The Sphere between Stereotomy and Cartography. From Stony Traits to the Representation of the Cosmos

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Abstract

In the Murcia Cathedral there is an important repertoire of vaulted systems showing very refined structures and decorations which were built with stereotomic technique. The painter and architect Jacopo Torni (1476-1526) and the essayist Alonso de Vandelvira (1544-1626) are some of the personalities who were involved in it. This paper focuses on the drawings published in Vandelvira's treatise and analyses in detail two uncommon case studies in the field of this construction technique: the Capilla de Junteron's vault and the one covering the room of the anti-sacristy. A digital restitution of the case studies will then be offered, with the aim of highlighting the geometric genesis of their stone joint through the intersection between architectural volumes and fundamental geometric entities. The contribution is also intended to investigate the relationship among stereotomy, astrolabes and cartography. We would like hypothesizing how the tools for the observation and calculation of celestial phenomena (astrolabes and planispheres) may have been assumed as inspiring models for the subdivision into blocks of some vaulted surfaces. Celestial and terrestrial maps, assumed as projections on the plane of spatial models, could therefore have indirectly influenced the history of constructions through a logic of subdivision into blocks that would have solved the problem of the development of the sphere on the plane according to cartographic logics, or by approximating meridians and parallels to portions of ruled surfaces.

Keywords: stereotomy, cartography, Murcia Cathedral, vaulted systems, spherical vaults, Alonso de Vandelvira.

The vault in Capilla de Junterón

The Murcia Cathedral (Spain) is the outcome of an unwearying construction activity which started first from the building of Capilla de los Vélez in 1491 and lasted until 1570 [Gutiérrez-Cortines Corral 1987]. Among the main supporters of this project one can find the protonotary apostolic don Gil Rodríguez de Junterón (1480?-1552), a prelate who lived and worked in Rome for a period in the earlier 1500s. After the return to his homeland, Junterón decided to commission the construction of a funeral chapel named after him. Thus far it is considered one of the most impressive structures in the whole building complex in terms of formal complexity and decorative aspects. In general this Murcia religious complex represents the prime model of the Spanish stereotomic school which considers Alonso de Vandelvira (1544-1626) to be as one of the most important essayists. As it happens in the chapels built in the mid-20s of sixteenth century in the same cathedral, this funeral chapel shows a style which recalls Italian Renaissance: in particular it refers to the architectonic production by Filippo Brunelleschi (1377-1446), Bramante (1444-1514) and Michelangelo (1475-1564). This fact has not to surprise since many of these rooms have been created by the painter and architect Jacopo Torni (1476-1526) called Jacopo Fiorentino at the time [1]. In addition to this funeral chapel, Torni was also the author of the belling tower's first order, the sacristy, the anti-sacristy and the vaulted passage connecting the two en-

Fig. 1. Point cloud of Capilla de Junterón's vault obtained with the laser scanner Faro Cam2 (rendering by A. Bortot).

vironments. This text is going to describe some hypotheses on the potential geometric strategies to be used in order to divide the ashlars of Capilla de Junterón's vault and those in the anti-sacristy.
The Capilla de Junterón (fig. 1) is characterized by a rectangular plan surrounded by two semi circumferences on the shorter sides. This building plan is defined as an 'ovalada' or an imperfect oval by Vandelvira. At the time –in terms of composition considering such a mapping configuration– it was generally common to include a barrel vault covering the rectangular area and two quarters of sphere on the two borders of the remaining curvilinear parts. Torni's solution, instead, appears to be quite original: as a matter of fact it deals with an annular vault comparable to a quarter of torus resulting from the 180 degrees rotation of one of the semi-equator around the transversal axis of the impost (fig. 2a) [2]. This environment is lighted by some small windows which are on the vertical surfaces, but also by a cylindric lantern put at the centre of the vault's upper part. As it was already known in the Roman epoch, it was more common to use a semitorus covering the circular colonnade, but in that case the axis of the surface is oriented vertically like in the Mausoleum of Santa Costanza in Rome (340 ca.). In his treatise Vandelvira [de Vandelvira 1585c; Barbé-Coquelin de Lisle 1977] proposes to divide the surface through the use of two series of coaxial cones: the first series is characterized by a common vertex and a horizontal axis which corresponds to the transversal one of the plan; the second series is characterized by an axis which follows the same direction, even if it has varied vertexes [Calvo López 2005, pp. 123-136] [3]. The Spanish essayist agrees that the most useful method to obtain the stereotomic apparatus is the same used in *capilla*

