Archaeoseismological evidence of a disruptive Late Antique earthquake at Alba Fucens (central Italy)

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ABSTRACT Paleoseimological investigations in the 1990s identified a surface faulting event in the Fucino Plain (central Italy) related to the 5th-6th century AD. This event originated along the same seismogenic source responsible for the 1915 earthquake (*Mw* 7.0) that caused damage over a vast region, including Rome. This earthquake was associated to the one that was responsible for damage to the Colosseum in Rome, just before 484 AD or 508 AD. Considering that this event was energetic enough to create surface faulting, significant effects would be expected on the settlements of the 5th-6th century AD. In modern archaeological publications, the destruction of Alba Fucens in the north-western sector of the Fucino area has been related to the effects of a destructive earthquake that occurred during the Late Antiquity. Archaeological evidence on the effects of the earthquake is mostly made up of collapsed layers including columns, statues, coins and other materials and layers formed by burnt remains (mainly parts of the wooden structures of the buildings). However, this Late Antique earthquake has been attributed to the 4th century AD in archaeological literature. With this discrepancy in mind, we have carried out a study of the archaeological sources and have collected new archaeological data, in order to cast light on this chronological problem. The review of the published and unpublished archaeological information regarding the excavations carried out at Alba Fucens between 1949 and 1979, plus the data collected at new excavations that have been going on since 2004 at different sites in the Fucino basin, suggest that the destruction of Alba Fucens and other towns and settlements of the region occurred later than assumed in archaeological literature. On the whole, the gathered data are consistent with the published paleoseismological information, and suggest that this destruction occurred during the 5th-6th century AD. Although the processing of the data concerning the archaeological investigations at Alba Fucens in 2006-2008 is still ongoing, the current, most plausible hypothesis at present, is that the 484-508 AD earthquake was probably responsible for the destruction of Alba Fucens.

1. Introduction

The archaeological site of Alba Fucens exposes part of the ruins of an ancient Roman town in the Abruzzi region, in central Italy. The town was founded on a hill of pre-Pliocene carbonate

rock and Plio-Pleistocene clayey-sandy deposits and carbonate breccias. The site had a strategic role, since it lay along the Valeria road, connecting Rome to the Adriatic regions of Italy, and located close to the shore of Lake Fucino (a large lacustrine basin that was initially drained by the Romans, and finally drained during the 19th century) (Ceccaroni, 2006). This area is seismically active and was struck by a large earthquake in 1915 [*Mw* 7.0, according to the Catalogue CPTI08 (Rovida and Working Group CPTI, 2009)] that completely destroyed the village of Alba, which had been built during the Middle Ages, close to the area previously occupied by the Roman settlement.

Among the paleoseismological investigations along the faults that were activated in 1915 (e.g., Giraudi, 1988; Galadini and Galli, 1996, 1999; Michetti *et al*., 1996; Saroli *et al*., 2008), some studies have reported the displacement of a Roman canal that was excavated in the Fucino basin, and have hypothesised the occurrence of another strong earthquake during the Late Antiquity. In particular, Galadini and Galli (1996) concluded that the earthquake that damaged the Colosseum in Rome in 484-508 AD (Guidoboni, 1989) might have been the same as the one responsible for the displacement of the Roman canal. Therefore, it probably originated in the Fucino basin, through the activation of the same source as for the 1915 event.

Since 2004, systematic archaeoseismological investigations have been carried out in the archaeological sites of the Fucino area (San Benedetto dei Marsi, Luco dei Marsi, Avezzano, Alba Fucens), to find traces of this ancient earthquake and to further define the chronological constraints. Most of these investigations were performed during excavations made with modern stratigraphic criteria. The most recent archaeological excavations at Alba Fucens began in 2006, but this site has a long archaeological tradition. Indeed, since 1949 archaeologists from Leuwen University, Belgium, repeatedly excavated there. For this reason, we also critically reviewed the material available from less recent archaeological activities, published since the 1960s or available in reports stored in the archives of the Soprintendenza per i Beni Archeologici dell'Abruzzo (herein Archaeological Authorities of Abruzzo).

After a short section summarizing the results of past paleoseismological investigations, this study reports on the archaeoseismological evidence of the destruction at Alba Fucens and the surrounding sites. These data will be: *i*) integrated with the information collected from other archaeological sites of the Fucino area (since a strong earthquake always has an impact over a significantly large area); and *ii*) compared with the results of the paleoseismological studies. The data and information that has been gathered provide a picture of an earthquake that certainly had a strong impact on the Late Antique settlements of the Fucino basin.

For the purpose of this study, we limited our analysis to a critical review of both published and unpublished archaeological data on Alba Fucens, collected by archaeologists between 1949 and 1979, introducing some data from new archaeological excavations that have been carried out at Alba since 2006.

2. Paleoseismological data

Paleoseismological investigations have been performed in the Fucino area along the 1915 earthquake faults by researchers from various institutions since the 1980s (Giraudi, 1988; Galadini and Galli, 1996, 1999; Michetti *et al*., 1996; Galadini *et al*., 1997; Saroli *et al*., 2008).

During the 1990s, investigations were carried out through the ad-hoc excavation of trenches across the faults with Holocene activity (Fig. 1). Galadini and Galli (1999) defined ten displacement events over the last 32,000 years, seven of which occurred during the Holocene. According to Galadini and Galli (1999), the Holocene displacements define a continuous paleoseismological succession. This allowed the estimation of a recurrence time, which ranges between 1,400 and 2,600 years.

