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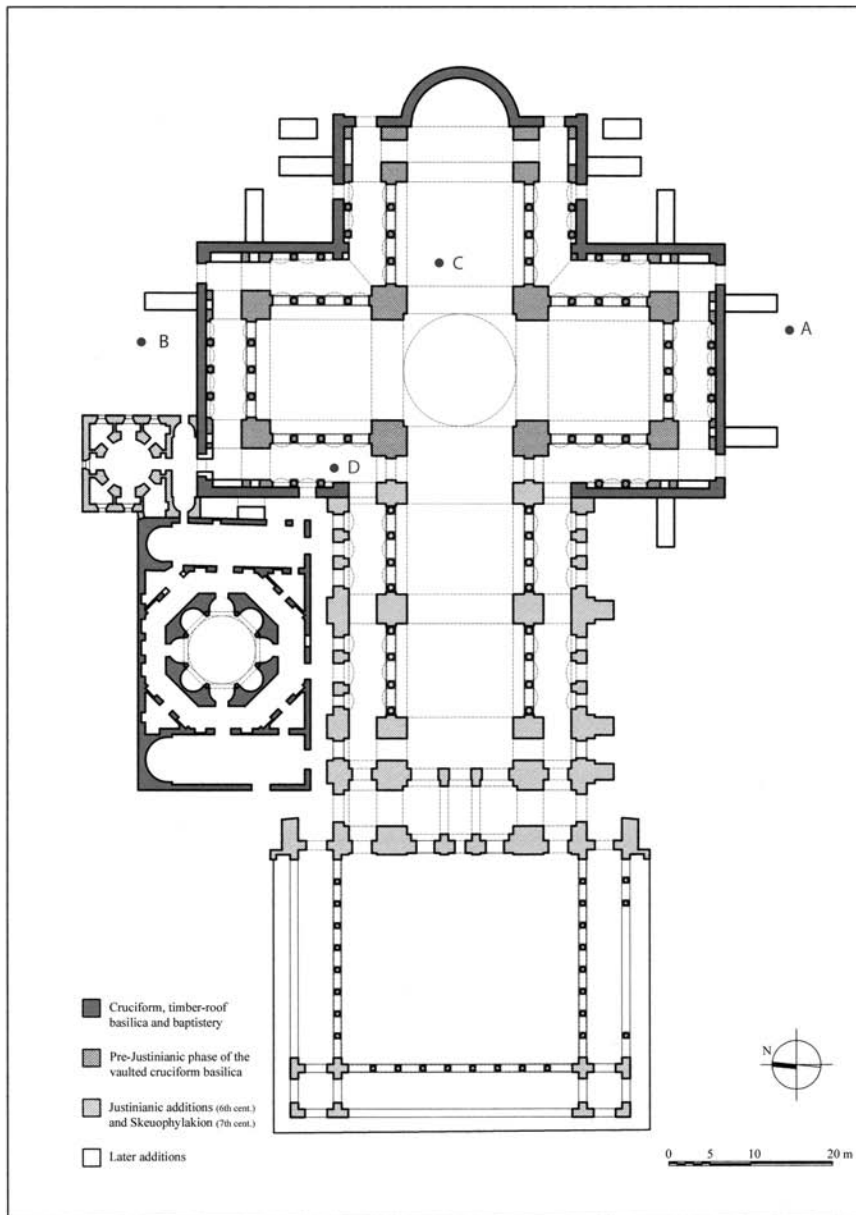
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**Figure 1** St. John at Ephesos, plan of Justinian's church at ground level, showing building phases and surviving vault fragments (drawing by the author and Carolina Vasilikou)

# The Vaults of St. John the Theologian at Ephesos

## Visualizing Justinian's Church

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Ever since the first excavation of the remains of the church of St. John the Theologian on the hill of Ayasoluk, the reconstruction of the vaulted, sixth-century phase of the monument has been a major challenge in the field of early Byzantine architecture. This is partly due to the historic significance of the building. According to the contemporary account of Procopius, the church, rebuilt and enlarged under the auspices of Justinian, constituted the Ephesian counterpart to the Constantinopolitan church of the Holy Apostles.<sup>1</sup> It was later to become the heart of medieval Ephesos and one of the most important pilgrimage churches in Asia Minor.<sup>2</sup> Besides its historical interest, the reconstruction of St. John's has a great significance for the study of early Byzantine vaulting technology. Indeed, reconstruction offers the only opportunity to recapture the form of the enormous brick vaults of the church, which are now lost. These sophisticated vaults, which seem to have survived in an earthquake-prone area for more than eight centuries, constitute a remarkable feat of structural engineering.<sup>3</sup> They must have been a highly innovative structure, erected at a time when most churches were timber-roofed.

The task of accurate and reasoned reconstruction through the scrutiny of archaeological evidence is more demanding than it may initially appear, in spite of the systematic exploration of the monument since its discovery in 1921. Eight decades of excavation and survey have made the ground plan of the aisled cruciform church as well as the footprint of its atrium, baptistery and skeuophylakion mostly clear (Figure 1).<sup>4</sup> Some parts have even become the object of full-scale physical reconstruction (Figure 2). In addition to this, Hans Hörmann, Mustafa Büyükkolancı, and Andreas Thiel have shed light on the building phases that preceded Justinian's vaulted church.<sup>5</sup> Still, in spite of several attempts at graphic reconstruction, our knowledge of the original form of the sixth-century church is limited. The major obstacle lies in the reconstruction of the vaults: the fragmentary nature and scarcity of their remains complicate their visualization.

The diversity of ways in which these vaults have been reconstructed during the last sixty years echoes the limited information available to the authors. Hörmann visualized the monument with six major full domes on pendentives.<sup>6</sup> He also envisioned five smaller cupolas over the west gallery and identical barrel vaults covering lateral aisles and galleries. This vaulting pattern and the massive flying buttresses abutting a continuous dome base are some of the highly idiomatic elements of a reconstructed form that can claim only a vague kinship to the surviving vaulted churches of the period of Justinian.



**Figure 2** St. John at Ephesos, general view of the remains from the chancel, looking west (author's photo)

Hugh Plommer revised this reconstruction based on stylistic criteria, representing the buttresses with sloping tops and modifying the proportions of the interior, but did not challenge the way in which Hörmann visualized the vaults.<sup>7</sup> Paolo Verzone was the first to do this, raising the possibility that the major bays were covered by pendentive domes rather than by full domes on pendentives.<sup>8</sup> In spite of the similar names and their common spherical nature, these two types of vaults are quite different, mainly in the geometrical form of the area above the level of the pendentives. In a pendentive dome, this area consists of a shallow spherical dome that shares the curvature of the pendentives. In other words, dome and pendentives belong to the same spherical surface. In contrast, in a dome on pendentives, the corresponding area constitutes a full hemispherical dome built on a smaller diameter than that of the pendentives beneath it. Thus, the profile of a pendentive dome is flatter than the one of a full dome on pendentives. By substituting Hörmann's domes on pendentives with a series of pendentive domes, Verzone

decreased the vertical emphasis of each bay. Verzone invites his reader to imagine a space that is at the same time less compartmentalized and more unified than the one featured in Hörmann's publication. However, Verzone overlooked the structural implications of his theory. Indeed, the repetitive use of pendentive domes would have required the builders to tackle serious constructional challenges: given its shallower profile and larger diameter, a pendentive dome exerts greater lateral thrusts on its supports than those of a dome of pendentives with the same span. In addition to this, the flatness of the shallow crown of a pendentive dome and the unavoidably steep pitch of its brick courses increase the need of formwork during construction. Unfortunately, Verzone hardly investigates the sophisticated technology and constructional expertise employed in St. John. In addition to this, his proposal lacked adequate substantiation as well as the drawings necessary to illustrate his daring hypothesis. As a result, its influence on other scholars was limited. Indeed, Alfons Maria Schneider and Mustafa Büyükkolancı

questioned the substance of some aspects of Hörmann's proposal (notably the flying buttresses and the small domes over the west gallery), and suggested that the central dome may have been more prominent than the domes over the cross arms.<sup>9</sup> Still, they overlooked Verzone's proposal, continuing to envision St. John's main vaults as full domes on pendentives.

A recent challenge to this assumption came from Andreas Thiel.<sup>10</sup> In a graphic reconstruction whose clarity and exhaustiveness compete with Hörmann's, Thiel represented Justinian's church with a full dome over the crossing and five pendentive domes surmounting the cross arms. Thiel's solitary, fenestrated hemispherical dome in the center had appeared in earlier reconstruction proposals. But it is only in Thiel's proposal that this dome, surrounded by shallower vaults, makes the crossing the indisputable climax of the design.

Examination of these proposals leaves a series of questions unanswered. For instance, we are in doubt whether to visualize the principal vaults as domes on pendentives or pendentive domes. Indeed, none of the authors has offered conclusive evidence for one of these two vaults. If the form of the primary vaults remains conjectural, their inner structure is unknown. The representation of vaults in the existing scholarship is invariably skin-deep: reconstruction drawings do not provide any information about brick patterns. This lacuna, reflecting the tendency to focus on geometry and form as opposed to structure, is all the more serious given the sophistication of early Byzantine vaulting techniques and their influence on vault forms.<sup>11</sup> Another problem that scholars have failed to address concerns the degree to which St. John's primary vaults constituted a homogeneous structure. There are many morphological and structural differences between the remains of the nave and those of the transept. The possibility that differences between morphology and structure also occurred at the level of the vaults has not been explored. As these problems persist, it is very difficult to visualize the vaults with certainty and to establish the way they were built.

Given their insufficient attention to construction detail and their inadequate substantiation, previous reconstruction proposals cannot be considered as ideal sources for the study of the use of vaulting in St. John. A new graphic reconstruction of the vault fabric is required that must go beyond and deeper than the visualization of the shape of the vaults in order to reconstruct their inner structure. For this, it is essential to take into account the archaeological evidence regarding the vaults. This evidence is not entirely lost. The present article investigates three surviving vault fragments whose potential to help in the reconstruction of the missing

vaults had been underestimated until now. Two of these fragments had escaped notice before, perhaps due to a certain difficulty of interpretation. Indeed, these gigantic elements can easily be dismissed as amorphous masses of mortar and brick. Careful analysis and interpretation, however, can offer proof for reconstruction, and reveal some of the vaulting methods followed in the monument.

This investigation starts from graphic recording. Cut-away axonometric drawings, showing simultaneously the horizontal and vertical disposition of the fragments of vaulting, have proven to be the best medium for their examination. The fragments have been investigated both for their overall form and for their brick pattern. The interpretation of these details is grounded by reference to surviving vaults from coeval churches. The aim is to establish the exact role of each fragment in the original structure and to deduce the form of its missing surroundings. Piecing together these seemingly random scraps of testimony and examining them in the light of our knowledge of early Byzantine vaulting patterns make it possible to deduce the main lines and structures of the vaults of St. John.

The form of the vaults must have played a crucial role in the spatial experience of the interior of the church. A look at the plan seems to indicate a space divided in rectangular and square bays. It is only through visualizing the vaults that we can establish whether these bays were segregated spatial units or elements of a unified design, whether they were identical or varied, and whether they accentuated or attenuated the differences between nave and transept. Resolving the above dilemmas, the visualization of the vaults helps to recapture the architectural experience of the church. At the same time, it offers the opportunity to study the sophisticated vaulting methods that made it possible to construct spherical vaults in a number and scale that were unprecedented in this earthquake-prone region. The uninvestigated fragments of these vaults offer essential evidence for vaulting methods whose use has rarely been recorded outside Ephesos. The occurrence of similar atypical construction methods elsewhere in the same city encourages us to reconsider the role of Ephesos in the development of vaulting methods in the early Byzantine period.

### Characteristics of the Vault Fragments

The large number of vault fragments recorded on the site is unique among the churches of west Asia Minor. Until the early 1920s, the only traces of the church of St. John to be found above ground were the numerous masses of mortar and brick that had once belonged to the vaults of the church. Georgios Lampakis's photographs of the monument, taken



**Figure 3** St. John at Ephesos, view of vault fragments before the excavations (photograph by G. Lampakis, 1907; Byzantine and Christian Museum of Athens, Historic Photographic Archive, record number XAE 5967)

in 1907, depict the dramatic impact of these giant masses in a barren, unexcavated landscape, which until then had hardly received any attention from archaeologists (Figure 3).<sup>12</sup> Had half of these fragments survived, the graphic reconstruction of the vaults would have been much easier than it is at present. Yet, unfortunately, the vast majority of them were destroyed, ironically, during the same period that marked the uncovering and rediscovery of the walls and supports: the more the plan emerged the more the vault fragments of the church were destroyed.

Hans Hörmann has attempted to justify the destruction of these fragments by his team as a prerequisite for the progress of the discovery of the ruins of the walls and supports of the church.<sup>13</sup> These ruins were buried immediately below the vault fragments, which were seen by the excavation team as obstacles. Although this argument sounds unconvincing today, it led to the breaking and removal of several sizeable fragments. The effects of this destruction were mitigated by the systematic photographic survey of the fragments prior to their irresponsible removal.<sup>14</sup>

The photographs of vault fragments published by Hörmann have been considered to be the only source of information about St. John's vaults.<sup>15</sup> Still, this record focuses on vault fragments from the west cross arm, and gives insufficient information about the vaults of the transept and the chancel. The assumption that fragments from the western vaults, such as the ones depicted in Hörmann's photographs, are indicative of all the vaults of the church is incorrect. It overlooks the possibility that the wide constructional and



**Figure 4** St. John at Ephesos, view of vault fragment A, looking west (author's photo)

stylistic differences between the west and the east part could betray structural differences at the level of the vaults as well.

