hydrography and astronomy. *Tomus II* analyses the bed and banks of the river, but primarily Roman archaeological remains. *Tomus III* studies the territory and underground areas as well as the minerals that can be found there; it studies and documents the position of the mines of gold, silver, copper, ferrous minerals, antimony, cinnabar, mercury, magnetite, garnet, opal and salt [Deák 2014, p. 103]. The minerals are then described in detail, on increasingly smaller scales, with important tables probably etched by Francesco M. Francia who worked from Italy [Deák 2014, p. 97]. *Tomus IV* describes the fishes in the Danube, while *Tomus V* illustrates the birds in the river area, the nest of several species and the description of their eggs. *Tomus VI* is dedicated to all the issues not covered in the previous books [Deák 2014, pp. 94, 95], including the anatomical characteristics of the animals. The dissections of these animals by Marsigli himself are shown in the tables.

[6] The map was probably etched in Italy by Francesco M. Francia (1657-1735): Deák 2014, pp. 95, 96.

[7] The maps drafted by Marsigli and Müller were studied and gathered together in Deák 2006. See also Ceregato 2015, p. 60.

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