One of the secondary faults of the Fucino plain (Trasacco fault; Fig. 1) was responsible for the displacement of a Roman canal built during the 1st-2nd century AD to drain Lake Fucino for agricultural purposes (Galadini and Galli, 1996; Giraudi *et al*., 2001). The displacement occurred when the drainage works had ceased operation, presumably due to lack of maintenance. In their summary of the displacement events, Galadini and Galli (1999) also identified this earthquake along the San Benedetto dei Marsi–Gioia dei Marsi fault (Fig. 1), according to the displacement of lacustrine silts related to the lacustrine ingression along the shore of the historical lake, following the cessation of the Roman drainage works. Therefore, the time of this lacustrine deposition is fundamental for the definition of the age of the pre-1915 seismic event. The radiocarbon dating of a peat level displaced by the fault indicated an age (at 2 sigma) of 426-782 AD (Galadini and Galli, 1999). On this basis, this study attributed the seismic event to the 5th-8th century AD. In the northern sector of the basin, excavations for the laying of a gas pipeline carried out during 1998 provided further information to define the timing of the earthquake. Indeed, Galadini and Galli (2001) analysed the remains of a mill found in lacustrine deposits of an age preceding the Roman drainage (2 sigma calibrated radiocarbon age: 50 BC-70 AD) and located close to the natural historical shoreline preceding the lake drainage of the 19th century. Fragments of wood from the structure indicated 2 sigma calibrated radiocarbon ages of 370-425 AD and 245-410 AD (Galadini and Galli, 2001). This mill that was built during the 4th-5th century AD exploited the water from a canal for which traces have been detected in the section at the border of the archaeological excavation. The canal was filled by lacustrine sediments deposited during the new ingression following the Roman drainage. The abandonment of the mill might have been a natural consequence of the lacustrine ingression. The deposits were radiocarbon dated at 556-688 AD [calibrated age; Galadini and Galli (2001)]. Considering that the age results from the bulk organic matter contained in the deposit, the lacustrine ingression and deposition in the shoreline area certainly occurred in a period slightly preceding the reported date. The whole data set suggests that the preferable time interval for the lacustrine ingression along the natural shoreline of the historical lake, and therefore for the Late Antique earthquake, is the 5th-6th century AD. Based on these data, and considering that destructive earthquakes of the central Apennines have always caused damage to Rome, this study related the co-seismic faulting of the 5th-6th century AD to the earthquake that damaged the Colosseum just before 484 or 508 AD; a well known fact of seismological literature (Guidoboni, 1989; Boschi *et al*., 1995). Indeed, this earthquake has been recalled in two epigraphs [CIL VI, 1716(a); CIL VI, 1716(b)] that are located at the main entrance of the Colosseum. The seismic event (*abominandi terraemotus* in the epigraphs) was responsible for damage to the *arena* and the *podium* of the amphitheatre, and traces of the related interventions have also been found by archaeologists (Rea, 1999, 2001).

