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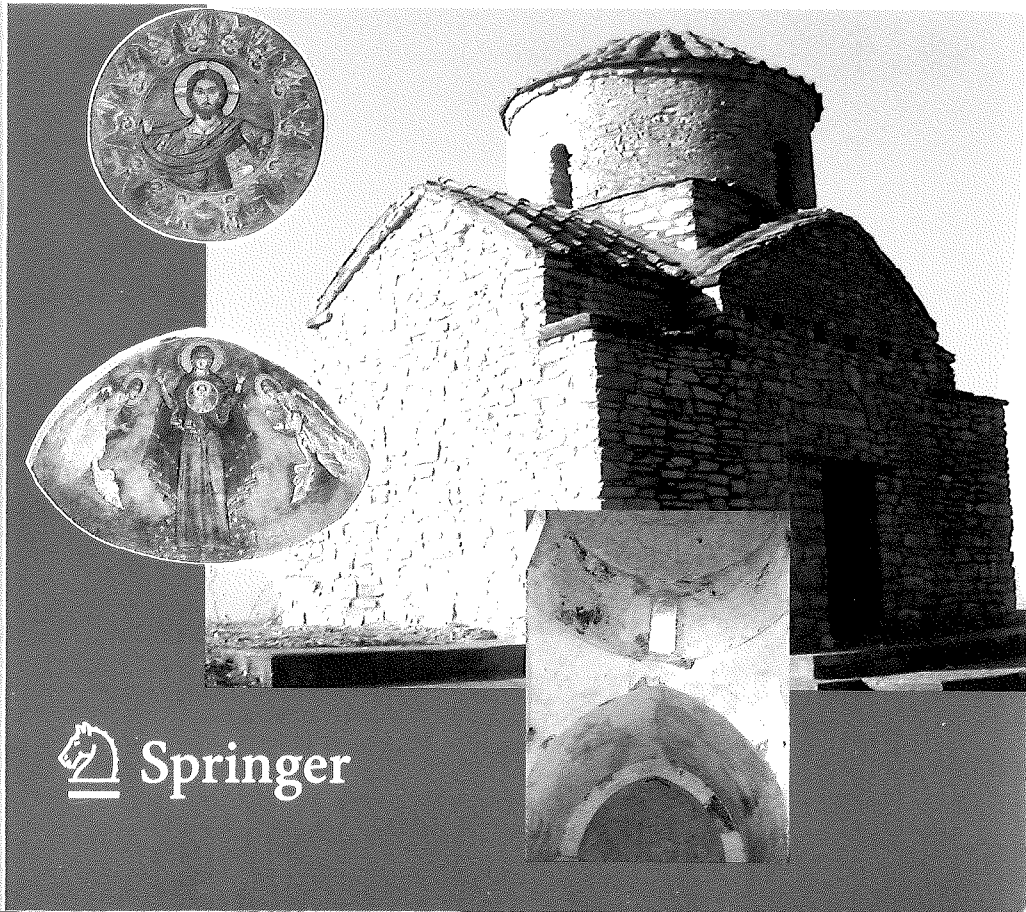
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Reviving Ancient Rome: Virtual Reality at the Service of Cultural Heritage

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Abstract. Since the Renaissance, the remains, myths and visual representations of ancient Rome have influenced not only European culture but also the architecture and urban planning of the big cities of Europe and of the Americas through the process of colonization. The University of Caen Basse-Normandie (France) has a famous visual representation of ancient Rome in the scale model of Paul Bigot, a French architect who lived at the beginning of the 20th century. This exceptional part of our cultural heritage has been the pretext for a virtual reconstruction of ancient Rome. The technologies used and, in particular, the interactive visit with access to ancient source materials give a new life to the myth. Our team has developed a fully interactive model of ancient Rome which allows a visitor to move freely in a full-scale city and enter the main public buildings as well as some private apartments. The aim is both scientific and didactic. Scholars can use the model as a regularly updated database for reference and possible experiments. The general public can visualize a world that is now beyond their reach. This paper will focus on a particular example: the temple of Venus and Rome in its condition as of the 4th century A.D.

Keywords: Ancient Rome, Architecture, European Heritage, Scientific reconstruction, Virtual Reality, Interactivity.