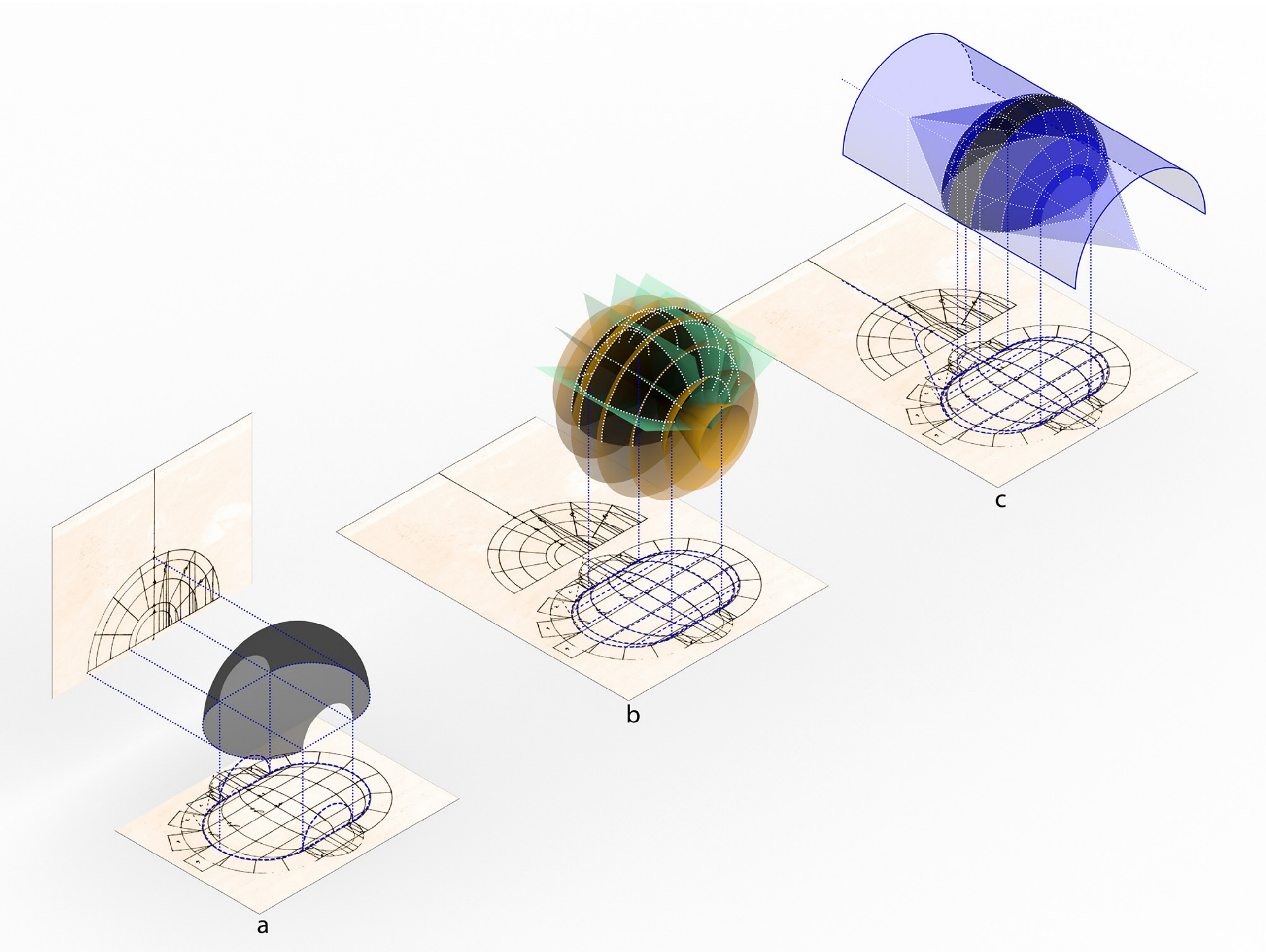


Fig. 2. Geometric reconstruction of the drawing by Alonso de Vandelvira (a), study of the subdivision of stereotomic apparatus into meridians and parallels (b), representation of the approximation of the intrados faces of the ashlars to portions of cones (c) (rendering by A . Bortot).

redonda en vuelta redonda or rather the hemispherical vault. Although both surfaces are considered to be the resulting rotation of the circumference around an axis, the solution –previously explained– causes a certain astonishment which has to be clarified. In the treatises of this period such problem is often repeated and refers specifically to the use of ruled surfaces, in order to make approximate the lower surface of every ashlar. In fact, since they are portions of spheres, are not developable and it's difficult to connect them to the so-called '*panneaux*'. So the examined cones will have a common axis and a variable vertex depending on the inclination of the generatrices that, while approaching the surface's equator, tend to be parallel to the axis of revolution. It emerges the extreme case close to the equator where the cone has an improper vertex, so it reduces the lower surfaces as portions of a cylinder (fig. 2c). In such cases the use of ruled developable surfaces became a common routine, a sort of geometric shortcut which was able to maintain an acceptable margin of approximation as demonstrated by other authors [Rabasa-Díaz 2000, pp. 174,175]. The problem certainly caught the scholars' attention, even if it was necessary to await the first decades of 1700s –in particular Jean-Baptiste de La Rue's work (1697-1743)– in terms of more refined geometrical solutions practically based on a method which could be defined as 'overturning' [Bortot, Calvo López 2020, pp. 21-34]. Anyway, the determination of the intrados surfaces of the stone blocks, approximated thanks to the generatrices of cones tangent to the various parallels that delimited the horizontal beds, was subsequently refined through the use of a tool called '*bevel*': it is a sort of a set square to be oriented towards the center of the dome, to which a further arm was hinged, whose profile was an arc of circumference [Palacios 1987].
The figures of Vandelvira's treatise which are combined with the description of the Junterón's chapel's vault are two. Both show their own surface by means of a couple of orthogonal projections (more in detail: an upper and a frontal view). While the first figure focuses on the projection of the ashlars' grout lines in a sort of mutual coordination, the second one proposes a rib decorative apparatus which can be integrated to the whole structure (fig. 3). The observation of the vault during the survey and the following analysis of the Spanish essayist's projections allowed us to speculate on geometric elements: after they have intersected the portion of an-