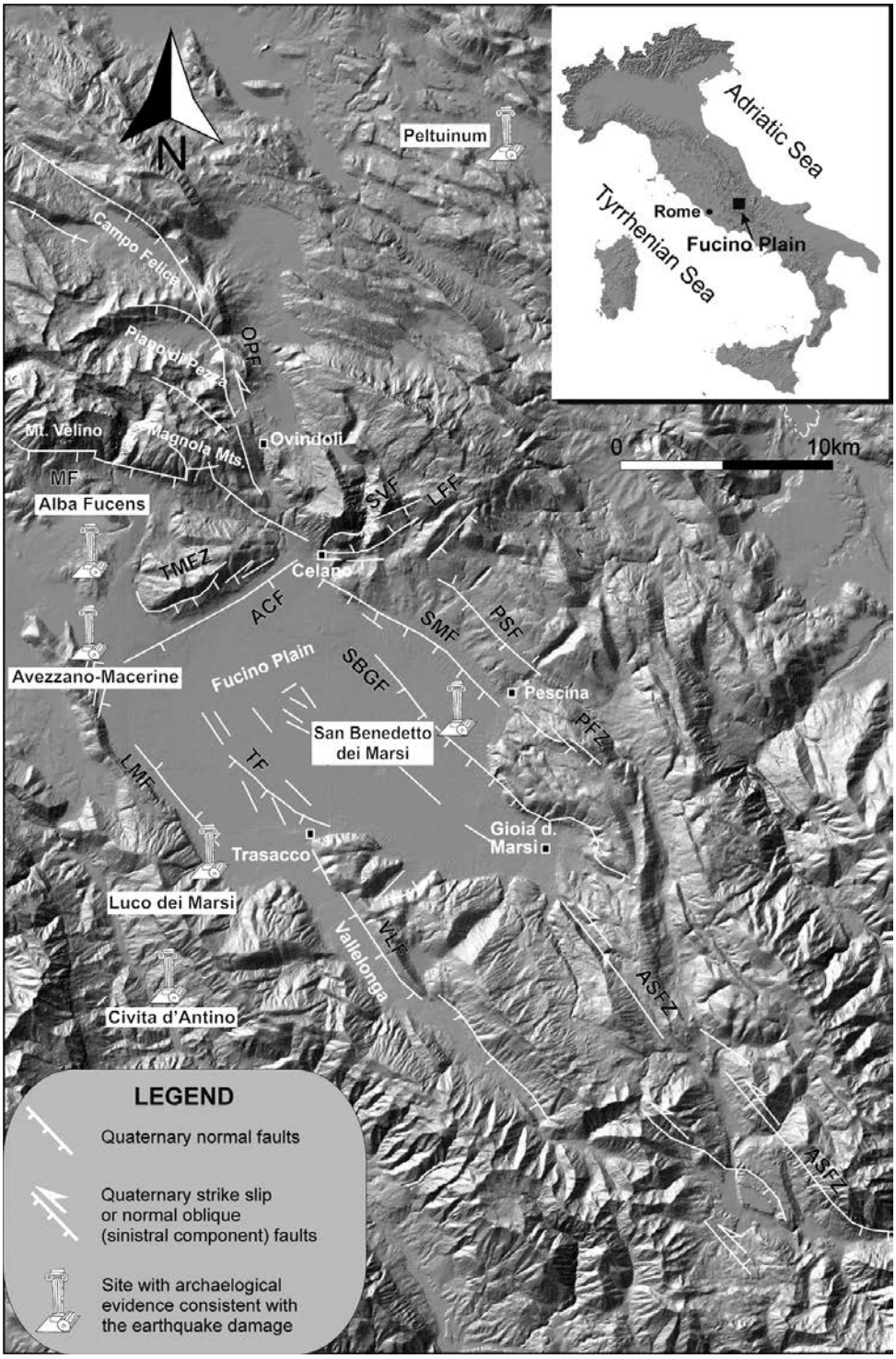

Fig. 1 – Map of the active faults and the archaeological sites mentioned in the main text. Faults: OPF, Ovindoli-Pezza fault; MF, Magnola fault; TMFZ, Tre Monti fault zone; ACF, Avezzano-Celano fault; SVF, San Vittorino fault; LFF, La Foce fault; PSF, Pescina Station fault; SMF, Strada Statale Marsicana fault; PFZ, Parasano fault zone; SBGF, San Benedetto dei Marsi-Gioia dei Marsi fault; TF, Trasacco fault; LMF, Luco dei Marsi fault; VLF, Vallelonga fault; ASFZ, Alto Sangro fault zone.

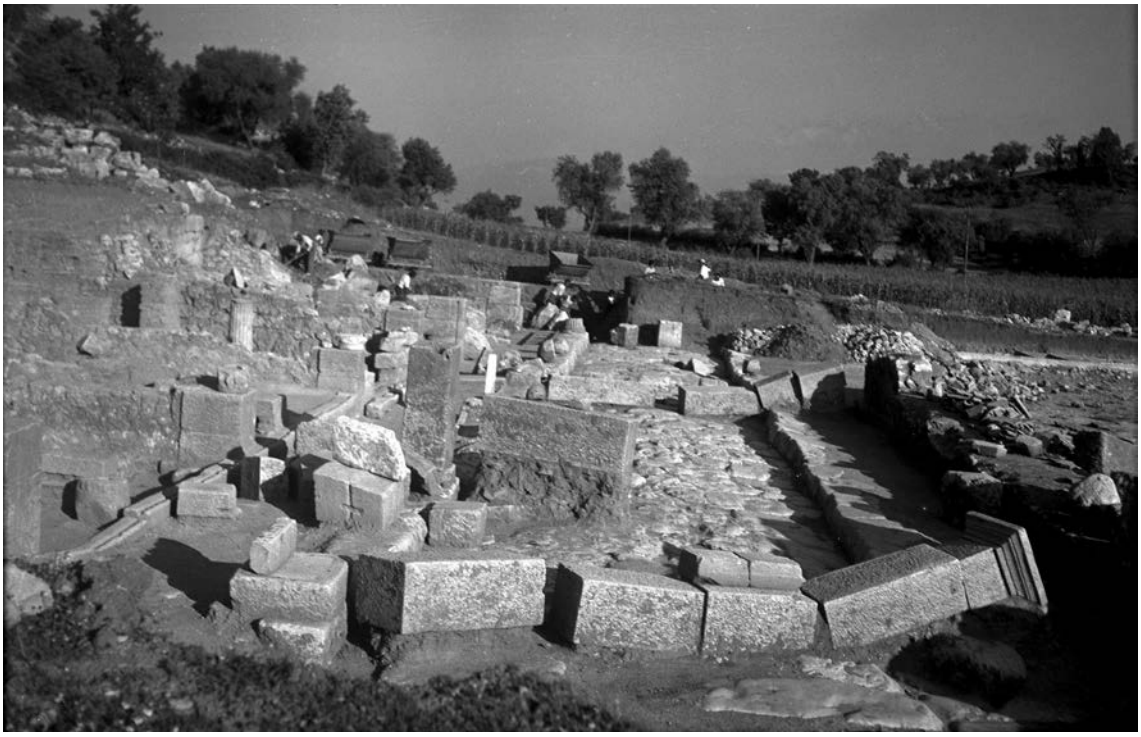

Fig. 2 – Alba Fucens: pillars collapsed across Via dei Pilastri. Due to the collapse, the operation of the road ceased until the modern archaeological excavation and the subsequent restoration of the pillars (courtesy of Soprintendenza per i Beni Archeologici dell'Abruzzo).

3. Archaeoseismological evidence at Alba Fucens

3.1. The available literature

The hypotheses relating to the seismic destruction of Alba were included in the publications by Mertens (1981, 1991), who reported the uncovering of pillars that had collapsed onto the pavement of one of the main roads of Alba (the so-called Via dei Pilastri; Fig. 2), together with the settlement of retaining walls and the subsequent filling of the inhabited area with layers of reworked materials, containing soil, ruins and ash. Life continued there after this event, but people stayed in temporary residences among the remains of the walls. Sculptures, columns and fragments of friezes provided the primary material for producing the lime. A radiocarbon dating (although on unspecified sediments) gave a calibrated date of 260-330 AD for the abandonment of previously frequented structures (Mertens, 1991). This date would be consistent with the coins of Constans the 2nd and Valens that were found on the pavement of the road. In Mertens (1991), the reference to Jacques and Bousquet (1984), who investigated the 365 AD earthquake, suggests that he considered this earthquake as being consistent with the destruction of Alba. The earthquake is well known in seismological literature, and has been conclusively attributed to the Aegean area (Stiros, 2001). Less precise chronological detail was expressed in Mertens (1981), with reports that the numerous layers extended throughout the town suggesting the occurrence of

a fire, and are testimony to the catastrophes that struck Alba at the end of the 4th and during the 5th century AD. Mertens (1991) also reported that a small church was built over the level of destruction. However, the chronological constraints for this building were not very narrow, and it was attributed to the 4th-8th century AD. The use of the town at a later stage, not in the same flourishing state as it was before the catastrophe, appears to be confirmed by the presence of the Byzantian troops close to or in Alba in 537 AD (Procopius of Caesarea, 6th cent. AD) and might be consistent with the uncovering of a large amount of material attributed to the 6th century AD (Redi, 2001; Tulipani, 2006).