1 Introduction

The work we are presenting is being carried out by the CIREVE at the University of Caen Basse-Normandie. The tasks of this technical platform are to favor the use of virtual reality in all the fields where it can be useful, in particular in the field of archeological reconstitution. Among the projects in this area, the most important is the virtual reconstruction of ancient Rome. The goal of the "Plan de Rome" team is to revive ancient Rome from the scientific and educational perspectives. We will first show that ancient Rome is a very important element of the cultural heritage of the western world, a great part of whose architecture and urban planning has been directly inspired by those of Rome. Secondly we will explain our objectives and the

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methodology we have used to reconstruct the entire city with virtual reality technologies. Finally we will present an example with an interactive visit with access to the metadata of the biggest temple of ancient Rome, the temple of Venus and Rome.

2 Rome: European Cultural Heritage

After 476 A.D., i.e. after the destruction of the Western Roman Empire, Rome died a slow political, religious and physical death. The capital of the empire was moved from Rome to Constantinople, the pagan religion was forbidden and the city of ancient Rome was largely destroyed by barbarian invasions and by the Romans themselves who used the ancient materials to build their dwellings and churches. However Rome also became the capital of the Christian world and in this sense it has remained the central point of Europe. Unlike Athens which ceased to deliver its message after the end of Antiquity, Rome has been a point of reference until today (Giardina 2000). It has stimulated many mental representations, aesthetic models and ideological references. Rome fed the consciousness of the peoples formerly subjected to its empire and even of those who had never belonged to it, from Ireland to Scandinavia and the Slavic countries. From the point of view of topography, the medieval *Mirabilia* are guides of ancient Rome used by generations of pilgrims and tourists. They are completed with maps indicating at the same time all the churches and all the ruins of ancient Rome. During this entire period, the guides had no scientific value and pagan Rome became a myth. An important change came with the Renaissance because at this point ancient Rome became an object of scientific research. Flavio Biondo (an Italian Renaissance humanist historian; see Raffarin-Dupuis 2005) was the first to use textual and archeological data to reconstruct ancient Rome. Nevertheless his reconstruction was entirely literary. Several years passed before visual representations were done in the same spirit. The map of Pirro Ligorio, "The ancient buildings which can be still seen in 1570" is one of the first of this type. Even though his map is not precise from the architectural and topographical points of view, it breaks with the tradition of round and fanciful maps. In the 19th century the visual representations became truly scientific with the works of R. Lanciani, the reconstructions of L. Canina and "Les envois de Rome" (Cassanelli, 2002). The 20th century was finally the century of the two great models of the Rome of Constantine: the scale model of Paul Bigot (Royo 2006) conserved at the University of Caen Basse-Normandie (a color copy is in the Brussels Museum of Art and History) and the scale model of I. Gismondi conserved in the museum of the Roman civilization in Rome. These scale models are real achievements. They summarize the literary, archeological and iconographical knowledge accumulated since the Renaissance.

Roman myths and visual representations have influenced not only European culture but also the architecture and urban planning of the big cities of Europe and the Americas through the process of colonization (D'Amico 2012). For instance, the Pantheon of Rome has an extraordinary heritage (fig. 1). Situated on the Campus Martius, the Pantheon is certainly the best preserved of all the Roman buildings. As

its Greek name indicates, this temple is consecrated to several gods, especially Mars and Venus. The Pantheon was first built under Augustus by Agrippa in 27 BC. Reconstructed under Hadrian in 128 AD, it was re-oriented, and the circular form it has kept until today was added to it. It is a unique building in the history of Roman architecture, because it represents a dual revolution. For the first time in the history of Rome, architects used a dome with a rectangular part in the front to build a temple. Secondly, it was the largest dome built in concrete until the 20th century. The original design of the Pantheon, i.e. the association of a dome with a classic pronaos, has of course influenced Saint Peter's Basilica in Rome (16th century - fig. 2), the Palladio villa in Vicenza (16th century - fig. 2) and also the Pantheon in Paris built by Soufflot (18th century - fig. 1), and, in the USA, the Capitol in Washington (18th century), the Library of the University of Virginia in Charlottesville (19th century - fig. 3), the Jefferson Memorial in Washington (20th century - fig. 3), the Supreme Court of Florida in Tallahassee (20th century) and so on.



Fig. 1. The Pantheon of Rome (Italy) in the 4th century (reconstructed in virtual reality thanks to a collaboration between the University of Virginia and the University of Caen) and The Pantheon of Paris (France).



Fig. 2. Saint Peter's Basilica in Rome and the Villa Rotonda in Vicenza (Italy)

There is much additional testimony to the influence of Roman architecture on European architecture. In Paris for example, the National Assembly and the church of the Madeleine are directly inspired by Roman temples, and the city also has a triumphal arch near the Louvre, an obelisk in the Place de la Concorde, the Austerlitz

column in the Place Vendome, which is inspired by the column of Trajan in ancient Rome. Some buildings like the Opera Garnier have Roman symbols such as Corinthian columns and Victories on the roof, and we find other examples in all European capital cities.

