

## APPENDIX TO

# REMOTE SENSING, ARCHAEOLOGY AND HISTORICAL RECORDS: LOOKING FOR 1624 EARTHQUAKE TRACES IN SAN GIORGIO PARISH CHURCH OF ARGENTA (ITALY)

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## Appendix A. The San Giorgio parish church in Argenta

Appendix A.1 is devoted to a description of the recognized settlement periods in the church's life; A.2 shows a summary of archeological studies; A.3 shows the stratigraphy of the walls; and A.4 the main results of archeological excavations carried out in 1980s.

### A.1. The San Giorgio parish church over time

Some basic information about the conditions of San Giorgio parish church over time, taken from Gelichi [1992], is summarized here in order to make archeological and historical data more understandable. Seven settlement periods, from the 5<sup>th</sup> century to the present day listed (briefly), can be recognized:

- 1) Period from V to mid-VI century. This is the period of time in which the original church was built. According to Agnello of Ravenna, the author of *Liber Pontificalis Ecclesiae Ravennatis*, the edification of the ancient church was ordered by the archbishop Sant'Agnello (487-570) who established in Argenta the "Monasterium Sancti Georgi". The church was built on an ancient construction probably dating back to the Roman Republican and Imperial era placed on a raised hill. The church had a semicircular apse and a mosaic floor, the latter deduced from the presence of lime.
- 2) Period from 550 to 575. Historical sources described the church as having a single hall and apse with three large windows in the lower part, with a semicircular geometry on the inside and polygonal (5 sides) on the outside. The floor is a polychrome mosaic and there are elements of connection between the apse and the external rooms. Moreover, it seems that the parish church carried out baptismal functions since its origins (6<sup>th</sup> century).
- 3) Period from 575 to 1115. In this period there is a large information gap. Probably in the early part of this period, the church served functions for a settlement (*castrum*) founded in 604. No documentation about its activity or abandonment was found. Archaeological explorations showed that part of the floor was exposed and found the presence of layers of non-alluvial deposits inside the church. Historical documents show that in 1115 the parish church was assigned to the canons of the basilica of Ravenna.
- 4) Period from 1122 to 1300. This was a period of reconstruction and expansion of the parish church with the creation of a structure with three naves, 11 m wide, 16 m long, with 6 arches and 5 pillars ending with a linear wall with corner pilasters and arches. The flooring of the naves was made of rammed earth with the addition of lime. The dating is certain due to the discovery of ancient coins in the foundations (XI-XII) and the date engraved on the portal (1122). There was a door on the southern perimeter wall and, moreover, an external room connected to a part of the apse and the northern

perimeter wall was built in the first half of the 13<sup>th</sup> century. The reconstruction of the parish church took place thanks to Archbishop Gualtiero. It was almost completely rebuilt and a cloister and a rectory were also added. It is important to note that between 1122 and 1252 the baptismal functions ceased and took place elsewhere, perhaps because of a process of centralization of the cities and slow abandonment of the countryside. After the mid-13<sup>th</sup> century, from archaeological sources and excavation activities, a period of long and slow degradation is hypothesized since there is no historical evidence until the 1571, where the poor conditions and the need for restoration are described.

- 5) Period from 1300 to 1400. Archaeological sources show that there were periods of use of the church alternating with periods of non-use. The layers that highlight the beating, trampling and therefore the use of the parts of the church date back to the end of the 14<sup>th</sup> and the beginning of the 15<sup>th</sup> century.
- 6) Period from 1571 to 1573. In this period the naves were demolished, the arches and columns were infilled and the church returned to a single nave shape. With the demolition of the ancient walls, the perimeter walls were raised. Furthermore, a new altar was built.
- 7) Post Renaissance era. Evidence of landfills in the late 17<sup>th</sup> century demonstrates that an active settlement was still present. Modern archaeological investigations highlight the presence of the rectory and traces of interventions related to the previous archaeological study carried out in 1700 by Bertoldi. Historical documents dating back to 1699, 1756 and 1770 still complain that the parish church is in terrible and serious conditions.