The hypothesis that the earthquake conditioned the history of Alba during the second half of the 4th century AD was reported in archaeological literature (Buonocore and Firpo, 1998; Campanelli, 2001a; Liberatore, 2001, 2004) subsequent to the studies of Mertens (1981, 1991). In Buonocore and Firpo (1998), the destruction was related to the 346 AD and 375 AD earthquakes. However, the former struck the Sannio-Matese region, with maximum damage about 100 km south of Alba (Galadini and Galli, 2004; Galli and Naso, 2009), and the latter struck the town of Benevento, more than 150 km south of Alba (Boschi *et al*., 1995). In both cases, the attribution of significant damage to this ancient town is at least debatable.

3.2. Evidence from archaeological excavation reports

We had the opportunity of reading the detailed excavation reports written between 1949 and 1953 (Berardinelli, 1949-1953). These reports frequently described traces of building collapse or the uncovering of statues included in collapse units over floors that were still frequented at the time of the destruction. In these cases, we infer that no layer of abandonment (colluvial sediments or reworked materials) was found between the collapse layers and the floors. For example, in the report of May 18, 1951, related to excavations along the road called Via Valeria, Berardinelli wrote that five marble fragments of a statue of a man in a toga were found on the pavement. Moreover, numerous drums of columns, capitals, marble slabs and friezes were uncovered onto the frequentation levels. Among the different cases, we can cite the report of April 29, 1950, again related to Via Valeria, recalling the uncovering of a capital and a huge block related to the capital, representing the continuation of a collapsed pillar. This description suggests that the pillar was in such a position as to indicate a sudden collapse.

Some of these discoveries can also be deduced from the photographs available from the 1950s and 1960s (Figs. 2 to 6). In general, the collapse of columns with their capitals (Fig. 3) over floors or pavements that were still frequented at the time of the destruction can be related to sudden toppling events. The capitals remained juxtaposed to the columns or slightly separated from them.

The reports by Berardinelli (1949-1953) also cited the above-mentioned uncovering of the collapsed pillars along Via dei Pilastri (Fig. 2). This occurred between June 4 and June 13, 1951. He explained in detail that - across the road - “four blocks of squared stone, probably related to a pillar, were uncovered... the capital found on June 4 certainly pertains to this pillar”. Moreover, on June 11, Berardinelli wrote “across the road, collapsed, parts of three pillars carved into the stone with their capitals have been uncovered. The bases will probably be found along the pavement, which has not yet been excavated”. These pillars are also described in De Visscher *et al*. (1955) and in Mertens (1969). The blocks of the three pillars were lying in such a way as the result of their toppling across the road. From the photographs available, we can see that the pillars

Fig. 3 – Alba Fucens: collapsed column and capital still juxtaposed after the collapse (courtesy of Soprintendenza per i Beni Archeologici dell'Abruzzo).

were lying over the pavement and no colluvium or reworked materials were present between the ruins and the road. The tiles of the *porticus* and of the adjacent *tabernae* contributed to form the thick layer of collapse. In the case of the two northernmost pillars, the parts closer to the bases probably collapsed later, as a thick layer of colluvial deposits indicate (De Visscher *et al*., 1955). Alternatively, these blocks may have collapsed contemporaneously with the other blocks, but in the presence of debris along the eastern side of the road. The sudden collapse of the pillars and of the related *porticus* certainly coincided with the destruction of the *tabernae* and the abandonment of the quarter. Indeed no attempts were made to clear these huge blocks from the road.

Evidence of collapse is also mentioned in the reports of July 18 and 21, 1951. In this case, the collapse involved walls in polygonal blocks, i.e. heavy and solid structures. This evidence is also mentioned in De Visscher *et al*. (1955), who reported that huge blocks were filling *tabernae* nos. 7 and 8.

Traces of fire, described in the archaeological reports, also testify the occurrence of a catastrophic event. A thick layer of ash and burnt remains was found in almost all of the *tabernae* of Via dei Pilastri and in the buildings along the western side of Via Valeria. The thickness of this layer varies from between 10 cm and 50 cm (June 19, 20, 21, 27, 1951; July 4, 5, 1951; May 9, 1952; July 7, 11, 1952; May 19, 1953). In some cases, the burnt materials and the ash had accumulated within the buildings after episode(s) of fire ("at 0.40 m over the floor, the reworked material is represented by a thick layer of burnt remains including a level of fragments of tiles"; June 27, 1951). These darkish layers provided abundant remains (e.g., coins, *fibulae*, gold *laminae*, bronze rings, spoons made of bone). The relationship between the layer relating to fires and the material collapsed from the roof is evident in the description available for the "first *taberna*": "0.30 m above the floor, a layer of burnt material, about 0.15 m thick, was found; a tangle of big tiles (entire, in some cases) was uncovered over this layer" (June 21, 1951). This evidence of fire appears consistent with that affecting the floors of *taberna*e G and H of Via degli Elefanti (De Visscher *et al*., 1955).

Sparse traces of fire have also been described for the "rectangular building ... along Via Valeria, at the intersection with Via del Miliario", in unpublished manuscripts relating to the first excavations (Anonymous, 1949; De Visscher *et al*., 1949). These traces are a sort of leitmotif for the archaeology of Alba, since the work by Promis (1836), who mentioned the layer of charcoal found in the excavation of a public building and hypothesised the occurrence of a fire. Similar traces of fire were also uncovered on numerous stones of the amphitheatre (Mertens, 1969).

The uncovering of an impressive number of coins (from the reports by Berardinelli: July 3, 1952, 10 coins; July 8, 1952, 48 coins; July 9, 1952, 32 coins; July 14, 1952, 13 coins; May 30, 1953, 28 coins; June 16, 1953, 9 coins) on the floors of the excavated buildings also support the hypothesis that a sudden and dramatic event occurred. Already during the first excavations, Berardinelli hypothesised that an earthquake caused the destruction of Alba. Indeed, as for the *thermae*, the floors of the rooms were defined as "entirely slid down" (June 7, 1949). In this case, the collapse of the *suspensurae* is related to "seismic shocks". The destruction was also mentioned in 1950, when the floor of the *thermae* is described as "entirely collapsed" (April 21 and 22, 1950).