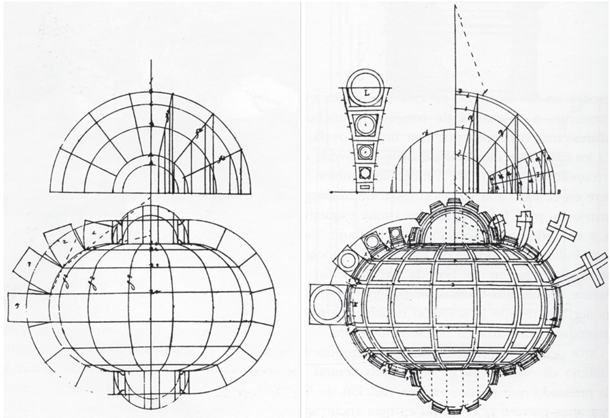


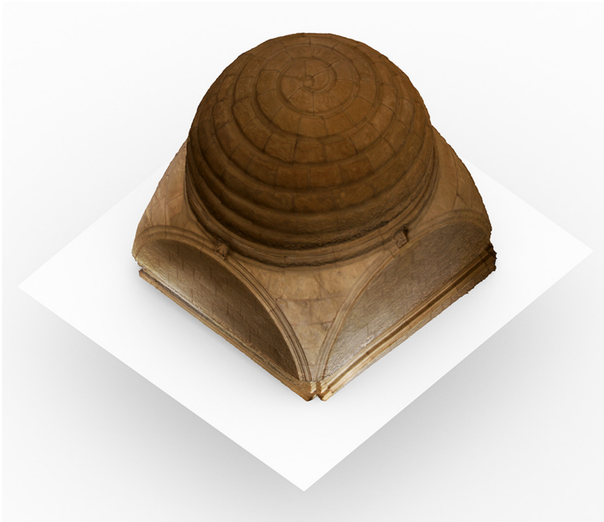
Fig. 3. On the left the drawing of Bóveda de Murcia, on the right the drawing of Bóveda de Murcia por cruceros, both illustrated in the manuscript by Vandelvira.

nular vault, they can allow to define meridians and parallels. While intersecting a series of cones (in this case with a common vertex –corresponding to the centre of the ovoid– and an horizontal axis –coincident with the transversal one of the ovoid) with the portion of toroid, there is a generation of parallels which are comparable to the ones drawn by Vandelvira. Instead, through the intersection of a horizontal sheaf of planes, it is assured the production of hemicircumferences in the space which, after being projected onto the horizontal plane, show the meridians in the form of ellipse arches (fig. 2b). This latter is the closest solution to Vandelvira's drawing and, among other things –as we'll soon explain– it is the one that can be applied to the division of a hemispherical vault into ashlars. So this solution is able to offer a clear interpretation of the Andalusian essayist's statement concerning the supposed stereotomic analogy between spherical and annular vaults. In addition to the originality of the structure, the described vault surprises for its hyper-decorativism: pagan images, often uncanny, seem to wriggle and arise from the single stony blocks. Moreover they seem to allude more to a cathartic passage and to an ascesis towards eternity than a funeral dimension [Vilella 1998, p. 93]. The sculptural high reliefs show an inclination of the stereotomic technique in Spanish area which marks a meaningful difference if compared to the contemporary cases in French context. In fact, these ones often show a structural plainness without extra decorative elements. Finally, the complexity of this apparatus suggests that the plastic forms have been excavated when the vault was completed, and that therefore the individual blocks would have been oversized during the construction towards the intrados surface to be then carved in order to bring out the decorations.

The vault in anti-sacristy space

The vault covering Murcia Cathedral's anti-sacristy (fig. 4), built in the early 1600s, is connected to the treatise by Vandelvira, where it is described as "*capilla redonda en vuela capazo*". The hemispherical vault is placed on four spherical pendentives which are leaning against four arches, respectively following the walls which surround the square room. Probably due to the collapse of the first order of the belling tower during the construction, this structure has been subjected to meaningful changes which are currently visible. Although in 2001 the restoration smoothed the dissimilarities among the ashlars of the vault and among those in the pendentive of the north-eastern part. The survey allowed to observe the extrados surface of the dome through a secondary passage which represented the entrance to the room above the anti-sacristy. On the extrados surface the ashlars appear to be rough-hewn in a more precise way, in order to follow the spherical shape of the extrados like in a three-dimensional offset operation. Moreover one can find a binding agent which reinforces the connection of the joints, probably inserted during the restoration we previously mentioned.

It's a quite rare case of subdivision of a spherical cap into ashlars based on a helicoidal path of the blocks. As already observed by José Calvo López [Calvo López 2005], an illustration of this problem arises in Vandelvira's manuscript (fig. 5a) and in Philibert de L'Orme's text (1514-1570) [de L'Orme 1567], who defines it "*en forme d'une coquille de limaçon*" (fig. 5b). When comparing it with de L'Orme's figure, one can immediately notice a certain discrepancy, especially if Murcia vault is taken into consideration. In fact the height of the series is approximately the same: this fact brings to the thought that when projecting the drawing of the helix on the horizontal plane, a logarithmic spiral (the distance among its spires is bigger and bigger) and not an Archimedean one (the distance of the spiraes is constant) arises. As a matter of fact, if we obtained a counterpro-