Thus the knowledge of the architecture of ancient Rome is critically important to understanding the architecture of Europe's major cities.



Fig. 3. Library of the University of Virginia and the Jefferson Memorial in Washington (USA)

3 Reviving Ancient Rome with Virtual Reality

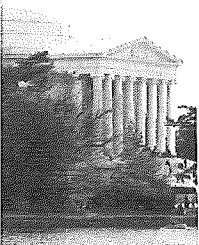
Today digital techniques offer new possibilities for reconstructing the past (see the international colloquiums of the CAA - Computer Applications and Quantitative Methods in Archaeology - www.caaconference.org). Many scholars around the world are working on ancient Rome, but only two teams are rebuilding the entire city as it was in the 4th century A.D.: the "Rome Reborn" team at the University of Virginia (USA - Frischer 2010) and the "Plan de Rome" team at the University of Caen, France (Fleury 2007, 2009 and Madeleine 2011) (the two teams signed a joint venture agreement in 2008).

At the University of Caen we chose to reconstruct the ancient Rome in virtual reality because we already had Paul Bigot's scale model known in French as the "Plan de Rome". This is a large plaster model covering nearly 70 square meters which represents ancient Rome in the 4th century A.D. Classified in the Inventory of Historic Monuments, it is the work of the architect Paul Bigot (1870-1942), winner of the Grand Prix of Rome and professor at the Ecole des Beaux-Arts in Paris (see fig. 4).

Work on developing a virtual model of the city of Rome in the 4th century A.D. began in Caen in 1994. The team "Plan de Rome" groups together teachers-researchers, engineers and postgraduate students. The represented disciplines are, for the basic nucleus, the sciences of Antiquity, Computing and Media Studies, but the seminars and the collaboration with other institutions spreads the initiative to History, Archaeology, Literature, and Architecture... The work involves the development of a fully interactive model of ancient Rome that includes both its architecture and the machinery in use (Fleury 2004). The visitor to the virtual model is able to wander through a full-scale city and enter most of its large public monuments and a few residences. He is walking and running at the same speed as a real human. He is

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subject to the law of gravity. He cannot fly or walk through an obstacle. Thus, the visitor is walking in real time, he can measure the time, what is not possible with other media. It is an important issue for the understanding of daily life in Antiquity. The expected project results are: 1/ a digital 3D model of Rome as it was in the 4th century A.D., 2/ a digital 3D model of the principal machinery used in the Roman world, and 3/ links for each digital model to the body of ancient source material (documentary, archaeological, and iconographic) used in their development. The body of source material is directly accessible via the interactive model.

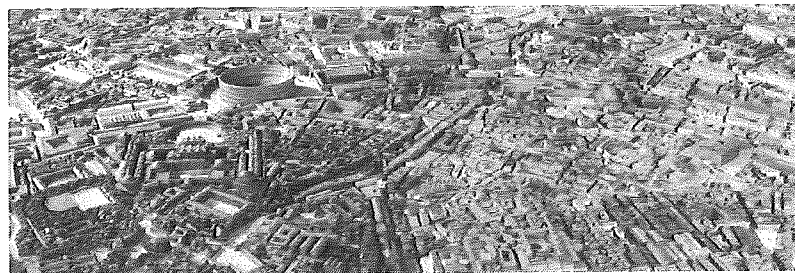


Fig. 4. Paul Bigot's plaster model

Two main objectives – one scientific and the other educational – are behind the reconstruction of ancient Rome. The scientific objective is to provide a tool for researchers to test their architectural and topographical assumptions, test the machines' functionalities and illustrate the assumptions developed regarding the reconstruction of the city. The virtual model is inseparable from the research on the history of the real model, and furthermore, the updating of Paul Bigot's work highlights the evolution of archaeological and historical knowledge of Ancient Rome. The educational objective is to provide students and secondary school pupils, but also the public at large, with a vivid illustration of Ancient Rome and an example of the ancient urban reality that is easily visualized on screen. Each year three thousand school children visit the model in Caen and the website developed by the project team (www.unicaen.fr/rome) receives more than three million visitors per year. These numerous visits are a testimony to the interest the "Plan de Rome" inspires throughout the world. The results of this virtual reconstruction of Rome are also accessible by stereoscopic displays at the University of Caen and publications and scientific papers in France and other countries. For four years (2009-2012), the "Plan de Rome" team has benefited from European Funds for Regional Development. The resources have been used to complete the work on the digital model. The Interdisciplinary Virtual Reality Centre (Centre Interdisciplinaire de Réalité Virtuelle or CIREVE) supports the work of building the virtual model of the ancient city of Rome. The CIREVE is a University of Caen shared resource that makes it possible to pool the staff and equipment for the application of virtual reality techniques for research purposes and is currently involved in 12 projects (www.unicaen.fr/cireve).