The unpublished reports on the first archaeological campaign (Anonymous, 1949; De Visscher *et al*., 1949) did not describe the destruction layers; only that a milestone was uncovered

Fig. 4 – Alba Fucens: collapsed capital along Via Valeria (courtesy of Soprintendenza per i Beni Archeologici dell'Abruzzo).

looking as though it had "collapsed over the pavement" (Anonymous, 1949), which suggests that the destruction occurred when the road (Via Valeria) was still in use, and not when it was sealed by reworked materials and colluvial deposits. Moreover, the buildings of the *thermae* were described as being "enough ruined". Published works also provide some information on the collapse units. Collapsed materials are reported for Via Valeria (De Visscher and De Ruyt, 1951): a rectangular capital, carved in a grey stone (perhaps that of Fig. 4), huge stones with inscriptions, a huge fragment of cornice with the capital of a pillar, bronze materials and marble fragments, and a small unguent jar. As for the *basilica in opus incertum*, De Visscher and De Ruyt (1951) described the uncovering of an acephalous marble bust on the floor. Drums of columns were uncovered in the zone of the *porticus*, close to "base no. 1", consistent with the capitals recovered in the area of the market. Toppled bases of statues were uncovered in the south-eastern rooms of the market. The authors also reported that the statue of a man in a toga and the head of Silla were discovered (years before the Belgian excavations) in a small room close to the north-western rampart and Porta Fellonica. These pieces were deposited in a hurry, "without any doubt after a destruction of the town".

The abundant materials found on the floors of the *tabernae* of Via Valeria were described by De Visscher *et al*. (1955). Remains of statues of men in togas (e.g., that of Fig. 5) lying over the floors were uncovered in the sanctuary of Hercules, together with a statue of the deity himself (Fig. 6) (Mertens, 1969). This latter appears to be one of the most significant discoveries from an archaeoseismological perspective. Information on the state of the statue can be derived from De Visscher (1961): the head of Hercules was found intact, facing up (Fig. 6). The trunk was found

Fig. 5 – Alba Fucens: remains of a collapsed statue of a man in a toga (courtesy of Soprintendenza per i Beni Archeologici dell'Abruzzo).

close and "behind" this fragment, broken into two parts at the height of the navel, with the back facing up (as documented in the photographs available; Fig. 6), the axis in a N-S direction. The other fragments of the statue were distributed in an E-W direction, at the limit or beyond the zone bordered by the columns.

All the information provided here is consistent with the hypothesis of the Late Antique earthquake, and can be summarised in the following points: *i*) numerous cases suggesting the sudden collapse of buildings over pavements and floors still frequented at the time of the destruction, i.e., no layers of abandonment are described between the collapsed layers and the units of frequentation; *ii*) the same orientation of the pillars collapsed across Via dei Pilastri, suggesting the sudden toppling of a huge wall delimiting the *tabernae* of this zone of Alba; *iii*) the position of the statue of Hercules, suggesting the occurrence of a sudden collapse; *iv*) traces of fire in different buildings; and *v*) the huge number of coins found on the floors.

3.3. Chronological constraints from archaeological sources

The age of the event could be based on the abundant numismatic material (mainly related to the 4th century, but with later coins by Valentinian 1st and Valentinian 2nd, and also a coin of the 5th century by Theodosius). It is well known, however, that coins of this period were used for quite a long time span after their coinage (e.g., Saguì and Rovelli, 1998; Molinari, 2002). Therefore, the numismatic dating is not completely reliable.

The radiocarbon age reported in Mertens (1991), of 260-330 AD, also appears problematic. Indeed, the organic fragments that were available from the excavations of Alba (generally

Fig. 6 – Alba Fucens: remains of the collapsed statue of Herakles Epitrapezios (courtesy of Soprintendenza per i Beni Archeologici dell'Abruzzo).

fragments of wood, and bones not related to burials) do not define the *ad quem* age for the deposition of the unit containing them, but only its lower chronological limit. This is certainly true for the colluvial deposits and for the abundant reworked materials sealing the ruins of Alba. This is a major problem also for a date obtained from most of the organic materials available in the collapsed units. In many cases, indeed, we can obtain dates from the remains of wooden beams. These remains provide information on the age of the construction or restoration of a building and define a *post quem* date for the destruction. Based on the above discussion, we can conclude that the 4th century AD (late 4th century, based on the coins) can be considered as the lower chronological limit for the seismic event.

This hypothesis is supported by the data relevant to the later archaeological material. Based on the analysis of the pottery and also of the style of a column that has been attributed to the 6th century (with a "basket weave" decoration), Redi (2001) invoked continuity between the Late Antique settlement and that of the High Middle Ages. This analysis was also confirmed by a more recent study (Tulipani, 2006), and indicates that no significant interruptions can be defined in the history of the town during the 4th century AD. By contrast, the remains analysed by Redi (2001) and Tulipani (2006) suggested the continuous life of the settlement until the 6th century AD, and a probable contraction or crisis in later periods.

3.4. Information from recent archaeological investigations

After the end of the long season of Belgian archaeological investigations in 1979, and after minor activity by the local Archaeological Authority, the latter promoted new excavations in