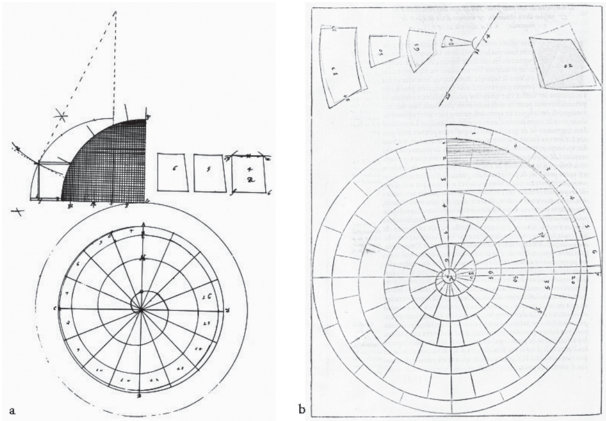
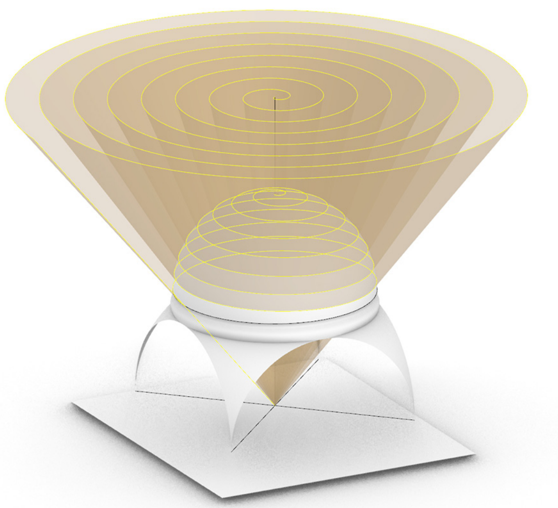


Fig. 4. Axonometric view of the textured model of the antisagresty vault obtained with photogrammetric methodology (rendering by A. Bortot).

Fig. 5. On the left the capilla redonda en vuelta capazo illustrated in the manuscript by Vandelvira, on the right La voute en forme d'une coqulle de limaçon illustrated in Le premier tome de l'Architecture by Philibert de L'Orme.



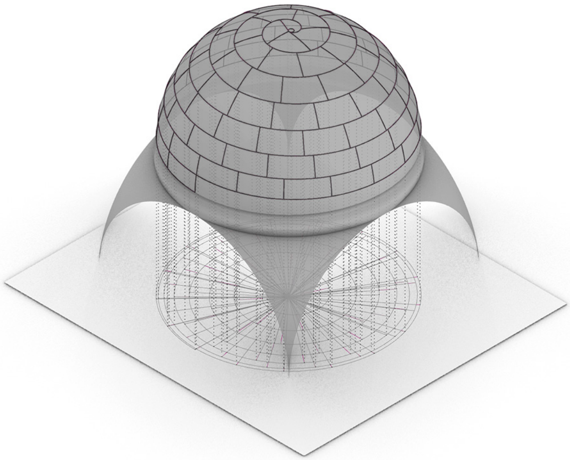


Fig. 6. Digital reconstruction of the spherical helix in order to obtain the bed joints of stone blocks for the antisagresty vault (rendering by A. Bortot).

Fig. 7. Digital reconstruction of the subdivision of vertical joints of the vault surface (rendering by A. Bortot).

jection of de L'Orme's logarithmic spiral from the impost towards the hemispherical surface, we would acquire a spherical helix with a variable height of spires, and so for the series of stone blocks. The graphical incongruity described so far, appears in both manuscripts (Ruiz 1560c) by Hernán Ruiz el Joven (1514-1569) and by Jean Chéreau (Chéreau 1570) –only to mention some of the authors who focused on this issue [4]. The analysis on Vandelvira's drawing carried out by Calvo López, illustrates, instead, how the figure represents the spiral of the planimetric projection starting from the spatial helix to be obtained. The procedure consists first in determining the height of every series of ashlars dividing the vertical section into equal parts, then in dividing the circumference of the plan into the same amount of blocks. From these points some straight lines are drawn towards the center of the vault, so the directions of the meridians –projected on the horizontal plane– are acquired on the spherical surface. Then, while projecting the sectors in section, it will be possible to pinpoint the constant distance among the turns of the spiral (in their first projection) on the straights lines previously identified that is to say, those which define the portions of the meridians. At this point it will be possible to draw the first projection of the spiral and know both the center and the distance among the single turns in a coherent way in respect with the vertical section. A spatial helix will correspond to this kind of spiral which can refer to the bed joints of the various blocks which, as a consequence, will be different from each other. The drawings by de L'Orme and the other authors already quoted, except for Vandelvira, are definitely unrealizable. It's unlikely that a stonecutter had agreed in working on a stereotomic sequential structure with different heights. Maybe it could have happened only for a precise static reason which, anyway, it is difficult identify in this specific case.

The digital reconstruction of Murcia Cathedral's vault is based on the geometrical analysis of this structure and the use of a textured mesh model of the intradox surface obtained from techniques connected to stereo-photogrammetry [5]. Considering the deformations of the vault due to the collapse of the belling tower during the construction, a first survey focused on the identification of the spatial curve which characterizes the bed joints. At the beginning we speculated on a loxodrome –well-known in the field of nautical science to chart the courses– able to join any two points on Earth's surface intersecting all the meridians with the same angle (instead, the complementary curve, called 'orthodromic distance', joins two points in their shorter