## A.2. Summary on archaeological studies

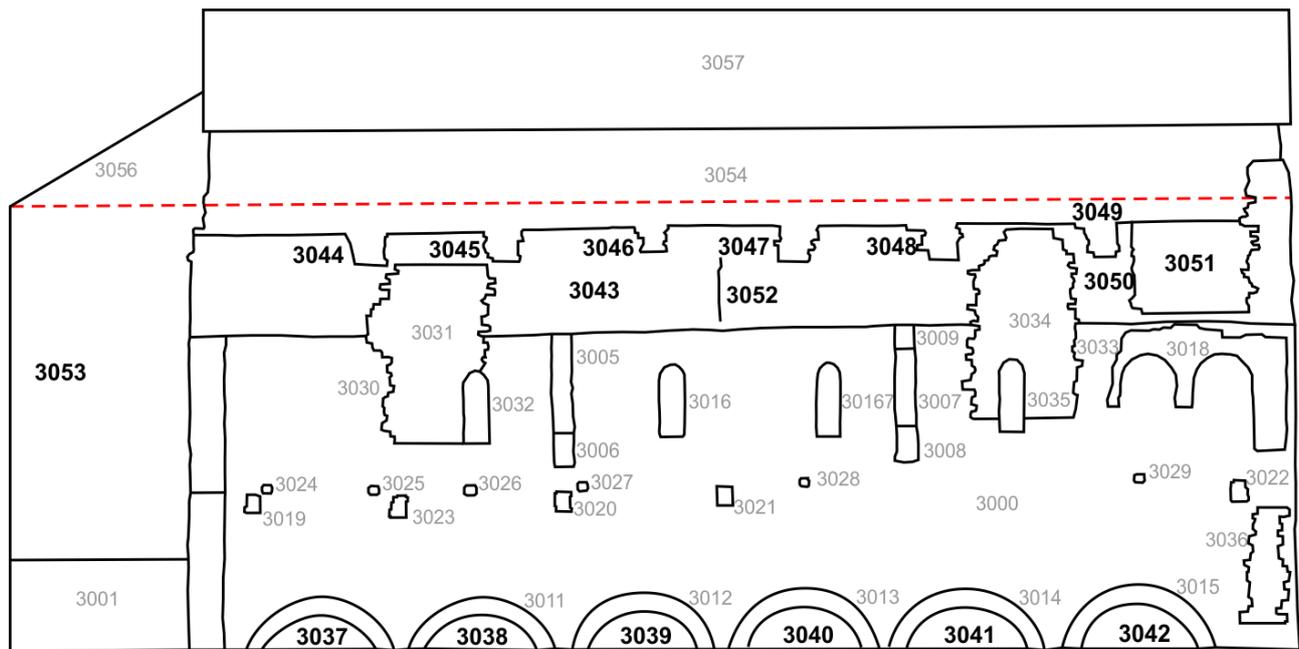
The parish church of San Giorgio was the object of archaeological studies and excavations during the centuries. The first excavation, performed by the priest F.L. Bertoldi, dates back to 1770 [Bertoldi, 1783]. The last study was carried out by S. Gelichi and consisted of three distinct excavation campaigns performed in 1982, 1983 and 1986 respectively [Gelichi, 1992]. Since the largest bulge of information derives from the Bertoldi and Gelichi's works, we focus on them and only mention G. Vandini, who excavated the San Giorgio area around the second half of the 19<sup>th</sup> century. The Bertoldi's excavations were rather short. They lasted from August 23<sup>rd</sup> to September 7<sup>th</sup> 1770 [Bertoldi, 1783]. However, the excavation area was quite large and included regions inside and outside the church. According to Franzoni [1992], Bertoldi decided to start the excavation a few months after the fire which, on February 7<sup>th</sup> 1770, destroyed the rectory and the church roof, as he was worried that the abandoned church would have gone to ruin quite soon. An impressive find of Bertoldi was a paleochristian mosaic showing that the San Giorgio church laid above a previously existing church dating back to the 6<sup>th</sup> century.