The methodology developed by the "Plan de Rome" team is inspired by the principles defined by J.-C. Golvin (Golvin 2010) with whom we have worked for a

long time. J.-C. Golvin is well known for his reconstructions of Classic Antiquity in watercolors (all these drawings are now exhibited in the Museum of Arles Antique – France), but many principles are common to the reconstructions in watercolors and to the reconstructions in virtual reality, in particular the fundamental principle of “pertinence”. A relevant virtual picture is the most likely picture given the data we have. It means that the pictures must be complete. Reconstructing only what is certain is not a good approach. The different systems used at times to distinguish what is certain from what is not certain (transparency effects, different colors, models without maps or with modern maps) are unsatisfactory. Nevertheless, the models must be based on ancient source materials and the visitors to the interactive model must know what is certain and what is less so, with all the nuances between the two possibilities. To solve this problem we work with an interactive model in five dimensions. The three dimensions of all models are of course height, width and depth. But a virtual model is more complete than a physical model since we can walk inside it. The x, y and z coordinates at a given time are not the same as they are at another point in time. So time is the fourth dimension. The fifth dimension is the interactive access to ancient sources of data. Behind the virtual model, there is a database with ancient texts, didactic videos, 2D pictures and a bibliography. The metadata is always accessible by a mouse click: all we have to do is click on an object. With this documentation, we provide the visitor with the possibility of consulting the overview of the research data.

The reconstruction of Rome is a photograph of the city at a given point in time: in order to be scientifically credible, the reconstruction must not mix elements from different periods. The team chose the period of Constantine, more specifically the beginning of his reign, between 310 and 320 A.D.: it is the same period as Paul Bigot’s model but three reasons explain why we do not use a 3D scan of the physical model and why we prefer modeling Rome by hand. First, the physical model scale is 1/400 and if we had realized a 3D scan, there would have been significant approximations of the measurements. The second difficulty is that Paul Bigot’s model was completed in 1913, with some corrections made between the two world wars. Since the 1950’s, there have been new discoveries and some data have been reinterpreted. Since the model in plaster is classified as a Historic Monument, we cannot update it, and thus all the corrections are made on the virtual model. Third, we cannot use the terrain of the physical model, because it is a “plan relief”: the hills are voluntarily erased so that all the buildings are visible from the edge of the model. The current terrain of Rome is used even though it has changed drastically in places over the past 2,000 years and it will be corrected afterwards in order to be more similar to the historical terrain.

Before modeling a building, the team’s researchers collect all ancient source materials which make it possible to understand its history and draw plans in 3D. They attempt first to collect all the Latin and Greek texts on the subject. They take care in finding texts, translating them if need be and extracting the data necessary for the reconstruction. The analysis of the iconographic and archaeological sources comes next. The study of the archaeological reports must be conducted using a rigorous historical method; it is the condition as of the 4th century which is reconstructed and

this condition must be isolated from all of the available information. When, for a building, all the data concerning the 4th century have been exhausted and information is still missing, we use what can be extracted from previous and posterior periods or work by analogy by studying better informed or preserved contemporary buildings which have the same function as the one which is to be reconstructed.

The main software used is 3D Studio Max (usa.autodesk.com) for modeling, rendering and passive animation, Poser (www.curiouslabs.com) for modeling sculptures, Photoshop (www.Adobe.com/Photoshop) for creating some textures, and Virtools or CryEngine for the interactive visit (www.virttools.com or <http://mycryengine.com>). Images are calculated by default to represent the situation on June 21st, the summer solstice, at 3 pm. As a rule, we don't use artificial light projections, so some spaces can be dark, but this corresponds to the ancient reality. However, in any case, when the room hasn't any windows, we have to use artificial light but this light always corresponds to an ancient system. In 2003, the team decided to reconstruct ancient Rome in order to access and render the model in real time. There are many advantages to making an interactive visit. First, people using the virtual model are no longer spectators but are actors. Whereas with a pre-calculated video, the visitor follows a precise script, the interactive world gives him the freedom to go where he wants, when he wants. Moreover, moving is calculated as in reality and the exploration of the model can be an experimentation of the time of moving in ancient Rome. Then, the machines can be manipulated too to see their functioning. Finally, the interactive visit is more attractive for the public at large, especially if there is a stereoscopic display.