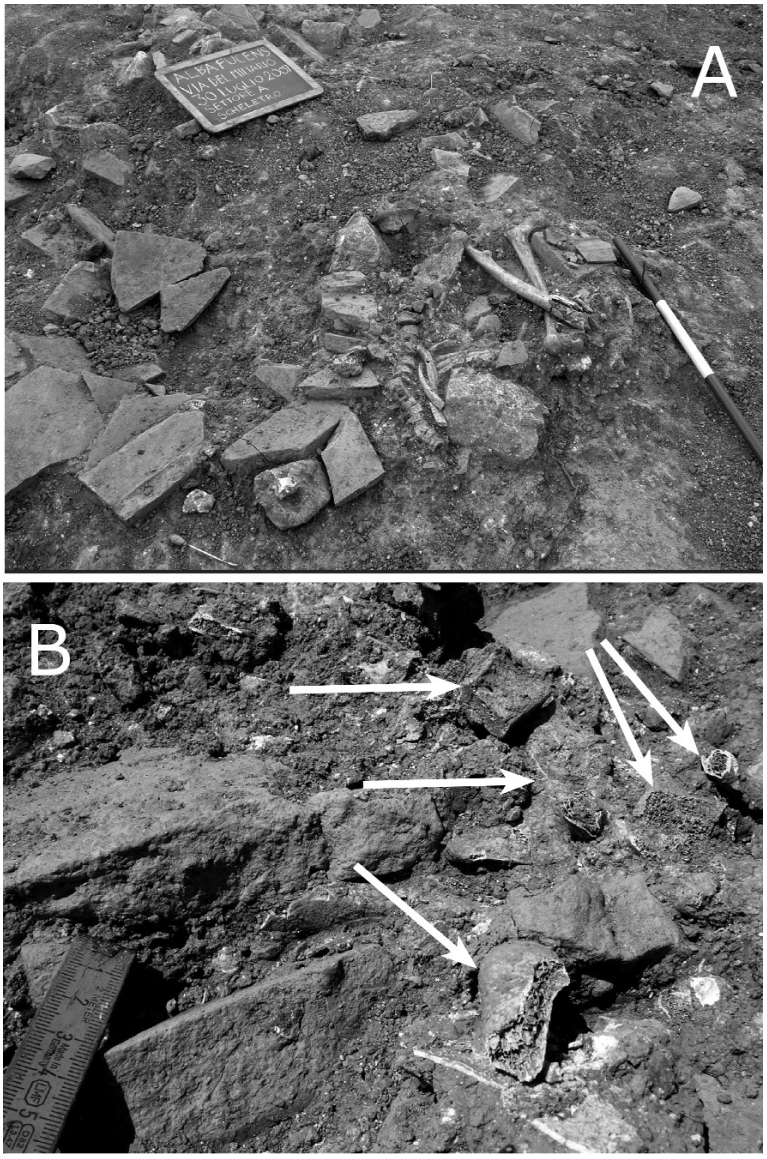

Fig. 7 – Alba Fucens: A) remains of human bones included in the collapse unit in a *taberna* along Via Valeria; the radiocarbon dating gave an age of 435-491/509-517/529-607 AD (2 sigma calibrated age); B) detail of A showing fragments of bones underlying fragments of tiles (white arrows).

2006-2008. In 2006, the limit of the Belgian archaeological yard – a scarp carved into the unconsolidated sediments filling the depression of Alba – was cleaned and analysed. The units included in this succession were mainly made of colluvial deposits and reworked materials. Both types of sediments – naturally or culturally deposited – contained pottery fragments, aging back to the 5th century AD (fragments of "*terra sigillata africana*" pottery, classified as Hayes 91 C23, Hayes 61 A21, Hayes 61 B29, Hayes 67). The deposition of this up-to-3-m-thick succession sealed the ruins of the town and certainly represented the end of the frequentation of the Late

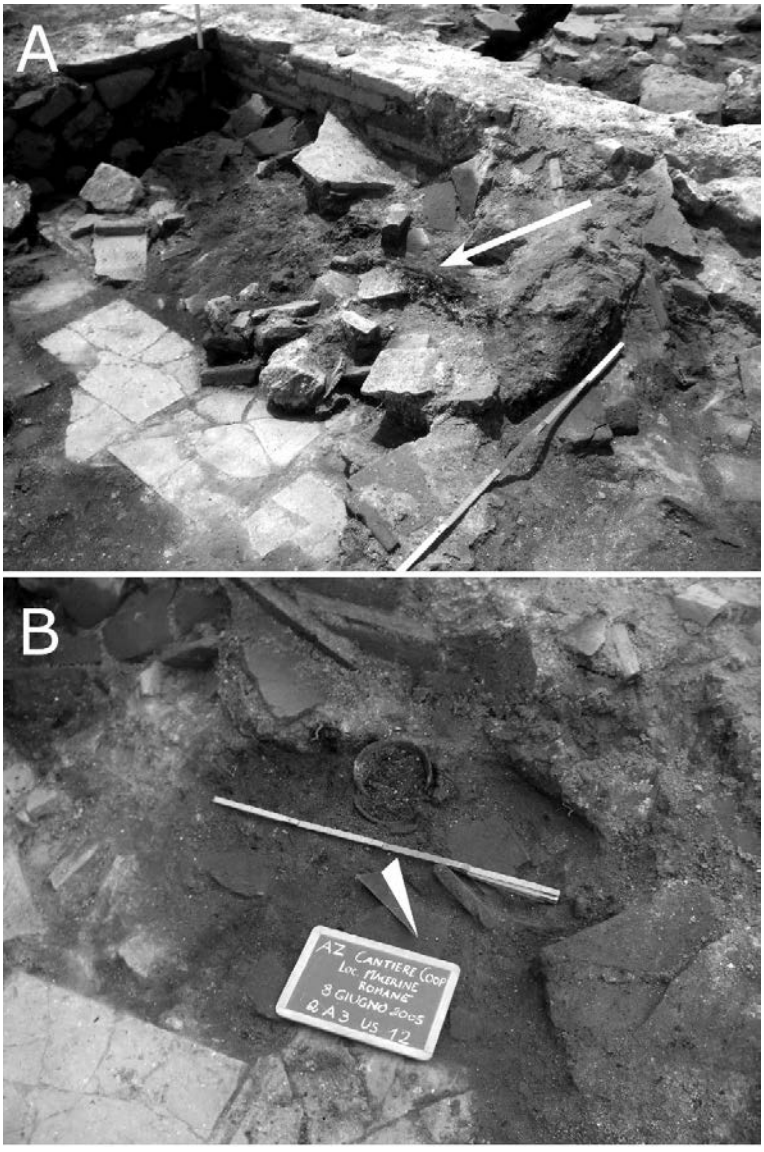

Fig. 8 – *Villa rustica* of Avezzano-Macerine: A) collapsed unit including a large fragment of a burnt beam; the collapse unit is lying directly over the floor (no interposing layer of abandonment); B) detail of the collapsed unit formed by tiles and remains of fictile materials.