A reason for some scholars' exclusive reliance on the photographed fragments is the failure to take full notice of the three vaulted fragments that still survive on site, near the transept (see Figure 1). Vault fragment A, consisting of a thin slice of masonry lying three meters south of the transept, seems to derive from the springing of the pendentive on top of one of the two south piers (Figure 4). Vault fragment B, found next to a fig tree north of the church, probably comes from the vaults surmounting the north piers of the transept (Figure 5). Unlike fragments A and B, hidden in the fringe



**Figure 5** St. John at Ephesos, view of vault fragment B, rotated to match the original position of the fragment (author's photo)

of the site, the enormous vault fragment C occupies a prominent location behind the central synthronon (see Figure 1). Its shape and location suggest that its origins are to be found in the springing of the pendentives that supported the central dome. Further evidence for reconstruction will be drawn from vault fragment D, the only remaining part of the aisle vaults, and the only fragment to have received the attention it deserves by the archaeologists.<sup>16</sup> It is now found restored to its original location, on top of the north junction between nave and transept (Figure 6).

To construct a plausible model for the nave vaults, a study of the fragments included in Hörmann's photographic survey is required. The most important of these fragments are the ones that include pendentive remains. Vault fragment G displays a very intriguing and unusual brick layout, which recurs in vault fragment H, probably the most impressive and sizeable one.<sup>17</sup> The information one can gather from Hörmann's brief descriptions, with the aid of poor-resolution black-and-white photographs, is limited. Yet, it can prove to be very valuable when seen in the light of the evidence drawn from fragments that still survive. Of these, fragments A, B, and C have never been analyzed before, and while the other fragments have already been recorded, many of their details had not been interpreted.

#### *Vault Fragment A*

Fragment A offers the opportunity to explore pendentive and broad arch remains from the south bay of the transept. The arch remains are immediately noticeable: observing the brick

masonry mass closer to the ground, one can easily distinguish a series of bricks laid radially (see Figure 4). These begin to form two broad arches, each consisting of two concentric rings of radial bricks. Drawing our attention to the corner where the two arches meet, we realize that the faces of their inner rings must have merged below this point. No part of this merged portion survives. Nonetheless, the merging of these rings can be deduced from the relative inclination of their lowest brick courses.

This fragment also includes a detail that bears a strong resemblance to a pendentive. Eleven brick courses form a wedge-shaped portion of masonry (Figure 7). This detail is indicative of a pendentive that was two bricks thick, with a second shell lying behind the extrados of the supporting arches, serving to anchor the pendentive into the vault core (Figure 8). The pendentive proper seems to be surrounded by a border consisting of three pitched brick courses.<sup>18</sup> It is vital to note that these courses lean against the chamfered, sloping faces of the outer rings of the broad arches. This detail will prove to be crucial for the reconstruction of the missing upper part of the vault.

#### *Vault Fragment B*

Found next to the north bay of the transept, fragment B also includes remains of broad arches and pendentives (Figure 9). Its similarity with fragment A seems to reflect the design symmetry between the north vault of the transept and its south counterpart. The segment in vault fragment B corresponds to an area immediately below the one included in



**Figure 6** St. John at Ephesos, vault fragment D, view from the southwest (author's photo)

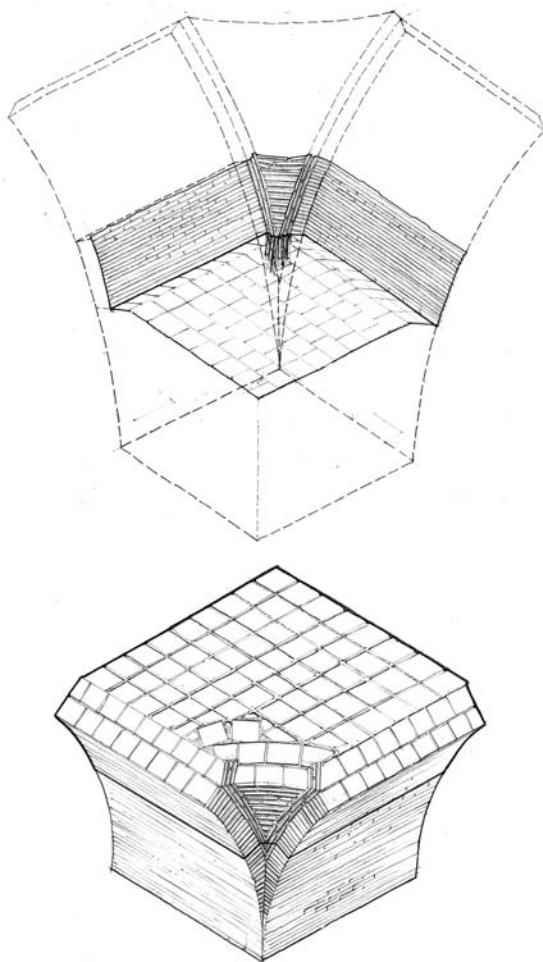


**Figure 7** St. John at Ephesos, detail of vault fragment A, showing remains of supporting arch and pendentive. The pendentive is flanked by two borders consisting of three brick courses (author's photo)

fragment A. The bottom end of the pendentive has survived, together with the springing of the two arches, whose merge appears more clearly here.

These details offer the opportunity to establish the location of the fragment in the original structure and to reconstruct its surroundings (Figure 10). They also make it possible to study the intrados of the supporting arches and its finish. The arches were built with large, thin bricks of three distinct types. There are big, rectangular bricks measuring 35 by 50 by 4.5 centimeters; medium-sized square bricks measuring 34 by 34 by 4.5 centimeters; and half-size bricks measuring 17 by 34 by 4.5 centimeters. These bricks were laid radially, in neat common bond, with their vertical joints staggered, on mortar beds approximately 4 centimeters thick.<sup>19</sup> The variety of brick sizes was required to allow interlocking, ensuring a neat bond within each element (arch ring, pendentive shell), but also an occasional but not systematic bond





**Figure 8** St. John at Ephesos, vault fragment A, reconstructed axonometric drawings, indicating extant remains (author's drawing)



**Figure 9** St. John at Ephesos, vault fragment B, view from the west. Detail of the convergence of two broad arches, showing the springing of a pendentive between them (author's photo)

between the elements themselves. For instance, some of the big rectangular bricks join the two rings of a broad arch.

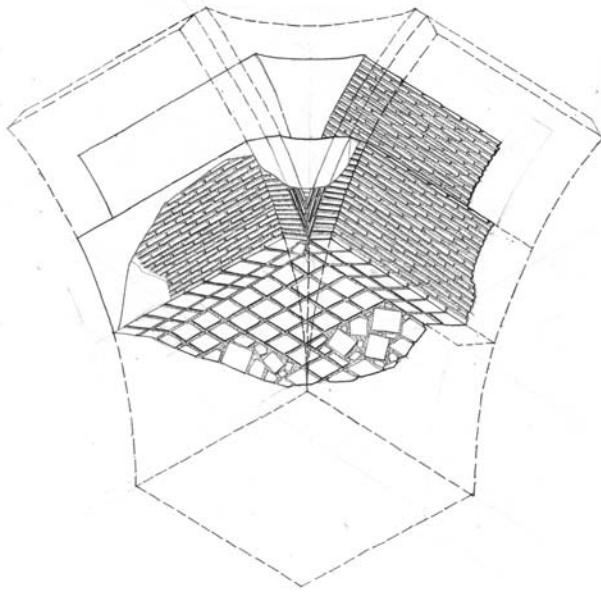
Fragment B includes a precious detail that provides a rare chance to visualize the external appearance of the vaults. This is a small patch of mosaic that covers the eight lowest courses of one of the broad arches at the point where the remains of this arch now meet the soil (Figure 11). This mosaic consists of white and dark cobalt blue tesserae.<sup>20</sup> Even though this is too small a trace to give us an idea about decorative patterns, it is a good indication of the nature of the revetment of the vaults.

The careful study of these remains prepares us to approach other fragments of vaulting, which are much more difficult to interpret. One of these is fragment C, the primary source of information for the visualization of the great vault that covered the crossing.

### *Vault Fragment C*

It is difficult to miss vault fragment C. This gigantic mass, located behind the reconstructed synthronon east of the crossing, is one of the most intriguing parts of the remains (Figure 12). Still, scholars have been reluctant to examine it in detail. A reason for this may be the decay of its surface, which makes it particularly difficult to establish its original location. However, a trained eye can spot a series of characteristics that indicate the fragment's role within the original structure.

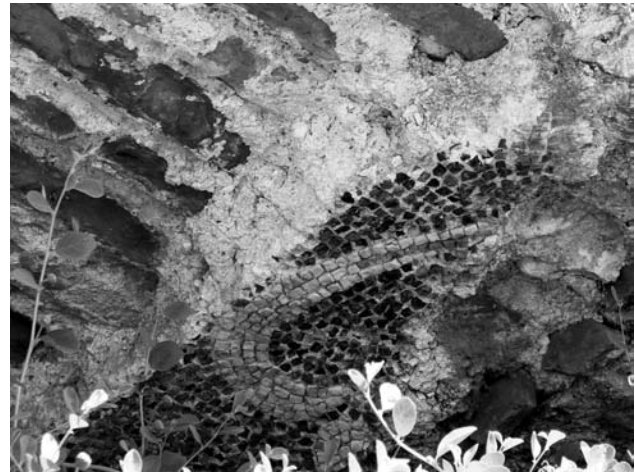
A detailed examination of this fragment and comparison with fragments A and B suggest that it also originates in the area of the springing of the pendentives. Indeed, its southeast



**Figure 10** St. John at Ephesus, vault fragment B, reconstructed axonometric view (author's drawing)

corner preserves the lower parts of two converging broad arches, each constructed with two concentric rings of radial bricks (Figure 13). There are substantial remains of the outer arch rings and only minor traces of the inner ones. The dilapidation of these arches discloses the fabric of the solid brick core of the vaults. As in other fragments, this core seems to have consisted of flat, horizontal courses of brick. Its surface, partly spherical and partly cylindrical, echoes the form of the arches and pendentives that originally surrounded it.

What distinguishes this particular fragment from the ones examined so far is the corner merging of the broad arches. A detail (shown as location K in Figure 13) proves



**Figure 11** St. John at Ephesus, remains of mosaic with white and blue-green tesserae (author's photo)

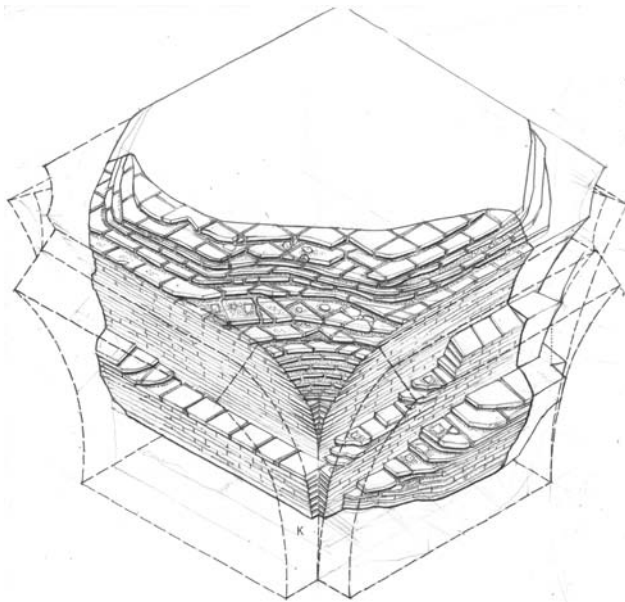
that here the inner arch rings were independent. We can deduce that these arch rings were carried by the pilasters of a pier with a re-entrant angle profile. The only piers with such a profile to be found in the church are the four piers surrounding the crossing. This confirms the association of fragment C with the vault over the central bay, which is also suggested by the present location of the fragment (see Figure 1).

In this same detail the faces of the outer arch rings were exposed (see Figure 13, K). As a consequence, the entire face of the supporting arches must have been visible. The fact that the arches surrounding the bay of the crossing had their structural mass exposed reveals much about the connection between arches and pendentive. The pendentives of the crossing must have rested on top of the extrados of the supporting arches, unlike the previous ones we examined, which lay against the sloping face of their outer arch rings, concealing them entirely. The nature of this connection will prove to be crucial for the reconstruction of the missing upper part of the vault.

The northwest corner of fragment C confirms that the fragment belonged to the vault over the crossing. In this corner, we can clearly distinguish the intersection between a pier mass and a broad arch (Figure 14). The width of the pier exceeds the soffit width of the arch. The only piers to be wider than the supporting arches were the ones of the crossing. Apart from confirming our identification of the origins of fragment C, this intersection between arch and pier provides the only available evidence for the form of the upper parts of the central piers. Indeed, in order for this intersection to exist, the piers must have risen at least 4 meters higher than the springing of the arches, behind the



**Figure 12** St. John at Ephesos, vault fragment C, view from the southeast, showing remains of supporting arches (with double arch-rings) and vault core (author's photo)



**Figure 13** St. John at Ephesos, vault fragment C, reconstructed axonometric showing visible remains (author's drawing)

pendentives, forming a square dome base. This must have been a prominent feature, quite visible from the exterior of the church.

Fragments A, B, and C help one to visualize some of the most important vaults of the monument, the ones over the tomb of St. John, and the adjacent bays. At the same time, these fragments hardly offer any information about the vaults

that covered secondary areas, such as aisles and galleries. The archaeological evidence for these humbler, smaller vaults is limited; there is only one small fragment that echoes their complex structural form.