arc). Redrawing this element directly on the digital clone, allowed to show that the curve looks like a spherical helix, despite with a certain approximation. So the preliminary analyses allowed the reconstruction of a solid and rectified digital model of the anti-sacristy's vault and of the related subdivision into ashlars. The 'parallels' (as we simply define the joints lying on the spherical helix) have been obtained due to the intersection of the half sphere with a cone whose vertex has been placed at the centre of the square identified by the lower vertexes of the spherical pendentives and whose directrix is an Archimedean spiral with the same number of turns of those really existing (fig. 6). Instead, the 'meridians' have been obtained from the division of the cone's directrix spiral into the same number of existing segments, so drawing some straight lines which can connect every segment's endpoints to the centre of the curve. Then some portions of the straight lines (those included from a turn and the second one) have been projected onto the half sphere (fig. 7). Finally an offset operation of the intradox surface has been carried out in order to obtain the extrados surface, moving from a surface model to a solid, divided into ashlars (fig. 8) where every block has portions of cone as head ashlars and portions of planes as joint faces. The resulting digital model has partly rectified the structure's effective state of conservation except for the deformations due to the collapse of the tower. Instead, this model has followed the amount and shape of every single ashlar. For this reason it is not surprising, in some cases, the lineup among the vertical joints of the consequential series that –although less efficient from the structural point of view– are placed in the antigresty's vault in this way.
This case study highlights the great influence of Spanish stereotomic practice in French context: Jean-Marie Pérouse de Montclos states that "the simple comparison of sixteenth-century stereotomic apparatuses recognizes the eminent role of Spain as catalyst" [Pérouse de Montclos 1982, p. 212]. Yet, the same author affirms that the case of *capilla redonda en vuelta capazo* defined by de L'Orme as "*en forme d'une coquille de limaçon*", is simply a sort of caprice, a virtuoso subdivision of a hemispherical vault into ashlars: too complex to become a repeatable model. In fact there are a few analogous examples, although in Spanish area sometimes one can observe similar joints covering helicoidal stair-cases like the one in the tower of Palacio de los Guzmanes in León (second half of 1600s), or the one in Plasencia Cathedral or the other of Monastery of Santa Catalina in Talavera de la Reina.

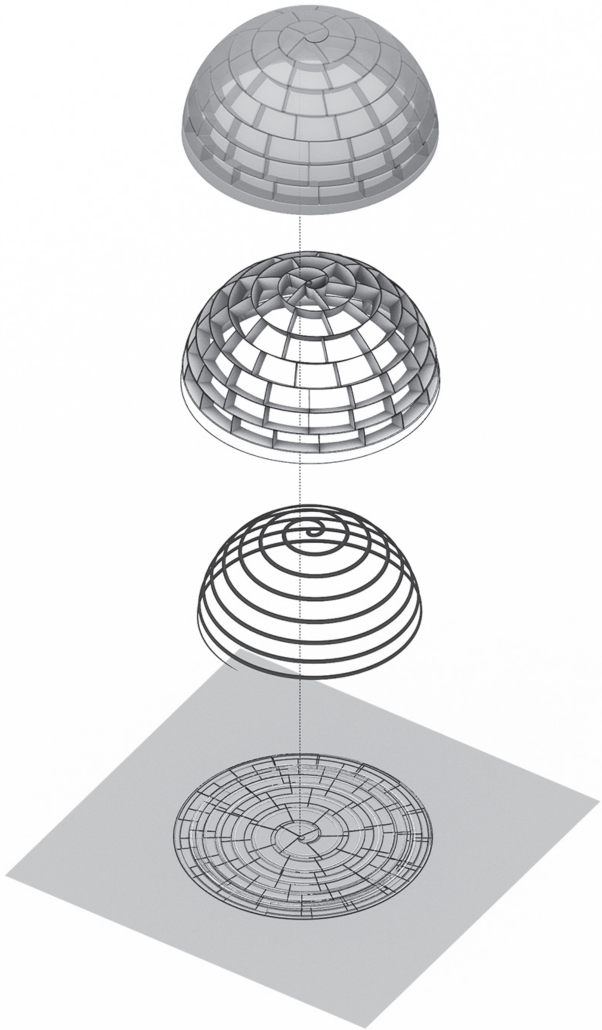


Fig. 8. Exploded axonometry of the anti-sagristy vault with the subdivision in stone blocks (rendering by A. Bortot).

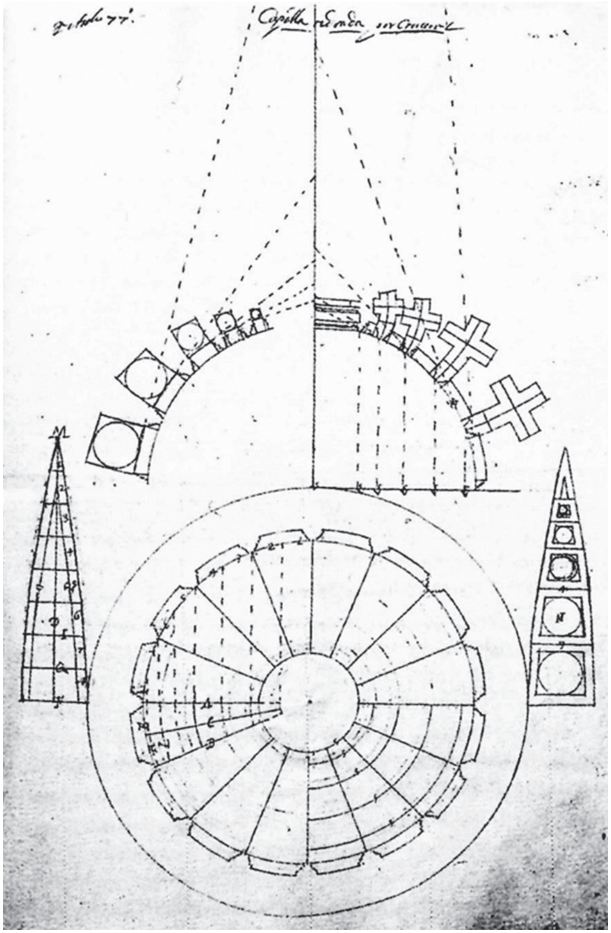


Fig. 9. A. de Vandelvira, *Libro de trazas de cortes de piedras*, p. 62 v.