Bertoldi faced a typical problem of Argenta area, i.e. the huge amount of water in the subsoil which causes relevant damages to the stratigraphic layers. His results were also strongly affected by the lack of excavation methods that were introduced in archaeology only much later [Harris, 1989]. Before 1979 the excavation campaigns were carried out without scientific criteria and focused only on finds. Thus, important information about anthropic and natural contamination was not considered and often was destroyed. Despite these problems, the Bertoldi's report is a very important document being in a way similar to modern excavation journals, as every single activity performed on each day is completely detailed. Moreover, Bertoldi's report provides information about finds location, helping the result interpretation. Some discrepancies among Bertoldi, Vandini and Gelichi's reports exist, particularly concerning the depth of the paleochristian mosaic. That is not unexpected since each excavation is related to a different archaeological context. As already stressed, only Gelichi's excavations were performed according to stratigraphic methodology. He also provided a set of pictures, maps and archaeological sections which turned out to be fundamental to describe the stratigraphy of horizontal and vertical planes.

## A.3. Stratigraphy of church walls

Historical and archaeological data describe San Giorgio church suffering for a slow and progressive decay since the second half of the 13<sup>th</sup> century. The church was restored around 1571, but in 1699 and 1756 its conditions got worse again. The 1624 earthquake could have played a significant role in the church degradation as testified by the removal of the Blessed Mother image from the external N wall of the church, which in 1651 was entirely detached and placed inside, an action likely motivated by wall plaster bad conditions. In 1756 the church walls were in a good state, but the church had been submerged by swamp waters which surely impacted on the subsoil stratigraphy and also on the possible archaeo-seismological traces. As mentioned in the paper, a fire occurred in 1770. Moreover, several rebuilding/renovation works like walls elevation, insertion of arches and their infill were carried out over the centuries.

The stratigraphic analysis of the N side of the church performed by Brunetti [1992] provides information about the church architecture. This side is particularly suitable for that kind of analysis being close to the excavated areas and in a good state of conservation. The stratigraphic units (SUs) in which earthquake traces could be recognized are shown in Figure A1, which is modified from Brunetti [1992]. Most SUs date back to 1571, the year in which the church was restored, the arches were infilled (SU 3037-3042) and the apse was raised up (SU 3053). The SU 3043 indicates the elevation of the church parietal walls, while the SUs between 3044 and 3049 correspond to the holes for a new roof anchorage. The SU 3050 indicates a truncation and SU 3051 its subsequent infill (possibly due to the removal of the Virgin image). Finally, SU 3052 is a jamb.



**Figure A1.** Stratigraphy of the wall, from Brunetti [1992] and drawn with the same nomenclature for stratigraphic units. The bold labels indicate the time span within which the 1624 earthquake occurred.

The absence of SUs related to restoration works of the N side of the church is surprising, because the geophysical analysis shown in Brunetti [1992] indicates that the earthquake effects were quite strong and also liquefactions occurred. The lack of written sources about church damages or documents concerning restoration is also surprising. On the other hand, even today no cracks or fissures can be noticed. However, it should be noted that the 1773 restoration might have hidden these evidences, which could be caught by a means of a deeper inspection. It should also be underlined that extensive and continuous deformation on a large scale does not necessarily cause well visible cracks or fissures but indicates a phenomenon that significantly affected the monument. In some cases, morphological analysis applied to historical buildings struck by 2012 Emilia Romagna earthquake showed patterns compatible with the deformations expected in the event of an earthquake even in the absence of discontinuities on the walls of the monument. If an architectural element can be deformed, there are not necessarily extensive and/or localized cracks.

#### A.4. Archaeological excavations in 1980s

The most reliable archaeological campaigns were performed by Gelichi in 1980s [Gelichi, 1992], which described and analyzed the evidences from each excavation independently site by site. He also divided the history of the church in seven periods of which the 6<sup>th</sup> and 7<sup>th</sup> ones (corresponding to the 16<sup>th</sup> and 17<sup>th</sup> centuries) are those of interest for the present study. The 6<sup>th</sup> period can be dated, according to written sources, to the years 1571-1573, as during that time the church naves were demolished and reduced to a single one, the intercolumniation were infilled and the parietal walls of the church were elevated. During the 7<sup>th</sup> period a number of structural works was performed, among which the ones probably connected

with the rectory. The presence of a couple of landfills, which were formed at the end of the 17<sup>th</sup> century, testifies that the area was still used at that time.