#### ***Vault Fragment D***

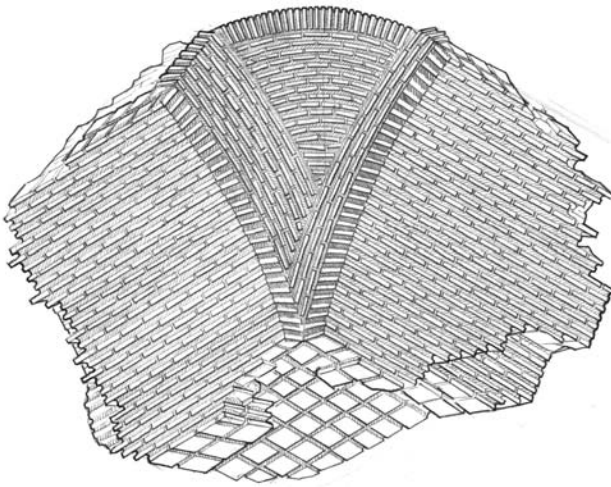
Vault fragment D is the only surviving part of the aisle vaults (see Figure 6). The multiplicity of vaulted surfaces included in it is indicative of a complex vault shell. A close observation reveals the remains of two arches: one parallel to the main axis of the aisle, and one perpendicular to the first. Between the two arch fragments, we can distinguish a groin marking the line of intersection between barrel vaults. This area consists of two zones: the lower part is made of some twenty horizontal oversailing brick courses, while the upper one is built with bricks pitched on their edge. This detail has been interpreted in two different ways: Verzone read the groin as evidence for cross vaults, whereas Thiel saw in it the traces of the intersection between barrel vaults of different size.<sup>21</sup>

#### ***The Photographic Survey of 1951***

The archaeological evidence presented so far is limited. Most of the vault fragments analyzed here derive from the transept vaults; it is doubtful whether they can be used to reconstruct the nave vaults as well. Indications for the nature of these vaults may be found in Hörmann's photographic survey. This record does not allow a close examination of construction details, but its photographs can establish to what extent the



**Figure 14** St. John at Ephesus, vault fragment C, view from the northwest. Note the intersection between pier and broad arch on the left part of the figure (author's photo)



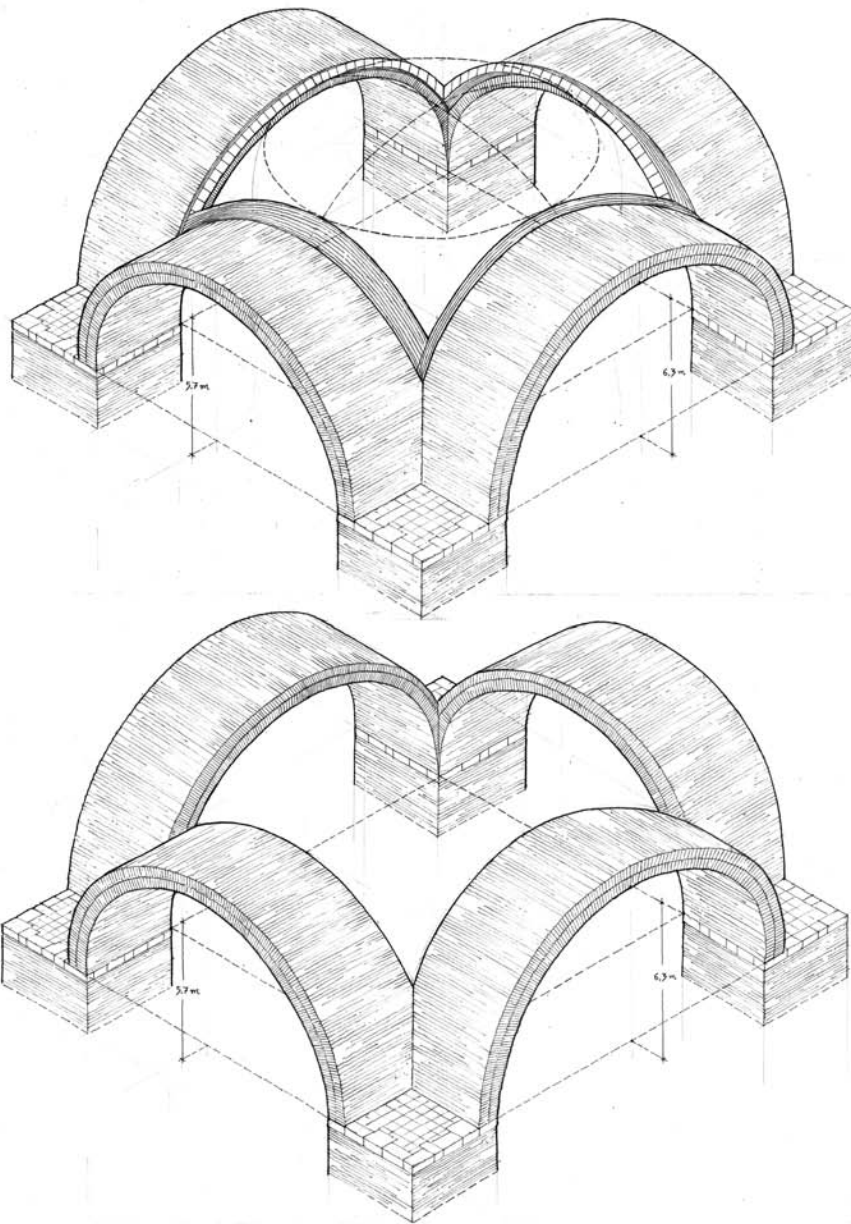
**Figure 15** St. John at Ephesus, representation of destroyed vault fragment H (author's drawing, based on photographs in Georgios A. Sotiriou, "Anaskafai tou Byzantinou Naou Ioannou tou Theologou en Efeso," *Archaologikon Deltion* 7 [1924], 92 and Hans Hörmann, *Die Johanneskirche, Forschungen in Ephesos IV/3* [Vienna: Österreichischen Archäologischen Institut, 1951], plate XXIV, 1)

nave vaults were different from the ones covering the transept.

On the one hand, there is hardly any difference between the arches of the two parts. Like their eastern counterparts, the western arches seem to have been built with radial courses of brick, which merged in a similar way close to the springing. On the other hand, the photographs of fragments

G and H seem to suggest that the pendentives of the nave differed markedly from the ones of the transept.<sup>22</sup> The first difference is found in the borders that lay against the face of the supporting arches and surrounded the pendentives. In vault fragment G, these borders have an unequal thickness: the one consists of nine pitched brick courses while the other comprises just three or four. On the contrary, the pendentive borders in fragments A and B have a uniform thickness. A second, more serious difference occurs in the structure of the pendentive itself. As vault fragment H demonstrates, the pendentives of the nave bays were formed with bricks laid in arched, concentric courses.<sup>23</sup> After fifteen courses, there are traces of a segmental arch with radiating bricks, crowning the lowest, wedge-shaped portion of the pendentive (Figure 15). This description is indicative of an unconventional pendentive structure, quite unlike the one observed in fragments A and B. Indeed, the non-uniform thickness of the pendentive borders and the use of arched, as opposed to circumferential courses are details that are not frequently encountered in early Byzantine architecture. The repetition of this peculiar structural form in more than two distinct fragments found lying in the west bays suggests its systematic use in the nave vaults.

The use of arched courses and borders of different thickness in the pendentives of the western part deviate from standard practice, exhibited in the remains of the transept. The use of such a peculiar pendentive structure in the nave must have been related to the oblong shape of its bays. One of the consequences of this shape is that the apexes of the

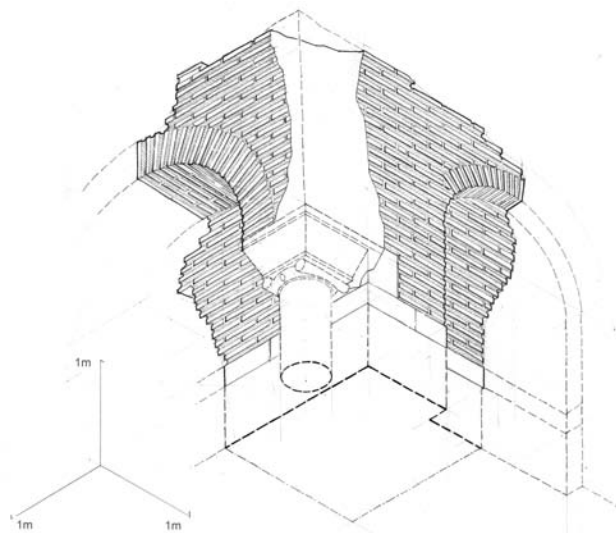


**Figure 16** St. John at Ephesos, axonometric drawing of the four arches surrounding the west bay of the church (nave). The addition of pendentive borders in the top illustration makes up for the height difference between the apices of the arches, which is illustrated in the bottom diagram (author's drawing)

arches spanning the short sides of the bay are at a lower level than the apexes of the arches over the long sides (Figure 16). This makes it impossible to support a hemispherical dome directly over the apexes of the arches. Elsewhere, Byzantine builders have dealt with this problem elevating the apex of the short arches. This was achieved by making the arches elliptical or by elevating their springing.<sup>24</sup> But in the nave of St. John's, the pendentive fragments betray the use of a different solution. This is to be found in the structure of the pendentives rather than in the tracing of the arches. Indeed, the use of a thick border over the short arch, combined with the use of a thinner border over the long arch, would

effectively serve to make up for the height difference of the arches.

So far, we have focused on the study of evidence for the main vaults of the nave. Still, Hörmann's publication also includes photographs of fragment J, which derives from the surroundings of the gallery vaults (Figure 17). This is the only part of the external wall of the gallery recorded so far.<sup>25</sup> It comes from the secondary pier in the junction between the south gallery of the west cross arm and the southwest gallery of the transept.<sup>26</sup> This fragment seems to preserve traces of two perpendicular pier faces, made essentially of brick masonry. Parts of blind arches occur in both faces, and a



**Figure 17** St. John at Ephesos, representation of destroyed vault fragment J (author's drawing, based on survey drawings and photographs published in Hörmann, *Forschungen in Ephesos*, 101, fig. 15, plate XXVII, 3)

string course made of squared stone blocks underlies the base of the fragment. There does not seem to be any trace of a barrel vault springing anywhere lower than the crown of the blind arches: this observation will prove to be essential for the reconstruction of the gallery vaults of St. John at Ephesos.

### *Summary of the Vault Fragments*

Although the analysis of these amorphous masses of masonry is difficult and somewhat pedantic, it yields important evidence for reconstruction and makes it possible to draw a series of preliminary conclusions:

- Both the nave and the transept of the church were covered by spherical vaults carried by broad arches.
- There is a structural difference between the spherical vaults over the cross arms and the one over the crossing. This is found in their springing: the pendentives of the central vault rested on the extrados of the supporting arches, while the pendentives of the other vaults lay against the face of the arches.
- Earlier reconstructions showing the rectangular bays of the nave covered by vaults built on an elliptical plan are not necessarily correct.<sup>27</sup> By inserting a pendentive border with varying thickness between the supporting arches and the pendentives in these bays, the construction of a spherical vault on a circular plan became possible.

- There is a structural difference between the pendentives of the west cross arm, made with bricks laid in arched courses, and the ones of the transept, made with bricks laid in circumferential brick courses.

Although most of the fragments examined derive from the main bays of the church, they reveal the use of at least two different vaulting methods. This seems to be at odds with the uniform vaulting pattern championed in previous graphic reconstruction proposals. The constructional differences between the main vaults of the nave and the ones of the transept could well indicate the coexistence of two different forms of spherical vaults: pendentive domes and domes on pendentives. On the other hand, these differences could simply reflect different ways of constructing the same type of vault. To resolve the dilemma between the above two interpretations, and to establish how homogeneous the vaulting pattern was, it is necessary to investigate a series of written records that provide useful clues for the architectural space of the church and the way its vaulted ceiling was experienced in different periods.

### **Textual Representations of the Vaulted Structure**

The survival of written testimonies, referring more or less directly to the vaults of St. John, is something exceptional among the early Byzantine churches of west Asia Minor. Even in the records referring to St. Mary at Ephesos, so closely linked with the Ecumenical Council of 431, no hints about architectural form are to be found. The existence of numerous written records referring to our church can be attributed to the links of this particular church with imperial initiative, as well as to its role as a key monument of one of the most important and lasting cities of the Byzantine Empire.

Cyril Mango, one of the most important living authorities on Byzantine architecture, has cautioned scholars of the “opacity” of Byzantine written records. “The written records of Byzantine civilization,” he writes, tend to “speak in clichés and seldom come down to the particular.”<sup>28</sup> Hence we need a critical reading of the documents, combined with an awareness that in this particular case, the archaeological evidence available is not only more plentiful than the documentary evidence, but also more unequivocal.