4 An Example: Interactive Visit of the Temple of Venus and Rome

An interactive visit of the temple of Venus and Rome allows us to show the results of using this methodology. Located in front of the Coliseum, this temple was inaugurated by Hadrian in 135 A.D. and completed by his successor. It is the largest temple in Ancient Rome (its podium measures 145 meters in length and 100 meters in width). It is a temple difficult to understand today, because it has been largely destroyed (fig. 5): converting it into a church in 847-853 accelerated the ruin of the building, which also underwent an earthquake in the same period. The virtual reconstruction is particularly interesting in this case, because it helps to perceive the exceptional size of the building and its decoration (fig. 6).

4.1 The Ancient Source Material

Textual Sources: We have only a few texts (see the list in Cassatella 1999) relating to the temple of Venus and Rome, and most of these texts are not useful for the reconstruction of its condition in the 4th century A.D. They inform us that before the construction of the temple of Venus and Rome, the terrain was occupied by the vestibule of the *domus aurea*, the palace of Nero, and more precisely by the colossus

of this emperor, a 35-meter high bronze statue which was moved near the coliseum by twenty-four elephants (Hist. Aug., *Had.* 19, 12). We have also some information about the two biggest statues installed inside the temple (Dion Cassius 69, 4). These seated statues are famous because the architect Apollodorus of Damascus thought that they were too high for the size of their *cellae*. His opinion was that if the statues had been alive, they would not have been able to get up to leave the temple. Hadrian, who was the architect of the temple, did not appreciate the remark and Apollodorus was subsequently killed. We know that the two men had had some disagreements before: when Trajan (Hadrian's predecessor) was the emperor of Rome, Apollodorus was his architect. One day Hadrian who was pluming himself upon some such drawing, tried to give some advice to Apollodorus who was speaking to the emperor. Upon being interrupted the architect told Hadrian: "Be off, and draw your gourds. You don't understand any of these matters." So if Hadrian tolerated the first affront when he had no power, once he became emperor he punished Apollodorus.

Archaeological Sources: Thus the archaeological data have been essential in order to reconstruct the temple even if it is not well preserved (see fig. 5). Several photos and measurements were taken on the site by a student member of the team, A. Favier, and completed with archeological publications (Monaco 2000, Danti 2000). The chamber (*cella*) of Rome on west side, with porphyry columns and polychrome marble pavement, is better preserved than that of Venus (Coliseum side).

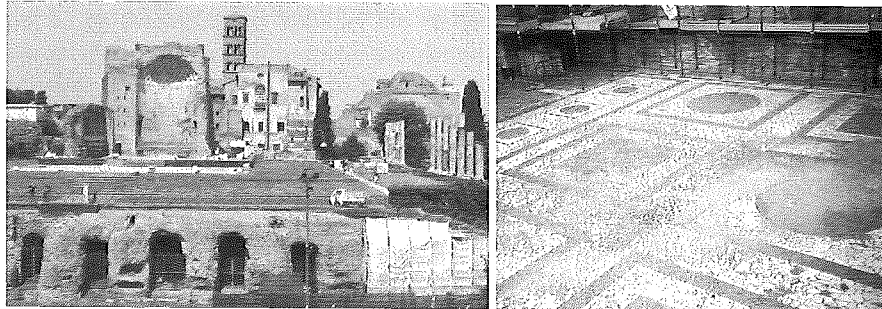
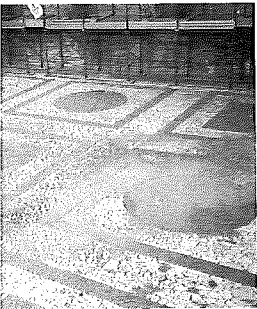


Fig. 5. The temple of Venus and Rome today from the Coliseum (apse of Venus on the background) and the *cella* of Rome today

Iconographical Sources: For this temple, two kinds of iconographical data were used: coins and the drawing of a sculpture that is lost today. Among the coins, a sesterce from 134-138 A.D. shows a decastyle temple with statues on the roof of the temple; we recognize Victories on each side and a chariot in the middle. A bas-relief showed the inauguration of the temple of Venus and Rome. The document is also lost today but it was seen during the Renaissance and we have drawings from this period. It is possible to recognize the fluted columns of the temple of Venus and Rome, with Corinthian capitals. We have details of the decoration of the fronton, which probably represents the she-wolf with Romulus and Remus, Rhea Silvia (their mother), Mars (their father), and the two shepherds who reared the children.