The information provided by Gelichi [1992] about the archaeological layers belonging to the 6<sup>th</sup> and 7<sup>th</sup> periods is summarized in Table A1, where the positions of the excavations with respect to the little church are also shown (left column). To clarify and complete Table A1, additional information is provided for each of the excavation sectors. As regards chronology, we refer to the settlement periods described in Section A.1.

Sector 1. The excavation of approximately 1 m made it possible to find part of the wall (50 cm wide) of the southern nave, built in settlement period 4, corresponding to the works of 1122. There was evidence of accretion layers of clay matrix alternating with natural composition or affected by the presence of shards, broken bricks and clay. The latter probably date back to settlement period 7, during which a fire damaged the parish church and was perhaps a further cause of the demolition of the naves (1571-1573).

Sector 2. There is no additional information.

Sector 3. The excavation of approximately 2.5 m revealed information on settlement periods 4 and 5, i.e. from 1112 to 1400. The remains of the wall of the north nave (50 cm wide) with the related foundation, made with broken and recovered bricks, highlights that it was built on previous burials. The walking surface was made of beaten clay, lime and a mixture of bricks. Various countryside plans were highlighted, in which the incorporated elements (graffita and majolica) allow the sequence to be dated between the late 14<sup>th</sup> and mid-15<sup>th</sup> century. The predation of the perimeter wall dates back to period 6 (1571-1573). Pits filled with brick waste material were also recognized.

Sector 4. As in the previous sector, the depth of the excavation reached 2.5 m. The found evidence dates back to settlement periods 3 to 7. The remains of the northern perimeter in the three-nave configuration were identified and the walking surface, full of brick and clay fragments, indicate the time of the construction site (1122). Burials dating back to that period and also to previous periods were found. Finally, alluvial deposits with a sandy matrix and, the most relevant, a clayey matrix (almost 1 m thick) were recognized.

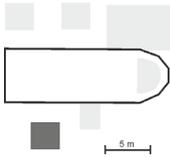
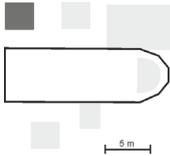
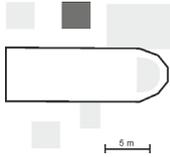
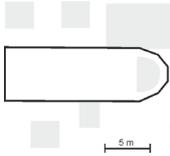
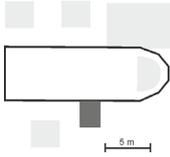
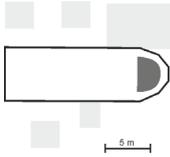
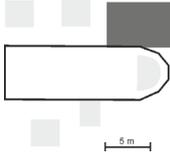
Sector 5. There is no additional information.

Sector 6. The excavation showed sequences from the settlement period 2 to 7 relating to the area between the main nave (currently the single hall) and the south nave, which no longer exists. Walls in a west-east direction were recognized, stripped and used as a support base for the pillars of the three-nave church. Some structures dating back to the Agnello's era, i.e. prior to the renovation of 1122, were found, together with many elements relating to construction operations. The surface of use was a compacted mixture of lime, bricks, coals and marble chips. Layers of clay were observed, sometimes beaten and sometimes not, revealing interruptions in the use of the parish church probably due to flooding phenomena. Some ceramic fragments allowed the dating of some layers between the end of the 14<sup>th</sup> and the beginning of the 15<sup>th</sup> century. The excavations revealed the infills of the arches and the residues of the demolitions, according to the historical documentation of 1571.

Sector 7. The excavation, of approximately 3.3 m, concerned the apse part, in which the settlement periods from I to VI could be identified. The deposits of clayey matrix, one of which is sterile and the other one has a large number of coals and brick fragments, showed the countryside level at the time of the construction of the church. There were remains such as amphorae and bones, left before the construction of the church, which were part of the pre-existing ancient Roman structures, including a collapsed wall towards the north. The mosaic on the floor, which was not entirely preserved, was found and restored. Some particular holes led to the hypothesis of the presence of consolidation elements in the church in its first form. The reconstruction of the apse of the parish church concerned the highest areas. The various sequences of floor layers, found in different excavations, indicate activities up to the end of the 12<sup>th</sup> century. Subsequently, as in the previous sectors, considerable layers of alluvial clay interspersed with organic or brick deposits were found. Finally, evidence of the reconstruction of 1571-1573 was found.