Stereotomy and cartography

We know that Alonso de Vandelvira was responsible for the construction of the hemispherical vaults located over the corridors of the Casa Lonja de Mercaderes in Seville (1572) whose overall project was entrusted to Juan de Herrera de Maliaño (1530-1597), famous for his work during the construction of the Escorial (1594). The house, initially conceived as a place of exchange for merchants due to the routes that had opened towards the New World, will also become the headquarters of the General Archive of the Indies. In this place, however, not only economic transactions took place, but also cultural exchanges combined with new geographical representation and, more generally, to a new conception of the world. Vincenzo Minenna highlights in this context the cultural role of Seville city in the European context, declaring that in the Casa de Mercaderes "the theories on the spherical track of Pedro de Apiano's *Tratado de la Esfera*, the methods of cartographic measurement of Martin Cortes and the geographic representation through the use of planispheres were studied" [Minenna 2014, p. 32]. The same scholar points out an implicit relation between the spreading of these new representations of the world and the choice to replace with a series of stony sail vaults the flat wooden roofs of the interior of the Casa, designed for the first project. It is sure that among the leading figures in the Sevillian panorama of those years we can find Alonso de Santa Cruz (1505-1567), cosmographer of Charles V and Philip II, as well as author of the *Islario general de todas las islas del mundo* (1541) and coauthor of the *Padrón Real*, a secret geographical map for sailors, continuously updated according to the discoveries that took place in those years. Broadening the field of investigation to the European context, it is important to remember that in his *Underweysung der Messung* (1525) Albrecht Dürer (1471-1528) had already proposed a method –useful also for the realization of globes– to develop the spherical surface on the plane through its subdivision into slices, a solution which obviously imply a certain degree of approximation. Dürer's illustrations show significant analogies with those proposed by Alonso de Vandelvira for the *Capilla redonda por cruceros* (fig. 9), in which the portions of stone blocks between two meridians are developed on the plane according to a logic that seems near to the method of the slices suggested by the German painter and essayist.

As already observed by Francisco Pinto Puerto [Pinto Puerto 2000], an interesting geometric relationship can be no-

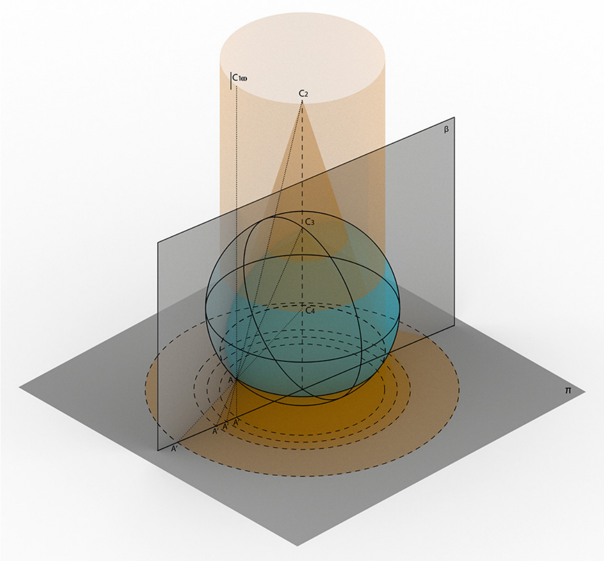


Fig. 10. Diagram in summary of the types of projection employed to obtain geographical maps.

ticed between the stereotomic solutions for the subdivision into ashlars of hemispherical surfaces and the geographical practices connected to the definition of nautical chart and terrestrial globes. In other words, the problem is obviously to transfer to the plane curves and surface portions belonging to the sphere, whether they are indicative of the *trait* for stereotomic cutting planes or the orographic profiles of the landmass. As a proof of this last observation, it will be enough, for example, to recall the previously described analysis relating to the Murcian vaults: the logic of meridians and parallels characterizing the Capilla de Junterón can be considered similar to a terrestrial or celestial globe. We can also suggest a hypothetical relation between the helical logic of the blocks for the vault of the anti-sacristy and the loxodrome curve used for tracing nautical routes.
We highlighted how the approximation of the spherical intrados surface thanks to the use of coaxial cones (with generatrices characterized by variable inclination) has allowed the architects of the past to approximate a non-developable surface to a developable one. In the history of cartography, since the classical era, various positions of the projection center and of the map plane were experimented in order to reduce as much as possible the level of distortion generated by the geometric process [6]. The evolution of cartography is therefore closely connected to the history of the concept of projection. In modern times, a cataloging of the so-called 'flat perspective maps' has been achieved, it is based precisely on the relationships between the position of the projection center [7] and the position of the plane of the map in relation to the sphere [8] (fig. 10). Analogously to what we have just observed in relation to stereotomic practices, also cartographers start to employ cones to approximate spherical surfaces. Instead of projecting directly onto a plane, it was therefore thought to employ quadric surfaces of rotation (cones and enveloping cylinders) which thanks to their geometric properties, can then be unrolled on the plane without tears. Among the most famous navigation charts obtained with the aforementioned method, we find the one by Gerhard Kremer (1512-1594), creator of the Mercator method which involves the use of a cylinder tangent to the equator of the globe and a centre of projection coincident with the centre of the sphere. This kind of projection is also called 'gnomonic'.
The adjective 'gnomonic' refers to another cartographic application, the representation of celestial vault, with explicit connection to the field of astronomy and to the realization of solar clocks (astrolabes): this proto-projective method was used by Thales of Miletus (636?-546? BC) for the tracing of his star maps [Snyder 1987, p. 164]. It could therefore be hypothesized that the main problem faced in this contribution –the representation on the plane of entities belonging to a spherical surface– can be traced back, not only to terrestrial cartography or even to stereotomy, rather than to the representation of celestial phenomena. The geometric cutting entities (cones and planes), used in stereotomic constructions and previously analyzed, could in this context be compared to same entities, made of light and shadow, employed in gnomonics since the Renaissance period to define the lines and curves of time (hour lines, meridians and celestial parallels, curves of the equinoxes and solstices, etc.).
"Any sundial is a precise projection of a sphere and its circles towards some surface or plane" [Maignan 1648, p. 46] states Emmanuel Maignan (1601-1676) in his treatise on gnomonics, referring to a tradition dated back to classical period. It is significant in this context the affirmation in the XV century of a method for tracing sundials defined as 'universal'. This method imposed to position at the centre of an armillary sphere, previously oriented according to the lati-