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4.2 Virtual Reconstruction

The temple of Venus and Rome is in fact made up of four different parts: the podium, the portico, the temple and the two inside chambers.

The Podium: The temple stood on a large podium which dominated the Via Sacra (fig. 6). The podium was also necessary because the architects needed a level surface to erect this temple installed on the slope of the Velia, one of the secondary hills of Rome. Inside the highest side of the podium (Coliseum side), there were rooms which probably gave service spaces for the amphitheater.

The Portico: A great portico with columns of grey Egyptian granite and Corinthian capitals of white marble surrounded the temple. There were two possibilities to gain access to the portico: the double flight of stairs on the coliseum side (fig. 6) and the staircase on the forum side near the arch of Titus. Between both points of access, there were two propylaeum, one on each side, with green marble columns.

The Temple: The temple itself is 107 meters long and is raised above the podium by seven steps. Its model was the temple of Olympian Zeus in Athena, but the Roman model exceeded it in size, even if the columns were probably of the same size, about 16.90 meters high with a diameter of about 1.90 meters. The exterior design was rich. The roof, for example, was covered with bronze tiles (fig. 6). In 625 A.D., the bronze tiles were taken by the pope Onorius I to cover Saint Peter's Basilica (*Lib. Pont.* I, 323).

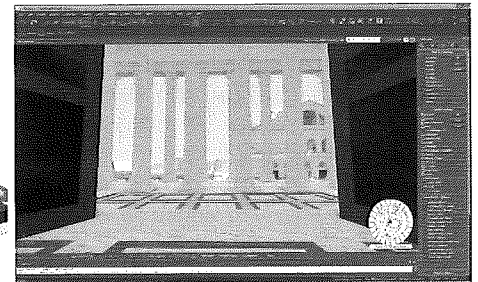
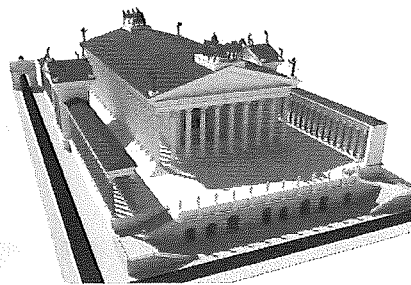


Fig. 6. The temple of Venus and Rome

The Chambers (*cellae*): This temple was very special because it had two cellae. The cellae were arranged symmetrically back-to-back. Rome's cella faced west, looking out over the Roman forum, the heart of the city, and Venus's cella faced east, looking out over the Coliseum. The semi circular chambers (one of them is still visible today, see fig. 5) were probably constructed after the fire of 306 A.D. The decoration of the inside was luxurious, with marble cladding (fig. 6). The roof had collapsed and the chambers were totally rebuilt, with niches surrounded by porphyry columns.

Beyond the virtual reconstitution, an interactive real-time model of the temple of Venus and Rome has been developed by the "Plan de Rome" team. The virtual tour is

available in English on the website www.unicaen.fr/rome, "Virtual reconstruction" / "Already realized" / "Guided tour".

5 Conclusion

The work produced can be accessed via research papers (e.g., Fleury 2009), via the website www.unicaen.fr/rome, and via a stereoscopic display at the University of Caen. Our aim is to provide access to recent research not only to scientists, but also to the public at large. Beyond the creation of pictures, the interactive visit can be a good approach to understanding our cultural heritage, preserving it and making it accessible in the entire world. The possibility of consulting an interactive visit on a website is perhaps a solution to make the public at large sensitive to our cultural heritage. The main difficulty is distinguishing scientific productions from imaginary ones because when a picture of the past is produced, it is often considered as a truth, even if it is only a hypothesis. Therefore we are members of the editorial board of *Digital Applications Archaeology and Cultural Heritage* (see www.elsevier.com/locate/daach) which is the world's first on-line, peer-reviewed journal in which scholars can publish 3D digital models of the world's cultural heritage sites, accompanied by related academic articles.

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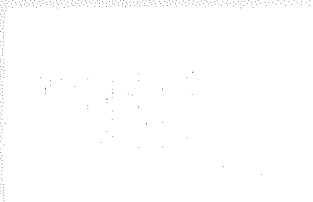
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