Ibn Battuta (1304–1368), a Moroccan explorer known for his extensive travels in Europe, Africa, and Asia, has left us a monumental account of his journeys, entitled *Rihla*, which contains one of the last written records on St. John's vaults. Written probably less than a century before the

church was destroyed, Ibn Battuta's description of the church is a puzzle for anyone trying to compare it to the archaeological remains.<sup>29</sup> The traveler mentions that the church had no less than "eleven domes of varying sizes." Hörmann seems to have taken this statement at face value. He envisioned domes not only above the six main bays, but also above each of the five bays of the gallery over the narthex.<sup>30</sup> This literal interpretation of Ibn Battuta's testimony overlooks both the fact that the Moroccan author fails to give any clues about the exact form or location of the eleven domes, as well as the exaggerated statements that seem to compromise his credibility. Indeed, Ibn Battuta also refers to the existence of basins with fountains under each dome of the building, a characteristic that is hardly typical of Byzantine Ephesos. Because of these inaccuracies, one should not give full credence to the number given by Ibn Battuta. Nevertheless, for all its imprecisions, this record constitutes significant evidence for the prominence of the vaults in the architectural experience of the monument. It also indicates that in spite of the use of repetitive domes, the vault pattern and dimensions of domes were not entirely uniform.

An interesting reference to the domes of the church occurs in one of the letters of Georgios Tornikes, who was the Metropolitan of Ephesos in the middle of the twelfth century.<sup>31</sup> This utterly pessimistic report refers to the bad condition of the domes, which caused parts of their mosaic revetment to fall on the floor.<sup>32</sup> Tornikes referred to St. John's domes as "*sphairomata*" (literally, "spheroids"), a term that could either describe hemispherical or shallow domes. One might argue that the damage mentioned by Tornikes would have been more likely in a shallow dome rather than in a hemispherical one. Indeed, in a shallow dome, because of the flatness of the profile, the stability of most of the surface elements (such as a mosaic's tesserae) depends almost entirely on their adhesion with the mortar bed. This adhesion can easily be undermined by decay and earthquake action, making mosaic detachment and fall a frequent phenomenon, as Tornikes complains. Of course, this is not a strong argument, and to establish the use of pendentive domes in the church, more explicit evidence, or at least, further indications are required. Such indications can be found in the account of Procopius, which is contemporary to the Justinianic remodeling of the vaulted church.

Procopius of Caesarea is the author of the unique account of the rebuilding of St. John's by Justinian. Included in the sixth-century historian's monumental survey of Justinian's building campaigns, and probably written around 554, this document does not say a word about the original form of the church.<sup>33</sup> Procopius's only hint in this respect is that the church, after Justinian's modification, "resembles very

closely in all respects, and is a rival to, the shrine which [Justinian] dedicated to all the Apostles in the imperial city."<sup>34</sup> This claim should be given much credit, as it comes from a writer contemporary to the inauguration of both buildings and in close contact with the emperor who commissioned them.

Procopius suggests that the visualization of the Justinianic phase of the church of the Holy Apostles at Constantinople, a church completed around 550, can give us an insight into the missing vaults of St. John at Ephesos. Unfortunately, the Constantinopolitan church was demolished in 1469. The building that Procopius compared with St. John can only be visualized through its sixth-century description by the same author. Subsequent descriptions by Constantine of Rhodes and Nikolaos Mesaritis are not relevant here, as they refer to the form of the church of the Holy Apostles after its ninth-century remodeling.<sup>35</sup>

Describing the vaults of the Holy Apostles, Procopius states that "the portion of the ceiling which is above the sanctuary (i.e., the spherical vault over the crossing) is built on the same design as the one of Hagia Sophia."<sup>36</sup> This description probably refers to Hagia Sophia's short-lived first dome, which collapsed in 558.<sup>37</sup> This was shallower than the present one, and its profile approximated the one of a pendentive dome.<sup>38</sup> It was such a shallow dome with a dense sequence of windows in its base that resembled the central dome of the Holy Apostles. Procopius mentions that similar but windowless domes surmounted the four projecting arms of the Holy Apostles.<sup>39</sup> Therefore, the sixth-century author, describing the Holy Apostles, gives us an outline of a cruciform building, with all its five major bays covered by shallow domes on pendentives, the central one being raised on a fenestrated drum.

The relevance of this description to the reconstruction of St. John is open to discussion. Procopius's statement concerning the similarity between St. John and the Holy Apostles does not necessarily suggest that the vaults of the two monuments were identical. Indeed, it may be argued that the same statement would be just as valid in case some or all of St. John's main vaults were hemispherical domes on pendentives, a kind of vault similar but not identical to the pendentive domes of the Holy Apostles. It may well be that Procopius did not consider the difference between a hemispherical dome and a shallow one to be important enough. However, if this was the case, then it is difficult to explain where the sixth-century author found the similarity between the two monuments. Their plans were quite different. The Ephesian monument had six major vaulted bays whereas the Constantinopolitan one had only five. Unlike Holy Apostles, St. John had a considerably elongated plan.

Its accentuated longitudinal axis must have given the Ephesian church a dynamic directional impact absent from the church of the Holy Apostles, with its quasi-centralized plan. These differences suggest that if there was a resemblance between the two buildings, this resemblance must have concerned either elements of their elevation or the design of specific bays, seen from the interior. In both these areas, the appreciation of the form of the vaulting would probably have been crucial in perceiving possible resemblances. Therefore, it is likely that one of the elements that made St. John and the Holy Apostles similar was the use of vaulting in the two monuments. And, as the shallow domes on pendentives were among the dominant characteristics of the Holy Apostles, it is probable that the same vault form was used for St. John as well.

According to this hypothetical interpretation, Procopius's description seems to be an indirect indication that shallow domes covered St. John's major bays. This evidence however, relying on only one of the possible interpretations of the words "close resemblance," used by Procopius, a person who was neither an architect nor a builder, is far from conclusive. The various uncertainties and ambiguities surrounding this examination prevent us from using it as proof for shallow domes. The account examined is nonetheless useful in another way: by raising the possibility of shallow domes, one that has often been overlooked, it warns the researcher against the use of stereotypical reconstruction solutions.

The examination of written records seems to justify Mango's caveat cited in the beginning of this section. Indeed, the records examined do not provide sufficient evidence for a specific vaulting pattern. Still, they suggest the possibility that the major bays were covered by a vault form other than the full dome on pendentives, which appears in most reconstructions. The awareness of such a possibility calls for a re-examination of the archaeological evidence presented in the beginning of this article. The interpretation of vault fragments in the light of comparable examples from other vaulted buildings can provide further evidence for the nature of the original vaults.

### **Vaulting Patterns in Comparable Coeval Churches**

Procopius expected his readers to understand something about the form of the church of St. John through its comparison with the church of the Holy Apostles. This seems to suggest that the study of monuments with a structure similar to the one of St. John can be relevant to the study of the Ephesian church. Indeed, the examination of late antique

and early Byzantine monuments in which extensive parts of their vaults have been preserved can help to interpret fragments of St. John's vaults, which, when isolated, seem to be little more than amorphous lumps of brick and mortar.

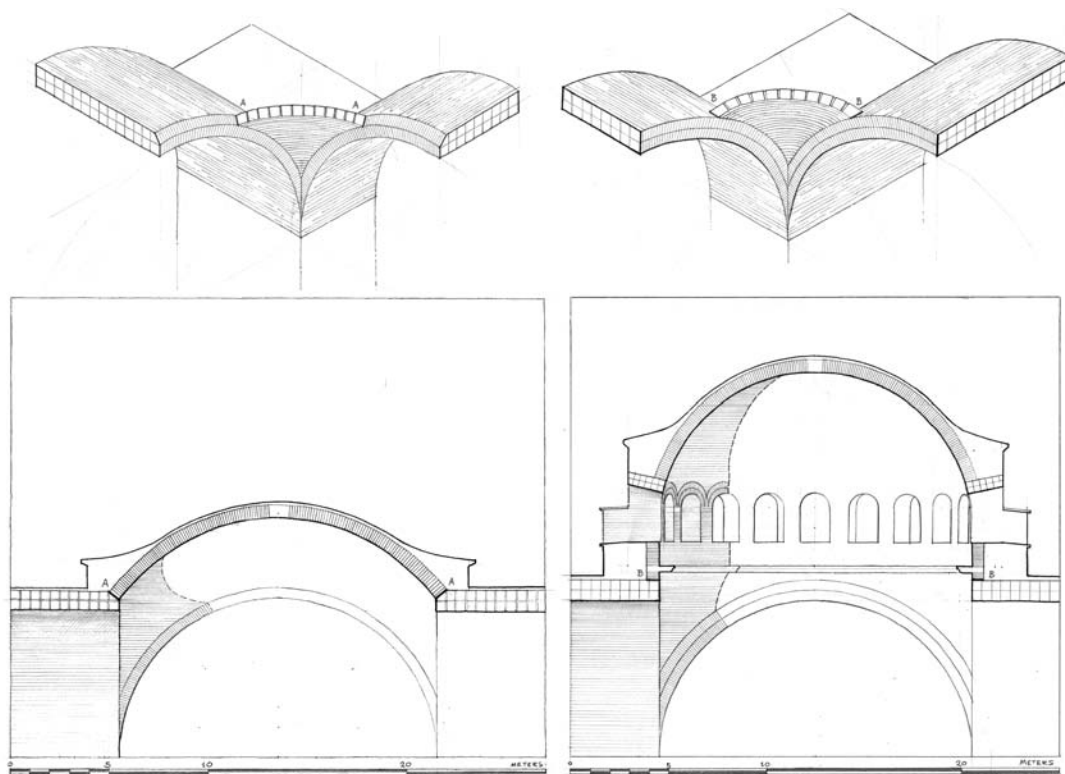
The idea for the study of the vault fragments of the church of St. John within the broad context of early Byzantine vaulting sprang from the observation that their structural fabric is reminiscent of surviving vaults found in other monuments. The pendentive remains observed in fragments A, B, and C bring to mind the spherical vaults of Hagia Sophia and St. Eirene in Constantinople. The arched brick courses in fragments G and H evoke a rarely encountered type of vault found in late antique and early Byzantine mausolea such as the ones at Spalato (Split) and Side. The composite brick pattern of fragment D evokes the narthex vaults of Basilica B at Philippi. The detailed study of all these monuments is therefore essential to the interpretation of the vault fragments of St. John at Ephesos.

### ***Spherical Vaults with Circumferential Courses in Constantinople***

Most of the vault fragments analyzed originate in the lower portion of the vaults, specifically, from the level of the springing of the arches and pendentives; not a single fragment of the caps has survived. We can explore the potential of these low-level fragments to offer evidence for the reconstruction of the upper portions of the vaults by comparing them with the technique of vault construction in surviving coeval vaulted churches, such as Hagia Sophia and St. Eirene in Constantinople. Both these churches have hemispherical and shallow domes on pendentives in their structural fabric. By examining how the springing of their pendentives indicates the overall form of the spherical vaults, we can decipher the factors that distinguish the pendentives that would have carried a hemispherical dome from the ones that would have supported the shallow cap of a pendentive dome. As these pendentives look identical, the constructional differences between them are often overlooked. Still, identifying these differences help to interpret the low-level pendentive fragments of St. John, establishing whether these fragments belonged to pendentive domes or to pendentives supporting full, hemispherical domes.

The vault structure of the church of St. Eirene juxtaposes a hemispherical dome on pendentives (raised on a short drum and pierced by windows in its base) and a major pendentive dome (Figure 18). W. S. George erroneously considered the lower parts of the two vaults to be identical.<sup>40</sup> He failed to notice that each vault comes in contact with the supporting arches in a different way: the pendentive dome lies against the sloping face of the outer ring of the arches, whereas the





**Figure 18** St. Eirene at Constantinople, cutaway axonometric drawings and cross-sections of the two spherical vaults over the nave showing the interface (A, B) between the vault and the broad arches. In the pendentive dome (left) the pendentives spring from the sloping face of the supporting arches. In the hemispherical dome on pendentives (right) the pendentives spring from the extrados of the supporting arches (author's drawing)

pendentives carrying the full hemispherical dome spring from the extrados of the arches. Comparing the faces of the supporting arches can prove this. On the one hand, the broad arches that carry the hemispherical dome have both their arch rings exposed. On the other hand, the arches supporting the pendentive dome have only their inner arch ring exposed. The existence of a concealed outer ring in these arches can be deduced by observing the transverse arch between the pendentive dome and the main dome: the face of this arch toward the dome consists of two rings, whereas the face toward the pendentive dome only has one ring.

This confirms that the pendentive dome springs from the sloping face of the arches, whereas the pendentives carrying the full dome spring from the extrados of the arches, leaving their faces fully exposed. The nature of each springing seems to reflect the structural behavior of the corresponding vault. The sloping face of an arch is better suited to counteract the increased lateral thrusts of a pendentive dome.<sup>41</sup> At the same time, the extrados of an arch seems to be more appropriate for the firm seating of pendentives that carry the considerable weight of an entire hemispherical vault, such as the dome of St. Eirene.

A similar pattern of difference between the lower portions of pendentive domes and domes on pendentives occurs in Hagia Sophia. This can be appreciated by comparing the springing of the pendentive domes of the gallery with the pendentives of the central dome. There is no doubt that the pendentive domes of the gallery spring from the face of the supporting arches: the latter are completely covered by the vault shell.<sup>42</sup> Also, it is very probable that the pendentives of the central dome lie on the extrados of the four broad arches.<sup>43</sup> We realize that, although the lower portions of the two vaults are similar, there is an obvious difference in the way they connect with the supporting arches.

The examination of the spherical vaults of Hagia Sophia and St. Eirene reveals a way to deduce the overall geometrical form of a spherical vault whose upper portion is missing: where the shell of the pendentive connects to the extrados of the supporting arch, leaving its face exposed, then the vault is a full dome on pendentives, but where the pendentive is attached to the sloping face of the arch, then the vault is a pendentive dome. As we have seen, this difference between the pendentive domes and domes on pendentives responds to structural considerations applicable to all

spherical vaults.<sup>44</sup> Therefore, it probably occurred in St. John at Ephesos as well.