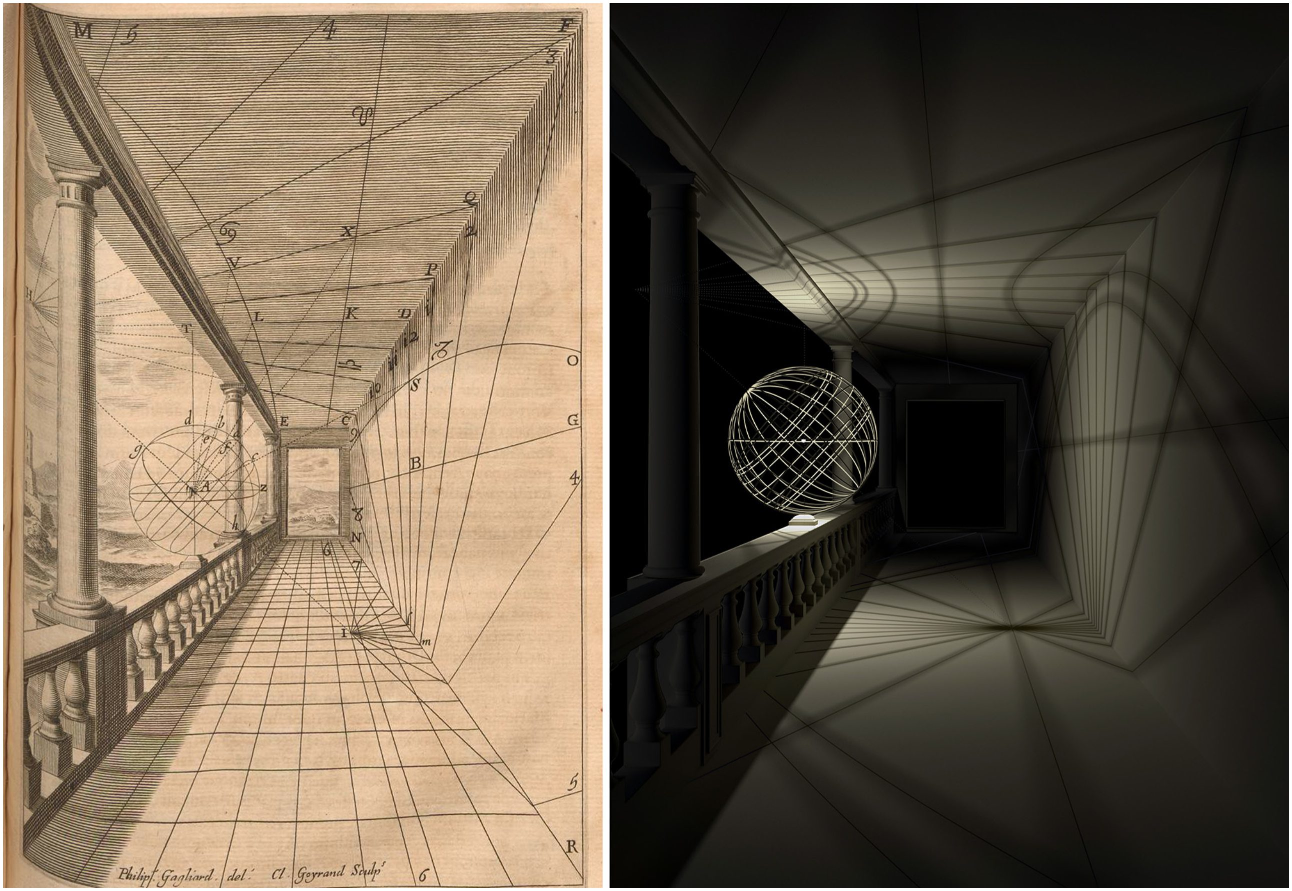


Fig. 11. On the left a drawing of the treatise by E. Maignan, Perspectiva Horaria… (Rome 1648), p. 334; on the right the 3d reconstruction of the same table with the simulation of the shadows cast by a point light source placed in the center of the armillary sphere, as suggested by Daniele Barbaro (rendering by A. Bortot).