Antique surfaces. The chronology of the materials defines the *post quem* date for the deposition, i.e., for a part of the local history which followed the destruction.

The archaeological campaign of 2007 included the excavation of a *taberna* along the road known as Via del Miliario. Part of a human skeleton was uncovered in a collapse unit mainly made of tiles, overlying the floor of the building (Fig. 7). A femur was radiocarbon dated at 435-491/509-517/529-607 AD (2 sigma calibrated age; probability of 19%, 1% and 80%, respectively). In our opinion, the bones were involved in the collapsed layer (Fig. 7b), i.e., the

individual was buried by the tiles during the collapse of the building. This is probably the best chronological information that can define the age of the earthquake that destroyed Alba.

On the whole, the information from archaeological sources as well as from recent investigations attribute the seismic event to a time span comprised between the late 4th century AD and the 6th century AD. The recently collected data (pottery fragments and the radiocarbon dating of the human skeleton) suggest that the latter part of the time span has to be preferred for the definition of the date of the earthquake.

4. The other archaeological sites

Since the impact of a destructive earthquake is areal, following the territorial approach to archaeoseismology (e.g., Guidoboni *et al*., 2000; Galadini *et al*., 2006), we consider data on other archaeological sites located in the Fucino basin and surrounding zones.

The excavations made in the northern suburbs of Avezzano (*villa rustica* of Macerine) also allow the collection of data on the Late Antique earthquake that struck Alba Fucens and the Fucino basin (Borghesi *et al*., 2006). Indeed, the final period of the settlement was conditioned by the collapse of roofs and walls, which is particularly evident in the western sector of the excavated area. The remains of the buildings were uncovered after excavation of collapsed units mainly made of tiles and of parts of walls (Fig. 8). These units were lying over the floors, without any interposed layers of abandonment. Large fragments of burnt wood were found, corresponding to the remains of the beams, together with wooden remains with dimensions in the order of a few millimetres or of centimetres (Fig. 8a). The latter fragments gave the typical greyish colour to the matrix of the collapse units. The absence of a layer of abandonment between the collapsed material and the floor excluded the fact that the destruction occurred as a consequence of aging and structural decay (hypothesis also excluded by the occurrence of fire, which demonstrates that the buildings were inhabited). In contrast, the hypothesis of the sudden collapse is supported by the uncovering of abundant fictile materials, related to almost whole or restorable artefacts (Fig. 8b). This means that the uncovered remains were still in use when the collapse occurred.

Further evidence of a sudden destruction is provided by the group of burials of women and children mentioned. The sharing of the same outfit among different burials and the presence of a double burial (woman and children together) suggest contemporary deaths of individuals.

Some points appear to be of particular importance to pinpoint the age of this event: *i*) the uncovering of abundant pottery fragments of the type "*terra sigillata africana"* attributed to the 4th-5th century AD (es. Hayes 61 B29), also with later fragments related to the 5th-6th century AD ; *ii*) the uncovering of numerous coins of the 4th century AD and of a coin related to the end of the 4th-beginning of the 5th century AD, the use of which certainly occurred over a long time period; *iii*) the evidence of interventions, preceding the destruction in the area, in the northern *porticus* of the villa, with the excavation of layers containing pottery fragments of the 4th-5th century AD; and *iv*) the outfits in the group of burials mentioned, related to the late 4th-6th century AD. On the whole, these data suggest that the fire and the final collapse of the buildings occurred during the 5th-6th century AD.

The results of the 2004 archaeological campaign by the Archaeological Authorities in the amphitheatre of San Benedetto dei Marsi (Fig. 9) are also important. Here, traces of the seismic

destruction are evident and can be summarised in the following points: *i*) synchronous collapse of the slabs which delimited the baldric, having been found with a "domino-like" attitude (Fig. 9a); *ii*) rotation around the vertical axis of part of a pier at the northern entry of the amphitheatre (Fig. 9b); *iii*) corner expulsion in the right room preceding the northern entry of the amphitheatre (Fig. 9c); *iv*) numerous fissures in the walls, also having a dip of a few degrees; and *v*) the collapse of huge portions of the structure.

Although an analysis of the materials has not yet been made, we can hypothesise that the collapse occurred during the Late Antiquity. The lower chronological limit is represented by the re-utilisation of the structure for purposes different from the original one. The same room affected by the corner expulsion experienced some restoration with a raising of the floor using slabs of the seats to form the new surface. This intervention was made before the final collapse (i.e., before the corner expulsion) and after post-Severian (i.e., since the 3rd century) restorations in the southern sector [identified by the re-utilization of a slab with an inscription related to Caracalla; Letta (1989)]. These modifications probably occurred within the framework of the superposition of the Late Antique structures on the original system of the town, already documented for San Benedetto dei Marsi (Campanelli, 2001b; d'Alessandro, 2001a). Moreover, similar to Alba and Avezzano-Macerine (although the units there also include pottery of the 5th-6th century), the later coins have been related to the second half of the 4th century AD (Di Stefano and Leoni, 2004). Considering this age as a *post quem* constraint for the destruction at San Benedetto and the co-seismic aspect of the collapse layers and of the displacements affecting the structure, we conclude that this amphitheatre also experienced the effects of the earthquake that destroyed Alba and the *villa rustica* of Avezzano.

Further excavations by the Archaeological Authorities at San Benedetto dei Marsi, close to Risorgimento Square, indicated a 5th-7th century AD re-utilisation of walls in *opus quasi-reticulatum* by the superposition of walls in *opus incertum* mixed with fragments of bricks (d'Alessandro, 2001a). Possibly, these restorations followed the crisis of the building heritage due to this earthquake.