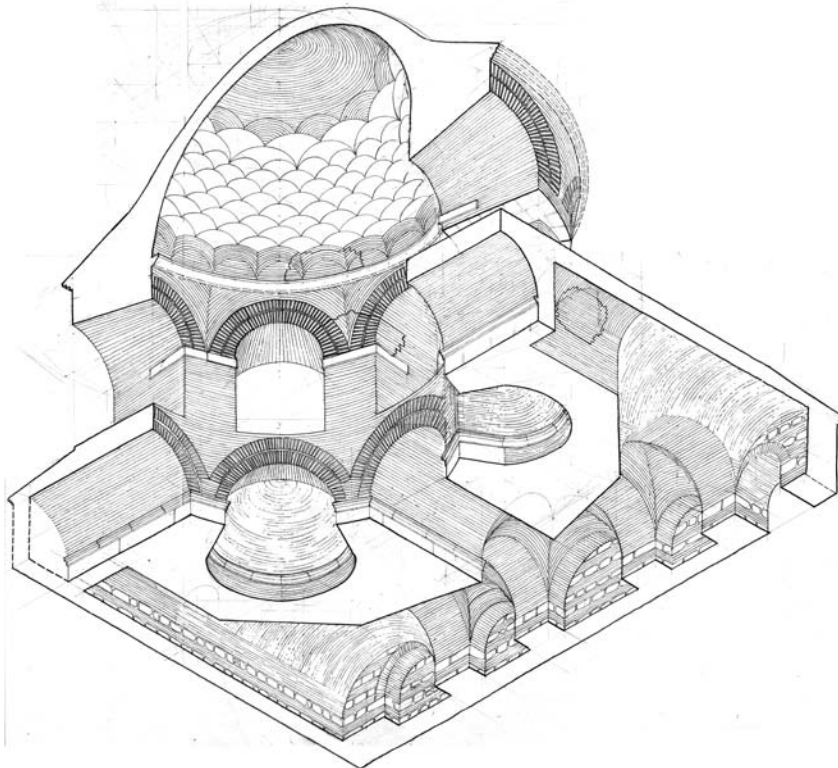
The distinction between the springing of a pendentive dome and the one of a dome on pendentives helps to interpret vault fragments A, B, and C. The pendentive remains in fragments A and B connect to the sloping face of the arches. This detail is typical of pendentive domes such as the one over the west bay of St. Eirene, or the ones surmounting the corner bays of the gallery of Hagia Sophia. Therefore, the pendentive remains in fragments A and B should be interpreted as parts of pendentive domes. Also, vault fragment C includes the remains of arches with their faces entirely exposed; any pendentives must have rested on the extrados of the arches. This particular construction detail seems to characterize the springing of great hemispherical domes on pendentives, such as the ones of Hagia Sophia and St. Eirene. Therefore, the relevant detail of fragment C should be interpreted as part of a pendentive that carried a hemispherical dome.

#### *Spherical Vaults with Arched Brick Courses: from Spalato to Ephesos*

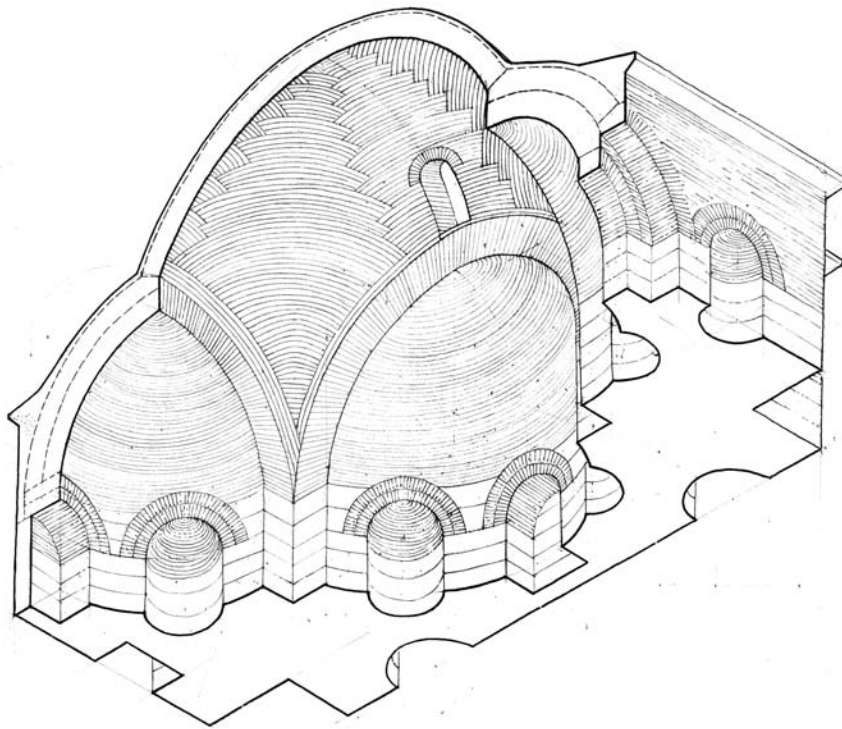
If the vault fragments of St. John's transept are reminiscent of standard vaulting practices employed in Constantinople,

the fragments recorded in the nave, with their arched brick courses, are indicative of a rare technique, only sporadically employed in early Byzantine architecture. A similar technique seems to have been used in the dome of the mausoleum in Diocletian's Palace at Spalato, in the shallow dome covering the east mausoleum at Side, as well as in the shallow dome over the Crypt of St. Demetrios in Thessaloniki. Despite its sparseness outside west Asia Minor, this vaulting technique must have occurred frequently in Ephesian monumental architecture. Indeed, the reconstruction of structures such as the dome of the baptistery of St. Mary in Ephesos,<sup>45</sup> and the vault surmounting an octagonal reception hall, or Nymphaeum in the same city,<sup>46</sup> makes early Byzantine Ephesos the locus classicus of the use of this vaulting pattern (Figure 19).

The remains of the shallow dome on pendentives of the east mausoleum at Side include parts that resemble the pendentive remains of fragments G and H, recorded in the nave of St. John (Figure 20).<sup>47</sup> It is interesting to note that both the central space of the mausoleum and the west bays of St. John are oblong in plan. Asymmetrical borders as well as arched brick courses occur in the pendentives of both monuments. Therefore, it is plausible that the dome at Side is indicative of the nature of the vault structure to which fragments G and H belonged.



**Figure 19** St. Mary at Ephesos, reconstructed axonometric drawing, indicating the surviving traces of vaulting (author's drawing)



**Figure 20** East Mausoleum at Side (South Asia Minor), reconstructed cutaway axonometric drawing, showing the asymmetrical pendentive borders and the arched brick courses in the dome (author's drawing)

The dome of the Mausoleum of Diocletian, within the famous palace the emperor built at Spalato at the end of the third century, also comes to mind when examining the same fragments.<sup>48</sup> Indeed, the double pendentive shell and the arched brick courses observed in these fragments occur in Spalato as well. There, we find a vault pattern divided in units whose shape is reminiscent of fish scales. Each of the lower scales consists of sixteen to eighteen arched brick courses. The same number and shape of brick courses are found in the pendentive unit preserved in fragment G. The similarity of vault fragments G and H with vault details observed at Spalato and Side make the vaults of these monuments plausible models for the reconstruction of the nave vaults.

These models, however, have to be used with particular caution. Although the fragments of St. John's nave vaults have some points in common with the structure of the domes of the mausolea at Side and Spalato, an essential part of these fragments is missing in these two examples: in fragment H, the arched courses were crowned by segmental arches built with bricks laid radially. Is this an indication of a dome where each scale-like unit is covered by a segmental brick arch? This possibility seems to be confirmed by the examination of the shallow semidome in the substructures of St. Dimitrios in Thessalonika. This vault also seems to have consisted of arched brick courses arranged in a network of interlocking units. Between these units there are small

segmental arches, built with radial bricks. This peculiar structure, incorporating all the elements of fragments G and H, is suggestive of how the domes over the nave might have looked. Yet, it remains that the vault in St. Dimitrios is only known indirectly through a diagrammatic sketch and a twentieth-century reconstruction; therefore, any connection with St. John must remain hypothetical.<sup>49</sup> The evidence from the better-preserved vaults in Spalato and Side is much clearer.

An examination of the different applications of this versatile vaulting technique, adaptable to domes as different as the ones at Side, Spalato, Thessalonika, and Ephesos, leads to two conclusions. Firstly, the three structures examined consist of bricks set in segmental arched courses. Secondly, this particular technique is used in spherical vaults with a continuous, stable curvature from springing to apex. Indeed, both in Spalato and Side, the dome has the same curvature as the pendentives. These characteristics could serve as a guide in the reconstruction of St. John's nave vaults.

### *Secondary Vaults in the Basilica B at Philippi*

Leaving the primary vaults over the nave, and moving to the secondary ones that covered the aisles, we discover that the archaeological evidence at our disposal is more limited, and the choice of comparable examples trickier. Indeed, as we have seen, fragment D, the meager surviving part of the aisle vaults, provides limited proof for reconstruction. As a result,



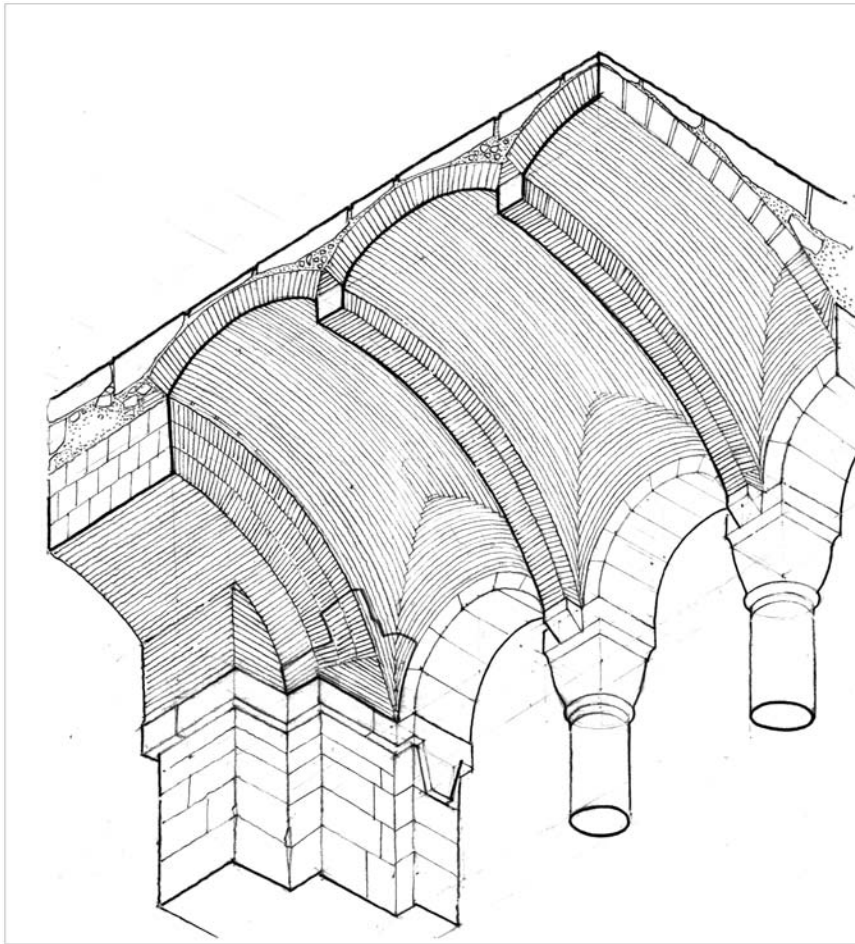
**Figure 21** Basilica B at Philippi, detail of aisle vault fragment, showing remains of the gallery floor (author's photo)

it is difficult to establish the form of the aisle vaults and the way their shell was inscribed into the surrounding structure. Given the limits of the archaeological evidence available for these vaults, the investigation of comparable examples assumes a considerable weight in their reconstruction.

A vault fragment with many similarities to fragment D is found in the ruins of Basilica B at Philippi (Figure 21). This church is almost contemporary with St. John at Ephesus, and seems to illustrate the use of fairly similar vaulting forms, techniques, and materials.<sup>50</sup> Indeed, in both monuments we find spherical vaults over major rectangular bays, as well as vaults with their bricks set pitched on their edge. Furthermore, the size of bricks and thickness of mortar beds are similar in the two monuments. But what makes Basilica B a parallel in this context is the similarity of its aisles and aisle

vault fragments to the ones of St. John. Indeed, the aisles of both churches seem to have been divided in oblong cells, and their aisle vault fragments consist largely of pitched brick courses laid parallel to the supporting arches, so as to interlock along diagonal ridges, or groins. Although the aisle vaults of Basilica B are not well preserved, their study may give us an insight into the nature of St. John's original aisle vaults.

Basilica B clarifies an aspect of the aisle vaults, which could not be properly understood until now: the original shape and size of the groin of fragment D. At Philippi, we can establish that the groins springing from the four corners of each small bay did not reach the crown of the vault. Instead, the pair of groins in each of the narrow sides met before reaching the apex. As the graphic reconstruction



**Figure 22** Basilica B at Philippi, reconstructed cutaway axonometric of the aisle vaults (author's drawing)

in Figure 22 demonstrates, these groins marked the line of intersection between a wide, longitudinal barrel vault, and a series of narrower, transverse barrel vaults, which corresponded to the arches of the side colonnades. It is highly probable that fragment D formed part of a similar vault pattern. Indeed, the two main vaulted surfaces of this fragment seem to have belonged to barrel vaults of unequal size: the longitudinal barrel vault seems to have been both higher and wider than the transverse ones.