tude of the place, a light source able to project the shadows cast by the instrument on the architectural surfaces chosen for the sundial (fig. 11). Among many illustrations of this device we find the one by Daniele Barbaro (1514-1570) illustrated in *La pratica della Prospettiva…* (1568), where in the place where the lamp should be –that is in the center of the sphere– we note the representation of an eye, to denounce the analogy between central and skiagraphic projections generated by a point light source. Finally, it could be observed how the gnomonic projection, probably the first to have been used in history, represents an ideal model of relationship between man and the cosmos: we have to think to the Earth as a point placed in the centre of an ideal celestial sphere, as we can see, for example, in the depictions of middle age treatises (fig. 12). The illustration, extracted from *De Sphaera* (1230 ca.) by Johannes de Sacrobosco (1195-1256 ca.), shows among other things the relationship between two surfaces already observed in this essay, the cone and the sphere, used by the astronomer to describe the phenomenon of the eclipse. In terrestrial cartography instead, man is positioned on the surface of the globe, he occupies the same space occupied by the entities that have to be projected onto the plane: a variation of the 'point of view' that seems even more significant. The stereotomic solutions relating to the *bóveda* proposed by Vandelvira could therefore have found a source of inspiration in a proto-projective geometrical model that shares a central point of view with the astronomical representations, where the geometric cutting entities are placed.
Finally, in Vandelvira's literary work –whose broad spreading as a manuscript is already known– it is possible to clearly perceive a certain inclination towards the practical solution of every single case more than a focus on the research of a general method. This latter will involve, instead, all the French authors of the following century. According to us the drawing of Murcia anti-sacristy's vaut (with some geometrical licences) shows a certain coherence due to the construction practice more than the pure speculation. Since it comes from an imaginative-projective habit which had developed in an epoch where project drawing had to concentrate on the solutions and not on the representation of its rigid execution. Finally, it seems plausible to suppose an underlying relation between the stereotomic solutions, referred to spherical vaults and the cartographic representations of earth and sky that embodied, in addition to geometric solutions, cosmological models able to affect the entire European culture.

QVOD AQVA SIT ROTVNDA.

Quòd autẽ aqua habeant tumorem, & accedat ad rotunditatem, ſic patet. Ponatur ſignum in littore maris, et exeat nauis à portu, & in tantum elongetur, q; oculus exiſtens iuxta pedem mali non poſſit uidere ſignum: ſtante uero naui, oculus eiuſdem exiſtentis in ſummitate mali bene uidebit ſignum illud, ſed oculus exiſtentis iuxta pedem mali melius deberet uidere ſignum, quàm qui eſt in ſummitate mali. ſicut patet per lineas ductas ab utroq; ad ſignum, & nulla alia huius rei cauſa eſt, quam tumor aquæ. Excludantur enim omnia alia impedimenta, ſicut nebulæ, & uapores aſcendentes. Item cum aqua ſit corpus homogeneum, totum cum partibus eiuſdem erit rationis, ſed partes aquæ: ſicut in guttulis, & roribus herbarum accidit: rotundam naturaliter appetunt formam, ergo & totum cuius ſunt partes.

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Fig. 12. An illustration extracted from De Sphera (1550) by Johannes de Sacrobosco, p. B IIIr.

Notes

[1] On the biographic details referring to this author, there are only a few information. The main source is still Vasari's work, cfr. Vasari, G. (1568). *Vite de' più eccellenti pittori, scultori, e architettori*, Firenze: appresso i Giunti.

[2] A similar stereotomic case is found in the church of Santiago in Orihuela, not far from Murcia. In this case, the toroidal surface is characterized by a system of ceiling coffers that seem to follow the method proposed by Vandelvira for the subdivision into ashlars of this type of vault.

[3] Cfr. Trevisan, E. (2014-2015). *Intreccio strutturale e vertigine dello sguardo: tettonica, decorazione e attualità della stereotomia nella Cattedrale di Murcia*. Ph.D. Thesis (unpublished). IUAV School of Doctorate Studies in Venice, supervisor prof. A. De Rosa, a.y. 2014-2015, pp. 125-143.

[4] Similar drawings also appear in other manuscripts and treatises following the vault's construction in Murcia. For instance, one can refer to: Tosca, V. (1794). *Tratado de arquitectura civil, montea y cantería y reloxes*. Valencia: Hermanos Orga; de Portor y Castro, J. (1708). *Cuaderno de arquitectura*. Madrid: Manuscript, Biblioteca Nacional.

[5] The survey has been carried out through the use of a camera Nikon D800e equipped with 24 mm F1.4 aspheric lens. After setting ISO value to 200, we have taken 88 photographs in Junterón's Capilla and 33 in the antisagresty's vault. The images have been processed with the *Agisoft Metashape* software. The 3D mesh model has been scaled and oriented thanks to the point cloud obtained with the laser scanner Faro Cam2.

[6] The methods for the development of the sphere on the plane necessarily represent a distortion or approximation of it, we have to notice that no terraqueous map is at the same time equivalent (preserve the proportion between the distances), equidistant (maintain the relationships between the areas) and isogonic (preserve the angles, for example between meridians and parallels), compared to what is depicted on the globe's surface. The attempt to reconcile these attributes in the same map has determined over time the spread of different cartographic methods.

[7] We speak about orthographic projection if the centre of projection (a fixed point or a point at infinity) is outside the earth; we speak about stereographic projection if the centre is located on the earth's surface and finally we speak about central projection when the centre of projection correspond with the centre of the earth.

[8] Tangent to a pole, to any point on the sphere or to the equator.

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