For the sector north of the Fucino area, the case of Peltuinum appears quite interesting. Indeed, seismic damage has been attributed to the 4th century based on the uncovering of a coin of Constans the 2nd, below the collapse unit (Sommella, 1989). Since coins have to be considered only as lower chronological limits for the dating of Late Antique events, this case should be reconsidered in the light of the Late Antique earthquake in the Fucino area.

In the case of Luco dei Marsi, at the south-western border of the Fucino basin, evidence has been collected for the use of the Augustean temple until the 5th-7th century AD (d'Alessandro, 2001b). At Civita d'Antino, west of Fucino, the archaeological data indicate a contraction of the settlement in the 5th-6th century AD (Morelli *et al*., 2001). These data may have different historical justifications, although they have to be considered at least as consistent with the effects of the Late Antique earthquake observed at the other sites.

5. Concluding remarks

The archaeological data on the destruction of Alba Fucens and of other Late Antique settlements confirm and improve the conclusions of previous paleoseismological investigations. The geological evidence was based on the displacement recorded by deposits related to the

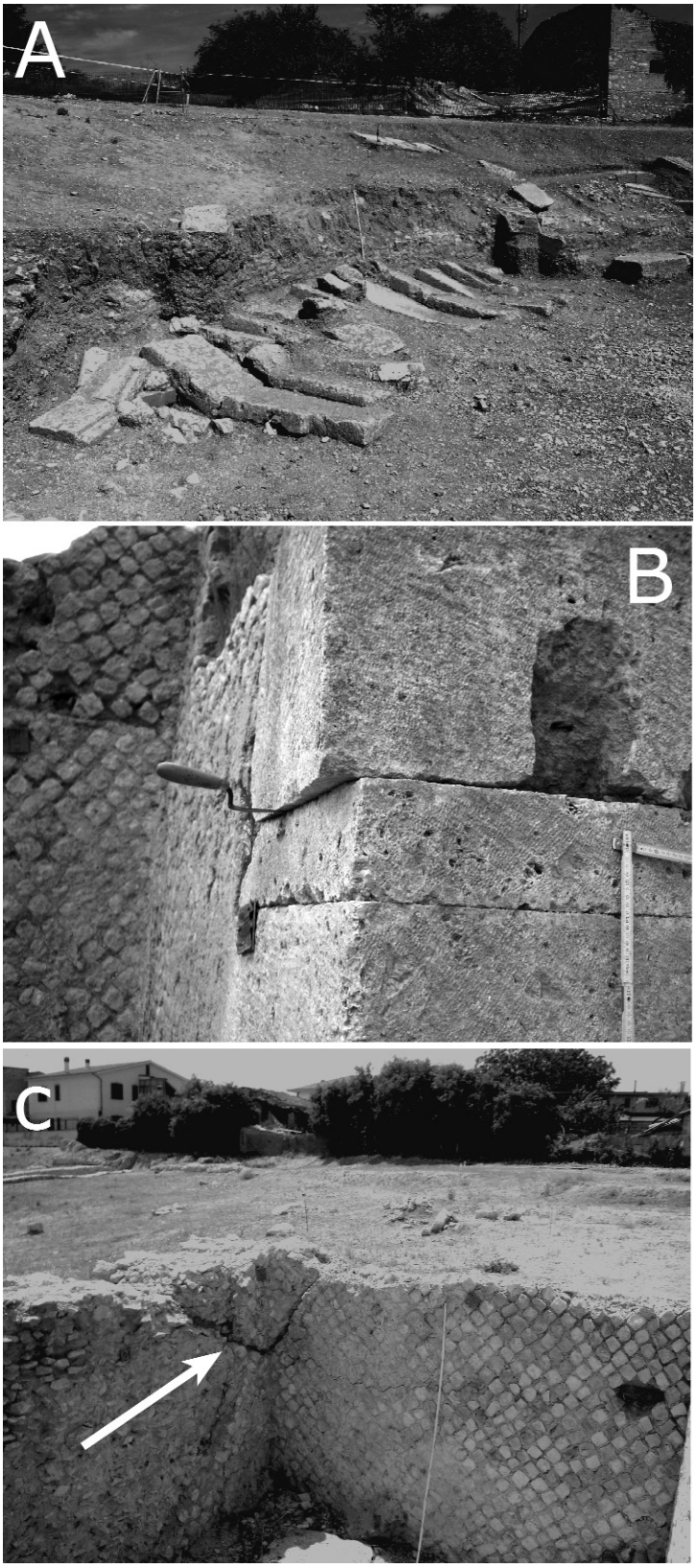

Fig. 9 – Amphitheatre of San Benedetto dei Marsi-Marruvium: A) view of the slabs bordering the *cavea* forming a collapsed unit characterised by a "domino-like" attitude; B) rotation of one of the blocks forming the right pier at the northern entry to the amphitheatre; C) corner expulsion (white arrow) in the room at the right of the northern entry.

lacustrine ingression along the historical shoreline, following the Roman drainage. Galadini and Galli (1996, 1999) attributed this displacement to the 5th-6th century AD. This chronological framework is confirmed by the archaeological data gathered both from the documents in the archives of the Archaeological Authorities and from more recent excavations. Particularly at Alba and at Avezzano-Macerine, the chronological information derives from the material (mainly pottery) of the 5th-6th century and from the numerical age of a bone of an individual probably involved in the collapse of a building. On the whole, the consistency of the geological and archaeological information appears convincing.

Once the seismic event is attributed to the above-mentioned time interval, we can also confirm the previous hypothesis (Galadini and Galli, 1996, 1999) that the earthquake that preceded the one that occurred in 1915 was also responsible for the damage to the Colosseum in Rome, in 484 or 508 AD (Guidoboni, 1989). Considering that surface faulting was associated with the Late Antique earthquake, and recalling the hypothesis of the characteristic behaviour of the source (Galadini and Galli, 1999), a magnitude similar to that of the event that occurred in 1915 (*Mw* 7.0) and severe shaking over a very large area can be attributed to the 484-508 AD earthquake. For this reason, we are confident that further evidence of this event will derive from future archaeological excavations once specific attention is dedicated to the archaeoseismological perspective.

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