One of the most interesting details observed in Philippi is the floor of the gallery (see Figure 21). This floor, laid on top of the vault shell, consists of reused marble blocks (mainly parts of ancient architraves, capitals, and cornices). Traces of a similar floor were discovered in 1962 at the church of St. John.<sup>51</sup> It is therefore probable that the gallery floor was built along the same lines as the surviving one at Basilica B. At Philippi, the thinness of the solid infill between the apex of the vault shell and the gallery floor, probably less than 10 centimeters, is remarkable. There is a contrast between the slenderness of this component and the excessive thickness given without adequate substantiation to this same

component in St. John's various reconstructions.<sup>52</sup> The thin gallery floor structure at Philippi seems to indicate that in Ephesus, the inert fill between aisle vaults and gallery floor was much thinner than the one appearing in most graphic reconstructions of the monument.

Another aspect of St. John's reconstruction that the aisle vaults of Basilica B could clarify has to do with the degree of structural continuity and bond between vaults and supporting arches. At Philippi, the shell of the aisle vaults is independent of the structure of the arches. The team that restored a portion of St. John's aisle vaults on site has overlooked the possibility for such an interruption between vault and arch (Figure 23). Yet, this interruption is by no means unique to Basilica B at Philippi; it is also typical of the Byzantine tendency to separate unequally loaded parts of the structure.<sup>53</sup> There is no reason to believe that St. John's deviated from this practice. It is likely that the church's side aisle vaults did not merge with the arches that carried them, but were separated by a joint.

The examination of aisle vaults in Basilica B and St. John's reveals some of the stylistic concepts that influenced the design. Both in Ephesus and Philippi, there is a



**Figure 23** St. John at Ephesos, nave, mid-twentieth-century partial restoration of the south colonnade (author's photo)

tendency to make the aisle vaults as compact as possible. The level of their springing, which coincides with the one of the supporting arches, is the lowest possible, and the thickness of their shell and overlying floor have been reduced to a minimum. The compression of these vaults must have minimized their aesthetic impact on the design of the elevations of the internal screens to such an extent that it would have been difficult to tell if these screens concealed a timber floor or a vault structure.

If St. John's secondary vaults were built according to the standard sixth-century vaulting patterns, then it is unlikely that the compactness and absence of vertical emphasis found in the aisle vaults occurred in the gallery vaults as well. Indeed, the following examination of a series of Justinianic vaulted churches shows that even when galleries and aisles have roughly the same plan, their vaults are often different.

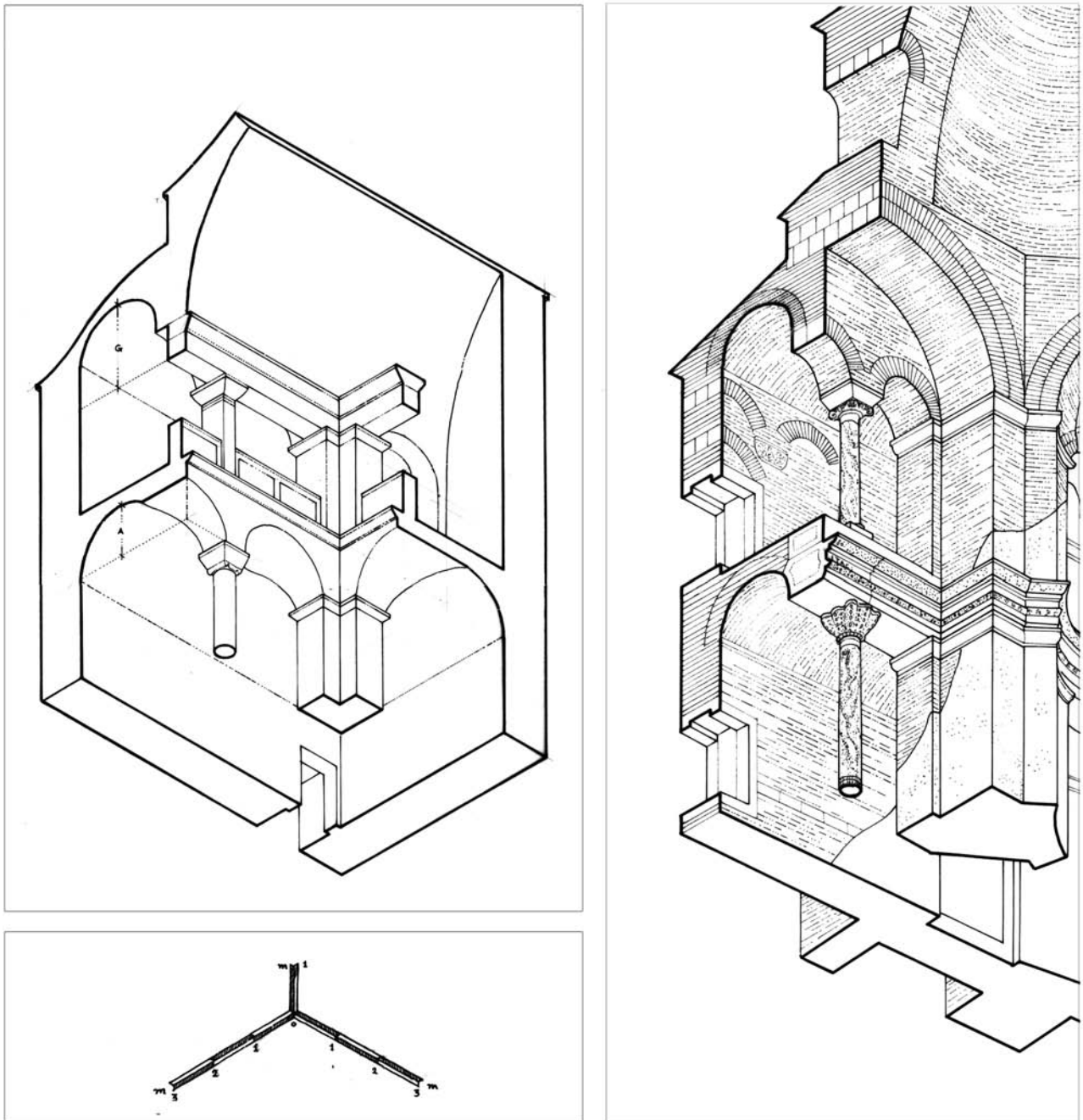
#### *Gallery Vaults in Early Byzantine Churches*

The archaeological evidence for St. John's gallery vaults is extremely limited. Here we rely on the photograph of a fragment that comes from the vicinity of the gallery vaults, but does not seem to have included any vaulted parts. An overview of gallery vaults in Justinianic churches could not fill the

lacunae created by this limited evidence. Such an overview could, however, bring to consideration the range of early Byzantine forms and building techniques employed in gallery vaults. Considering these forms and techniques is crucial to the creative interpretation and constructive use of the limited materials at our disposal.

Hagia Sophia and Sts. Sergios and Bakchos at Constantinople, as well as Hekatontapyliani on the island of Paros in the Cyclades preserve large parts of their original gallery vaults. Of course, this is not a homogeneous group. There are important typological and constructional differences between these churches, and their kinship with St. John at Ephesos is hardly obvious. Still, in this context, the design of their secondary vaults is useful to the process of reconstruction, as a comparison of the aisle and gallery vaults in each church is likely to reveal design principles that may apply to St. John's secondary vaults.

The aisles of the transept of Hekatontapyliani are covered by a barrel vault springing from the same level as the arches of the colonnade, and intersected by a series of transverse barrel vaults. This compact vaulting pattern is not repeated in the galleries. The latter are "roofed with barrel vaults which have their springing line above the crown



**Figure 24** Hekatontapyliani (Paros) and Sts. Sergios and Bakchos (Constantinople), cutaway axonometric drawings of the secondary vaults. In the south transept of Hekatontapyliani (left), the distance between the apex of the vaults and the top of the capitals is greater in the gallery (G) than in the aisle beneath it (A). Similarly, in Sergios and Bakchos (right) the profile of the gallery vaults is steeper than the one of the aisle vaults (author's drawings)

of the . . . arches of the upper arcade."<sup>54</sup> In this church, the vaults of the gallery seem to be a steeper version of the aisle vaults below them (Figure 24).

This last characteristic echoes, to a certain extent, the pattern of the secondary vaults of Hagia Sophia. Here

the north and south gallery vaults, although different from the ones in Hekatontapyliani's transept, also seem to constitute a steeper version of the aisle vaults. The aisles are covered with groin vaults, while the galleries above them are roofed with pendentive domes. Auguste Choisy claimed

that “this distinction between aisle and gallery vaults is not limited to Hagia Sophia,” but is also found in many other Byzantine monuments.<sup>55</sup>

The church of Sts. Sergios and Bakchos seems to confirm the tendency to give the gallery vaults a steeper profile than the one of the vaults over the aisles (see Figure 24).<sup>56</sup> Indeed, the south ambulatory juxtaposes a barrel vault on the ground floor, and a series of domical groin vaults on the floor above. In the north ambulatory, the barrel vault of the gallery, with its springing raised considerably higher than the apices of the supporting arches, contrasts with the shallow barrel vault immediately below, which rests directly on a horizontal entablature. Irrespective of the nature of the vaults each time, the design of the gallery vaults receives a greater vertical emphasis than the one of the aisle vaults.

We realize that even though galleries and aisles often have the same plan, the gallery vaults do not reproduce the pattern of the aisle vaults. Still, the vault forms in these two levels are seldom entirely different. On the contrary, there is a tendency to produce variations on the same theme by making the gallery vaults a steeper version of the aisle vaults. This conclusion calls for a return to St. John’s vault fabric to investigate whether the vaults of the gallery were not a mechanical reproduction of the compact barrel vaults of the aisles, like the one championed by earlier reconstructions, but followed a different layout, which gave a greater emphasis to the vertical axis.

## Reconstruction

The archaeological and written materials discussed so far have yielded crucial evidence for constructing a plausible model of St. John’s vaulted roof. It is now possible to establish the original form and structure of the vaults over the major bays of the transept and the nave. There is also sufficient proof for a credible construction of the aisle vaults in the west cross arm. However, some areas remain obscure. Visualizing the vaults over the chancel and the aisles surrounding the transept involves a certain degree of speculation, and the form of the vaults over the narthex is still unknown. However, these parts represent only a small part of the overall vault structure. Despite this lacuna, this study has presented one of the most complete representations of the vaults to date, the first one to evaluate the full potential of the remains to provide proof for reconstruction.

Following a methodology based on the study of construction details, we have so far examined sections of the vaulted structure separately. In conclusion, it is helpful to synthesize all the reconstructed parts and summarize the

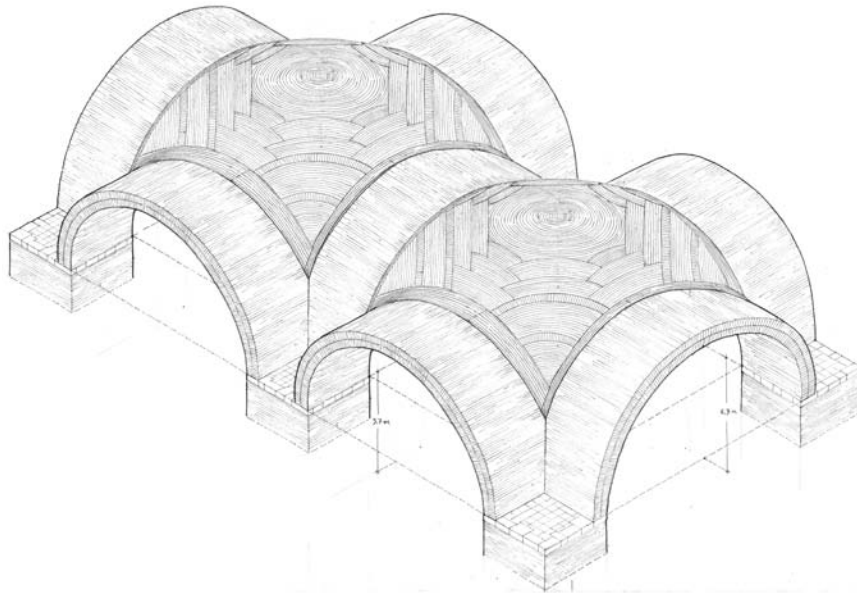
evidence on which the visualization of the vaults has been based, starting with the vaults over St. John’s six major bays. This vast vaulted structure was by no means as homogeneous as Hörmann believed. The fragments discovered indicate the use of two different vault forms and two different structures. Although the use of two forms—full domes on pendentives and pendentive domes—seems to have obeyed a specific design concept, the use of different structures in otherwise identical vaults is harder to explain. The use of arched brick courses over the nave and circumferential courses over the transept could indicate that the two parts belong to different building phases. For this reason, these two groups of major vaults will be presented separately.