Sector 8. It concerned the area between a part of the apse and the north façade. Conducted in order to observe any structural relationships between various walls for chronological purposes, the excavation had a depth of 3.2 m. Ancient

finds relating to the very first settlements were discovered, including a small pre-Agnello's necropolis and a small building with a semicircular apse. The remains of the demolition and construction of the parish church were found and highlighted that a part of an ancient wall was probably incorporated in the construction of the north wall. Many largely overlapping burials were found at various levels. Evidence emerged of a quadrangular shape annex joining part of the apse and a portion of the north wall to form a room of use and dating back to after the construction of the church.

Excavation sector	Evidences
<p>1</p> 	<ul style="list-style-type: none"> <li>- Edification of a building, likely to be the rectory, occurred between the 16<sup>th</sup> and 17<sup>th</sup> century.</li> <li>- Trench having partially destroyed layers and structures of the 17<sup>th</sup> century.</li> </ul>
<p>3</p> 	<ul style="list-style-type: none"> <li>- Spoliation of the church walls occurred after the 16<sup>th</sup> century.</li> <li>- Deep trench (used to store garbage) which can be accurately dated to the end of the 17<sup>th</sup> century due to the presence of etched ceramic.</li> </ul>
<p>4</p> 	<ul style="list-style-type: none"> <li>- Narrow and regular trench filled with spoliation debris. Its age was derived by means of an altimetric comparison with the layers found in sector 6 and has been found to correspond to the 16<sup>th</sup> century.</li> <li>- 1 m deep trench filled with yellow clay soil and brick pieces, dated to 17<sup>th</sup> century.</li> </ul>
<p>5</p> 	<ul style="list-style-type: none"> <li>- 17<sup>th</sup> century ceramic landfill.</li> </ul>
<p>6</p> 	<ul style="list-style-type: none"> <li>- The alluvial deposits thickness testifies a slow and progressive degradation of the church indicating how the latter was almost abandoned. The derived age (end of 16<sup>th</sup> century) is early and close to the demolition of the southern nave.</li> <li>- Thick debris deposit mainly composed by roof tiles testifying the nave roof demolition.</li> </ul>
<p>7</p> 	<ul style="list-style-type: none"> <li>- As in sector 6: the presence of an entire plane of wall plasters is likely to be due to church restoration occurred between 1571 and 1573.</li> </ul>
<p>8</p> 	<ul style="list-style-type: none"> <li>- A big hole, an alluvial deposit and several debris likely to be due to the northern nave demolition. If that is the case, then the age corresponds to the second half of the 16<sup>th</sup> century.</li> <li>- Almost complete abandon of the northern nave area inferred by lack of any trace of frequentation and presence of several alluvial deposits.</li> </ul>

**Table A1.** Main results from Gelichi [1992] related to a time span around 1624. Naming and positions of sectors (drawn in the left column) and evidences (reported in the right column) are taken from that work.

It is not easy to obtain convincing information regarding the effects of ancient earthquakes on the basis of archaeological excavations, as highlighted by Galadini et al. [2013] about earthquakes occurred in the Rome area during the AD first millennium. In general, it is not only complex to attribute archaeological remains to a specific seismic episode, but it is also difficult to associate the remains with any earthquake. Thus, it is not surprising that Gelichi did not find clear

archeological evidence of the 1624 earthquake which, according to Caracciolo et al. [2012], produced high disruption in the Argenta area. More specifically, the structures are expected to have suffered for seismic collapse which effects would be: wall pieces in collapsed or inclined positions; sinkholes; differential settlements inducing floor inclination; deformations and displacements; walls broken in pieces which could even be overturned; messy debris accumulation. The main reason for that discrepancy relates to the difficulty of finding traces of an earthquake in archaeological excavations [Ambraseys et al., 2005], something which applies particularly well to the San Giorgio church area as it was excavated before the introduction of stratigraphy in archaeological studies. Looking for indirect coseismic effects [Bertoldi, 1783], no clear evidence was found in the church walls, probably because of restoration works. Therefore, the San Giorgio area looked as the ideal place in which remote sensing could provide further information to integrate available archaeological data and eventually get evidences for the 1624 earthquake.