The great spherical vaults over the nave sprang from semicircular arches of unequal height. Indeed, given the oblong shape of the bays, the transverse arches spanning the nave must have been higher than the arches covering the lateral screens. As we have seen, this height difference must have complicated the erection of full domes on pendentives over these bays. This problem could have been resolved in two ways. The first consisted of raising the apex of the narrow arches to the same level as the crown of the wide arches. A second solution was to abandon the form of the full dome altogether, in favor of a pendentive dome, that is, a vault in which pendentives and shallow dome form a continuous spherical surface. This solution is observed in the west bay of St. Eirene, in the corner bays of the gallery of Hagia Sophia, and, probably, in the nave of Basilica B, at Philippi.<sup>57</sup>

Vault fragments G and H indicate the existence of similar pendentive domes in the nave of St. John. The peculiar structure of these fragments, consisting of arched courses of brick, is only found in spherical vaults in which the pendentives and the dome are co-spherical. This is hardly surprising; a shell made of arched brick courses cannot adapt to a change of curvature as easily as a shell made of horizontal, circumferential courses. It is difficult to imagine how pendentives made of arched courses could form the horizontal upper ring required for the erection of a hemispherical dome. Pendentives built in this way are more likely to have continued above the supporting arches, forming a pendentive dome.

The builders maintained that the main, central portion of these pendentive domes would be circular, rather than oval in plan. This was achieved by giving the pendentive border on top of the narrow arches more than twice the thickness of the border on top of the wide arches. Thus, four arched surfaces of equal height were created, ready to support a pendentive dome with a circular plan. Evidence from fragments G and H excludes the possibility of the existence of domes built





**Figure 25** St. John at Ephesos, nave, reconstructed axonometric of pendentive domes (author's drawing)

on oval plans, despite the fact that such vaults have often been considered the only form adaptable to rectangular bays.<sup>58</sup>

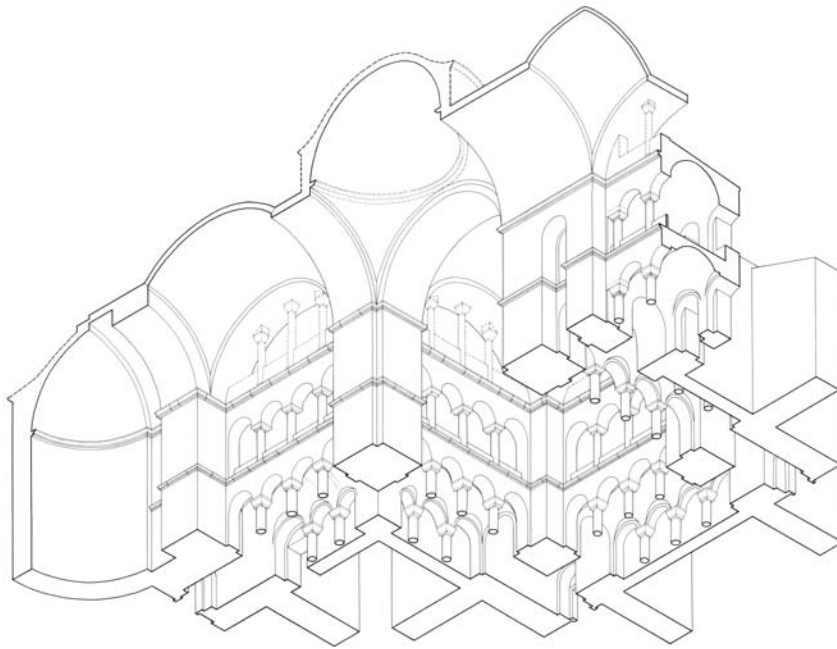
The interpretation of the same fragments and their comparison with similar construction details elsewhere provided the opportunity to study this unconventional vault structure in detail. Like the domes of the mausolea at Side and Spalato, the pendentive domes of St. John at Ephesos could have consisted of arched courses of brick laid both diagonally across the corners of the vault, and parallel to the arches (Figure 25). These courses probably formed interlocking and superimposed wedge-shaped components crowned by arches made of radial bricks. The result would have appeared as a network of superimposed segmental arches alternating with an infill of arched brick courses.

The vaults surmounting the bays of the transept are easier to visualize. The reconstruction proposed in this article is based on evidence from pendentive fragments that still survive and can be examined in detail. None of these fragments preserves parts of the central portion of the vaults, hence the dilemma between pendentive domes and domes on pendentives.<sup>59</sup> The interpretation of vault fragments A, B, and C presented here for the first time, grounded by reference to the details of spherical vaults in coeval Constantinopolitan churches, resolves this dilemma. Indeed, these low-level fragments, and in particular the detail of the connection between pendentives and arches, can be used as proof for the overall form of the vaults.

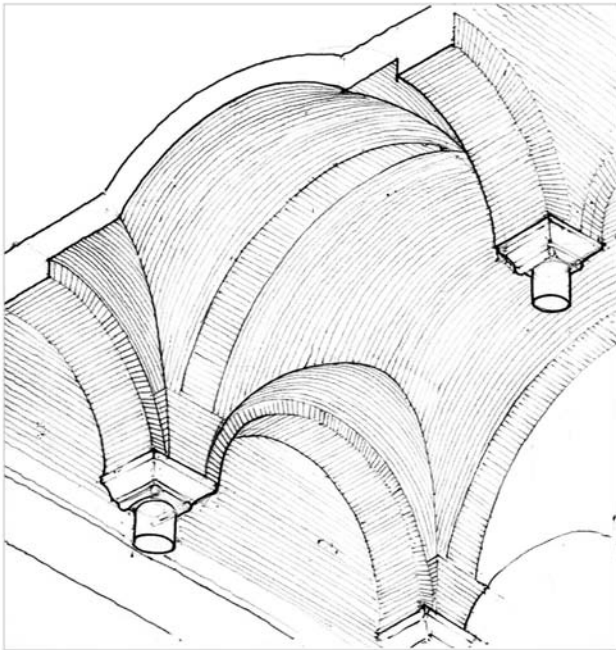
The connection between arches and pendentives in vault fragments A and B is identical to the one observed in the pendentive domes of St. Eirene and Hagia Sophia.

However, the equivalent detail in fragment C is typical of a full dome on pendentives. Therefore, the major north and south vaults of the transept can be visualized as pendentive domes and the central vault as a hemispherical dome on pendentives. It would be tempting to reconstruct this central vault with a low, external drum pierced by windows, following the example of most contemporary vaulted churches. The fragments examined suggest that the main shell of the transept vaults was built with bricks laid in circumferential courses with a gradually increasing inclination from the horizontal. This vault form and structure constitutes a fair interpretation of archaeological evidence, and is credible architecturally. Indeed, the prominence of the central dome, which constitutes the climax of this vaulting pattern, not only echoes the emphasis given to the crossing by the cruciform plan, it is also regularly encountered in early Byzantine religious architecture (Figure 26).

In the shadow of the vast vaulted ceiling that crowned the central bays of the church lay the modest secondary vaults, which covered the aisles and galleries. The reconstruction of the aisle vaults has drawn evidence from two sources: fragment D, their only surviving part, and the aisle vaults of Basilica B at Philippi. The groin-like ridge in fragment D has been interpreted as an indication for the interpenetration between a wide, longitudinal barrel vault and a series of transverse barrel vaults.<sup>60</sup> These vaults had a composite structure. Their springing consisted of horizontal, oversailing courses of brick, while their upper part was built with bricks laid on edge. The vertical brick courses of the vaults interlocked along the diagonals of each bay, creating groins (Figure 27).



**Figure 26** St. John at Ephesos, reconstructed axonometric (drawing by Carolina Vasiliikou and the author)



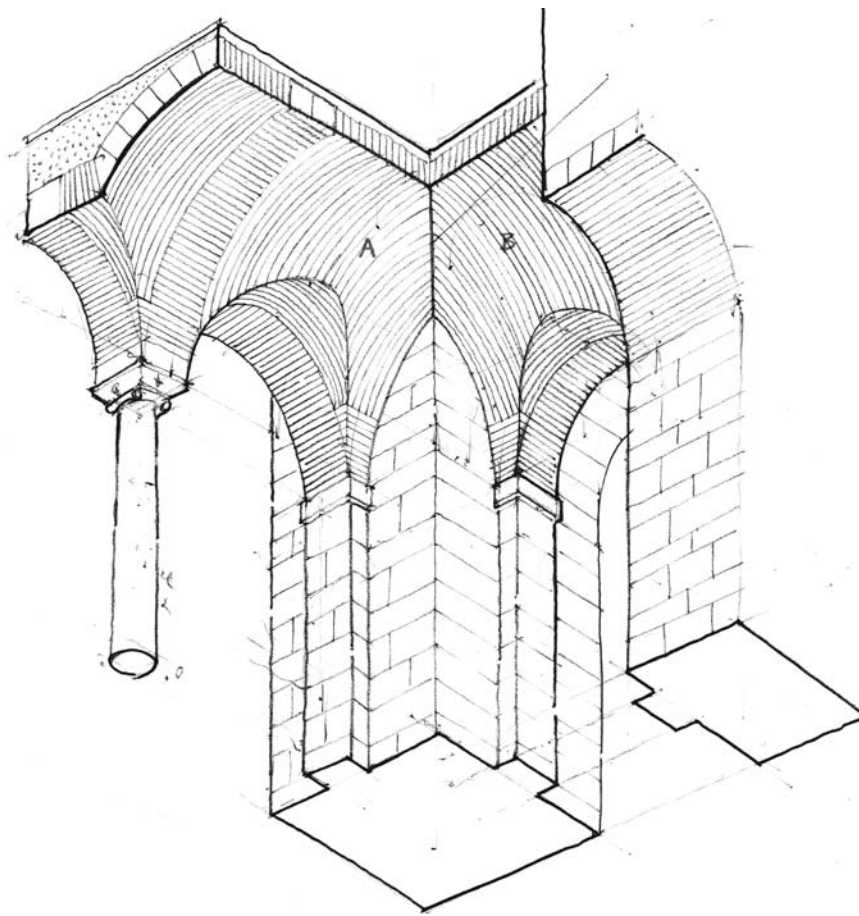
**Figure 27** St. John at Ephesos, reconstructed axonometric of typical aisle vault (author's drawing)

Vaults and supporting arches did not form part of the same shell. The full-scale reconstruction carried out on site is misleading in this respect. Indeed, as fragment D clearly shows, not only was the shell of the aisle vaults separated from the arches, it also had a different structure from them—with pitched brick courses as opposed to radial ones.

The secondary bays of the east part of the church had the same shape and proportions with the ones of the west cross arm (with the exception of the external walls, where independent columns take the place of pilasters). This, however, does not automatically suggest that the two parts had similar aisle vaults. Even if east and west aisle vaults were similar, a variation would have been required in the irregularly shaped bays next to the four piers of the crossing. The protrusion of the piers, which gives these spaces an L-shaped plan, suggests that each of them was covered by two barrel vaults, probably built with pitched bricks, and interlocking along a diagonal line of intersection (Figure 28).

The absence of surviving fragments from the shell of the gallery vaults limits our knowledge about their structure. Nonetheless, the photographs of fragment J are sufficient to establish that the vaults of the galleries were different from the ones of the aisles.<sup>61</sup> They probably consisted of a barrel vault springing from a level above the crowns of the supporting arches. The comparisons drawn with churches such as Hekatontapyliani and Sts. Sergios and Bakchos seem to confirm this hypothesis.

This new evidence is crucial for re-visioning the original form and structure of one of the most important early Byzantine vaulted churches. Previous reconstructions had given many scholars an overall impression of a monument with a compartmentalized interior space, consisting of domed bays cut off from each other.<sup>62</sup> The new reconstruction challenges this assumption. It appears that the design of the vaults of St. John at Ephesos did not emphasize the



**Figure 28** St. John at Ephesos, reconstructed axonometric of the transept aisle vaults showing diagonal intersection between barrel vaults (author's drawing)

divisions of the plan. In many cases, the vaults tended to unify spaces, which appear clearly demarcated in plan. In the aisles, for instance, the use of continuous barrel vaults instead of series of cross vaults must have transformed a sequence of bays into a continuous space. One might argue that the spherical vaults over the central bays, cut off from each other by transverse arches, maintained some degree of independence. Nonetheless, these vaults, because of their shallowness, must have appeared as a unified design. The only major interruption occurred at the crossing. The use of a hemispherical dome must have given this central bay a unique vertical emphasis. But this was not meant to separate it from the neighboring ones, but to symbolize its role as the climax of a space that emanates from a center and unfolds in four directions in a fluid movement. This fluidity, combined with the clear hierarchical differentiation between arms and crossing, must have created a complex yet integrative architectural experience.

With five major pendentive domes, an enormous hemispherical dome on pendentives, and a large number of smaller but remarkably complex secondary vaults, the church of St. John displayed a complex vault structure. The

present reconstruction, the first to explore this structure in detail, demonstrates that even identical vaults could have different structures. Some spherical vaults had their bricks set radially, while others were made with bricks laid in arched courses. This reflects the use of different building strategies and methods. The spherical vaults over the transept must have required temporary wooden centering to prevent the bricks of the flatter upper portion of the vault from sliding off during construction. Although the nave vaults had the same shape and materials, the ingenious setting of their bricks must have reduced the necessity for centering. Indeed, arched brick courses, combined with the division of the vault shell in self-supportive units, allowed replacing centering with simpler devices, such as movable templates. The limitation of temporary support during construction would have been inscribed in a “freehand” method of building. It would have required exceptional building skills and considerable reliance on the judgment of the builders. That most of the vaulted shells of the nave of St. John at Ephesos were built in the air, without centering, testifies to the workmanship and genius of the church’s early Byzantine builders.

## Notes

1. See Procopius, *Buildings* (Cambridge: Harvard University Press, 1954), Book 5.1.4–7.
2. See Clive Foss, “Pilgrimage in Medieval Asia Minor,” *Dumbarton Oaks Papers* 56 (2002), 132.
3. For an investigation of the earthquake activity in Ephesus and the surrounding region during the early Byzantine period, see Foss, *Ephesus after Antiquity* (Cambridge: Cambridge University Press, 1979), 190; and Erhan Altunel, “L’Attività Sismica a Hierapolis e Nelle Zone Limitrofe,” in *Ricerche Archeologiche Turche nella Valle del Lykos*, ed. F. D’Andria, F. Silvestrelli (Galatina: Università di Lecce, Congedo Editore, 2000), 299.
4. The first excavation of the monument was carried out under the direction of Georgios A. Sotiriou and published in Georgios A. Sotiriou, “Anaskafai tou Byzantinou Naou Ioannou tou Theologou en Efeso,” *Archaiologikon Deltion* 7 (1924), 90–206. Until 1922, when the excavation was interrupted under duress, it had revealed the eastern part of the building. The Austrian Archaeological Institute resumed the excavations, revealing the entire church and its atrium, as well as the foundations of two pre-Justinianic phases: a centralized mausoleum, and a cruciform aisled basilica. For these finds, see Hans Hörmann, *Die Johanneskirche, Forschungen in Ephesos IV/3* (Vienna: Österreichischen Archäologischen Institut, 1951). For the results of more recent excavations, which revealed the baptistery and the skeuophylakion, see Mustafa Büyükkolancı, *Das Leben des Heiligen Johannes und die Johanneskirche* (Selçuk: Efes Vakfı, 2000).
5. Hörmann, *Forschungen in Ephesos*, 100–101; Büyükkolancı, *Johannes und Johanneskirche*, 48–49; Andreas Thiel, *Die Johanneskirche in Ephesos* (Wiesbaden: Reichert, 2005), 39, 110–11.
6. Hörmann, *Forschungen in Ephesos*, 165–69, fig. 4.
7. See Hugh Plommer, “St. John’s Church, Ephesus,” *Anatolian Studies* 12 (1962), 126.
8. See Paolo Verzone, “S. Giovanni e S. Maria di Efeso e la Ricostruzione della Città nell’ VIII secolo,” in *Corsi di Cultura Sull’ Arte Ravennate e Bizantina* (Ravenna: Dante, 1965), 609.
9. See Büyükkolancı, *Johannes und Johanneskirche*, 51 and Alfons Maria Schneider, “Rezension zu H. Hörmann, Die Johanneskirche (FiE IV,3),” *Byzantinische Zeitschrift* 46 (1953), 179–82.
10. See Thiel, *Die Johanneskirche*, 42–48, 110.
11. See John Bryan Ward-Perkins, “Notes on the Structure and Building Methods of Early Byzantine Architecture,” in *The Great Palace of the Byzantine Emperors, Second Report*, ed. David Talbot Rice (Edinburgh: Walker Trust, University of St. Andrews, 1958), 52–104, at 59, and Walter S. George, *The Church of St. Eirene at Constantinople* (London: Oxford University Press, 1913), 36.
12. See Georgios Lampakis, Lampakis Archive, XAE 5967, Christian Archaeological Museum, Athens, Greece. For additional photographs of vault fragments see Sotiriou, “Anaskafai,” 92.
13. See Hörmann, *Forschungen in Ephesos*, 93.
14. *Ibid.*, 92–103, tables XX–XXVII.
15. See Thiel, *Die Johanneskirche*, 42–48.
16. For an attribution of the fragment to the vaults of the gallery, see Hörmann, *Forschungen in Ephesos*, 98. For an identification of this fragment as part of the aisle vaults, see Büyükkolancı, *Johannes und Johanneskirche*, 63; and Thiel, *Die Johanneskirche*, 27.
17. See Hörmann, *Forschungen in Ephesos*, 93–95, tables XXIII–XXIV.
18. For more information on pendentive structures, see Auguste Choisy, *L’ Art de bâtir chez les byzantins* (Paris: Société Anonyme de Publications Périodiques, 1883), 92.
19. For a comment about the thinness of mortar beds in St. John, see Hazel Dodge, “Brick Construction in Roman Greece and Asia Minor,” in *Roman*

- Architecture in the Greek World*, ed. S. Macready, F. H. Thompson (London: Society of Antiquaries of London, Burlington House, 1987), 112.
20. To my knowledge, this is the only surviving mosaic from the vaults of St. John. The find of similar mosaic traces has been reported in Sotiriou, “Anaskafai,” 109, without any accompanying descriptions or photographs. The mosaic on vault fragment B is likely to be the one described in Hörmann, *Forschungen in Ephesos*, 98, and considered lost in Thiel, *Die Johanneskirche*, 42–44, note 283.
  21. See Verzone, “S. Giovanni,” 605, and Thiel, *Die Johanneskirche*, 29.
  22. For fragments G and H, see Hörmann, *Forschungen in Ephesos*, tables XXIII, 2, and XXIV, 1 respectively.
  23. According to Hörmann, seven such courses survived in fragment G and fifteen in fragment H. See Hörmann, *Forschungen in Ephesos*, 94.
  24. For similar arches in St. Eirene at Constantinople, see George, *St. Eirene*, 41, fig. 22, as well as Cyril Mango, *Byzantine Architecture* (Milan: Electa, 1978), 87, fig. 118. The use of elliptical arches in the nave of St. John has been excluded by Thiel, *Die Johanneskirche*, 42. In Hörmann, *Forschungen in Ephesos*, table LXIX, it is suggested that the builders tried to respond to the unequal height of arches in the bays of the nave, by slightly elevating the springing of the narrow arches. This, however, is in conflict with the evidence drawn from fragments E and F.
  25. Vault fragment J has been published in Hörmann, *Forschungen in Ephesos*, 100, plate XXVII, 3.
  26. For further information about fragment J, see Thiel, *Die Johanneskirche*, 31.
  27. See Hörmann, *Forschungen in Ephesos*, 165–69, and Furio Fasolo, “La Basilica del Concilio di Efeso, con Alcune Note Sull’ Architettura Romana della Vale del Meandro,” *Palladio* 5 (1956), 11, fig. 14, and Thiel, *Die Johanneskirche*, 47–48.
  28. See Mango, *Byzantine Architecture*, 8.
  29. For the dating of the destruction of the church, see Thiel, *Die Johanneskirche*, 109. See Büyükkolancı, *Johannes und Johanneskirche*, 39.
  30. See Hörmann, *Forschungen in Ephesos*, 160.
  31. See Sotiriou, “Anaskafai,” 128.
  32. ...and, occasionally, on worshippers’ heads, as Tornikes laments. See Sotiriou, “Anaskafai,” 128.
  33. Averil Cameron, *Procopius and the 6th Century* (Berkeley and Los Angeles: University of California Press, 1985), 84–112; and Cyril Mango, “Byzantine Writers on the Fabric of Hagia Sophia,” in *Hagia Sophia from the Age of Justinian to the Present*, ed. Robert Mark, Ahmet S. Çakmak (Cambridge: Cambridge University Press, 1992), 42, attribute this text to 554. For an attribution to a later date, between 559 and 561, see Michael Whitby, “Justinian’s Bridge over the Sangarius and the Date of Procopius’ de Aedificiis,” *The Journal of Hellenic Studies* 105 (1985), 141–47.
  34. See Procopius, *Buildings*, 5.1.6. The sixth-century author, in his comparison, uses the adjective *empheréstatos*, which means “resembling closely.” The same adjective is used again in Procopius, *History of the Wars*, 1.23. 23, to denote a very close resemblance.
  35. According to Richard Krautheimer, “by the late eleventh century, the church of the Holy Apostles was no longer quite Justinian’s original building. The five low domes of Justinian’s structure . . . had been replaced by domes raised on high drums . . .” See Richard Krautheimer, *Early Christian and Byzantine Architecture* (New Haven: Yale University Press, 1986), 242, 407.
  36. See Procopius, *Buildings*, 1.4.14–15.
  37. See Rabun Taylor, “A Literary and Structural Analysis of the First Dome on Justinian’s Hagia Sophia, Constantinople,” *JSAH* 55, no. 1 (March 1996), 69.
  38. Rowland Mainstone, *Hagia Sophia: Architecture, Structure and Liturgy of Justinian’s Great Church* (London: Thames & Hudson, 1988), 90.

39. Procopius, *Buildings*, 1.4.16–17.
40. George, *St. Eirene*, 44.
41. According to Taylor, “A Literary and Structural Analysis,” *JSAH* 55, no. 1 (March 1996), 74–75, “domes of shallow profile tend to exert greater horizontal forces on their supports than those of semicircular profile.”
42. See Mainstone, *Hagia Sophia*, figs. 67, 134, 137.
43. Mainstone, *Hagia Sophia*, 78, notes that the junction between pendentives and arches, as well as the face of the main arches have been obscured by a thick layer of plaster (a nineteenth-century addition). Still, he mentions earlier surveys of the building, which suggest that the entire face of the arches had originally been exposed.
44. Choisy, *L’art de bâtir chez les byzantins*, 102–3, was the first to notice this rule. As he claimed: “a pendentive dome never rests on the extrados of an arch: it is always fixed against the face of the supporting arch.”
45. For the use of arched brick courses in the dome of the baptistery of St. Mary, see Fritz Knoll and Josef Keil, *Die Marienkirche, Forschungen in Ephesos IV, 1* (Vienna: Österreichischen Archäologischen Institut, 1932), 49. An excellent illustration and a description of the “articulazione arcuata” in the same baptistery are in Fasolo, “La Basilica del Concilio di Efeso,” 6, fig. 9.
46. For an identification of the Nymphaeum as part of the palace of the governor and its sixth-century dating based on building techniques, see Foss, *Ephesus after Antiquity*, 51. A graphic reconstruction occurs in Piero Sanpaolesi, “Strutture a Cupola Autoportanti,” *Palladio* 21 (1971), 43, fig. 54.
47. Not having had the chance of visiting this remarkable monument, I have relied on the excellent survey published in Sanpaolesi, “Strutture a Cupola Autoportanti,” 21–23, and 53–56, figs. 69–73. A somewhat less accurate survey occurs in Arid Mufid Mansel, *Side 1947–1966 Yılları Kazıları ve Araştırmalarının Sonuçları* (Ankara: Türk Tarih Kurumu Basımevi, 1978), 318–23, figs. 377–81.
48. For an illustrated description of the dome of Diocletian’s Mausoleum, Spalato see Donald S. Robertson, *Greek and Roman Architecture* (Cambridge: Cambridge University Press, 1983), 257, fig. 108. For an analysis of its structure within the broad context of late antique dome construction, see Sanpaolesi, “Strutture a Cupola Autoportanti,” 10. The similarity between St. John’s vault fragments and the structure of the dome in Spalato is mentioned in Thiel, *Die Johanneskirche*, 43.
49. The actual structure is a reconstruction made under the supervision of Sotiriou, and a mere echo of the original fifth-century structure. A sketch of the original vault occurs in Choisy, *L’Art de bâtir chez les Byzantins*, 102.
50. Justinian’s St. John has been dated to the period between 527 and 548 (see Büyükkolancı, *Johannes und Johanneskirche*, 68). Both Paul Lemerle (*Philippes et la macédoine orientale à l’Époque Chrétienne et Byzantine* [Paris: De Boccard, 1945], 415–518), and Krautheimer (*Early Christian and Byzantine Architecture*, 253) claim that Basilica B at Philippi was built shortly before 540.
51. Thiel, *Die Johanneskirche*, 26.
52. For instance, in the reconstruction published in *ibid.*, 25, the gallery floor is 80–100 cm thick.
53. Choisy, *L’art de bâtir chez les byzantins*, 110–15.
54. Harry Herbert Jewell and Frederick William Hasluck, *The Church of Our Lady of the Hundred Gates (Panagia Hekatompyliani) on Paros* (London: Macmillan, 1920) 34–35.
55. Choisy, *L’Art de bâtir chez les byzantins*, 108.
56. See Thomas Mathews, *The Early Churches of Constantinople: Architecture and Liturgy* (University Park: Pennsylvania State University Press, 1971), 47–50.
57. See George, *St. Eirene*, 42, fig. 22; Mainstone, *Hagia Sophia*, 81, fig. 67; Lemerle, *Philippes et la macédoine orientale à l’Époque chrétienne et byzantine*, 453.
58. For some typical examples of this tendency, see Thiel, *Die Johanneskirche*, table 12; Hörmann, *Forschungen in Ephesos*, table LX; H. Buchwald, “Western Asia Minor as a Generator of Architectural Forms in the Byzantine Period: Provincial Back-Wash or Dynamic Center of Production?” *Jahrbuch der Österreichischen Byzantinistik* 34 (1984), 211; Plommer, “St. John’s Church,” 122.
59. In earlier reconstructions, the choice between the two forms was mainly based on arbitrary assumptions and stylistic criteria. Indeed, Thiel, *Die Johanneskirche*, 47–48, claims that “if shallow domes occurred in the nave, then the vaults in the rest of the church must have had similar vaults.” This, however, is only an assumption. The Austrian author goes on to suggest that if the major bays of the east parts of the church had been covered by domes on pendentives, then “this part would have been given a gravity that does not fit to the general aspect of the church.” This is a stylistic criterion used without evidence.
60. A similar reconstruction occurs in Sotiriou, “Anaskafai,” 143.
61. Hörmann, *Forschungen in Ephesos*, 100, plate XXVII, 3.
62. See Krautheimer, *Early Christian and Byzantine Architecture*, 242, and Buchwald, “Western Asia Minor as a Generator of Architectural Forms,” 209.