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ERSAR

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WWI
Global Wastewater Initiative

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ICQHS
International Center on Qanats and Historic Hydraulic Structures

IWHA
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LNEC
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Preliminary Results of the Archaeological Surveys Conducted at the Álamo Roman Dam (Alcoutim, Portugal) During the Years of 2006 and 2007 [1]

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Abstract
The remarkable Roman Álamo Dam identified by Estácio da Veiga in 1877 was investigated between 2006 and 2007 by a team directed by the first author and with ongoing participation of the second. The archaeological works performed close to the upstream wall of the dam allowed showing the remarkable height of the construction, currently partially buried in the sediments accumulated at the bottom of the old reservoir. The remains contained several fragments of amphorae whose typological characterization suggests that the structure would functioned at least between the 3rd and the 5th centuries d.C., although over the past years it has been already completely silted, thus constituting one swampy zone to where they would be thrown objects no longer in use, including the fragments of more modern amphorae. Regarding this issue, it is noteworthy that this will be the first work of this kind performed in Portugal.

Keywords:
Siltation; reservoir; dam; roman period; Portugal

INTRODUCTION AND GEOGRAPHICAL LOCATION

The Roman Álamo Dam is located in the village of Álamo, about 11 km south of the village of Alcoutim in the eastern Alto Algarve (council of Alcoutim), at the following exact geographic coordinates, taken with GPS using the system WGS84: 7°26'39'' long. W; 37°23'17'' lat. N.

The hydraulic construction was established in the Barranco of Foupana near the Guadiana (*Anas*) river and it sits in a plain with a height of 20 m.

The dam consists of a wall approx. 40 m long (more 10 m identified by the survey of 2006) and a thickness of 2.80 m, reinforced by 7 visible buttresses of 1.5 m length on the downstream side (Fig. 1). Spacing between buttresses is approximately 3 m. The entire construction, including the buttresses, was achieved using greywacke blocks with mortar, laid in horizontal layers (*opus incertum*). Near the north end it contains also a short section with a buttress that separated and collapsed probably due to lack of foundation support.

[1] This work was performed in Portuguese by the first author, based on the archaeological report he presented at the Portuguese authorities in 2013; the second author made its translation into English. The two field campaigns of 2006 and 2007, directed by the first author, with the permanent support of the second author, were only possible by the resources assured by the Alcoutim Municipality. The authors wish to thank to Dr. Filipe Martins and Dr.ª Sofia Albuquerque by their excellent collaboration in the excavations and to all the young participants of the Project OTL/2006.

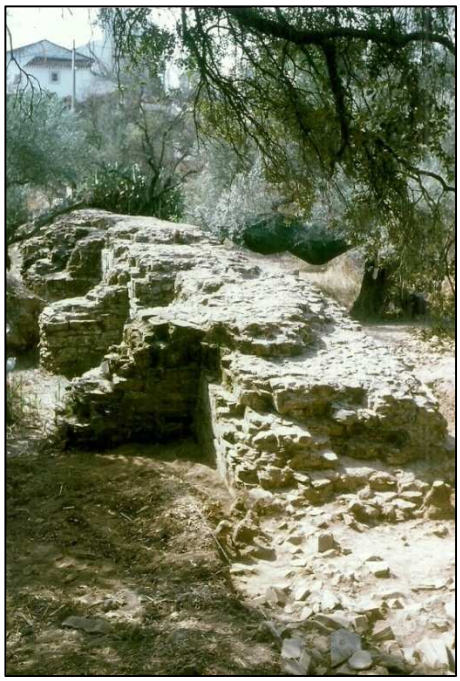

Figure 1. Dam of Álamo. General view. Note the constructive technique, by the successive layers of cemented blocks, that constitutes the nucleus of the structure. Both walls and buttresses are covered by horizontal layers of blocks of greywacke (*opus incertum*). Photo J. L. Cardoso.

In 1877, the Algarve-born archaeologist S. P. M. Estácio da Veiga, made the first graphic records of the dam, with the assistance of A. de Serpa (Fig. 2) and he also registered a roman *villa*, with corresponding acropolis located downstream. During the excavations made at the site he recovered a few objects. The most important amongst them was a marble statue representing the young god *Apollo*. It is presumed that there was an association between this roman structures and the dam, the water collection of which was presumably for irrigation and possibly for domestic use (Quintela, Cardoso & Mascarenhas, 1986; Cardoso, 1990).

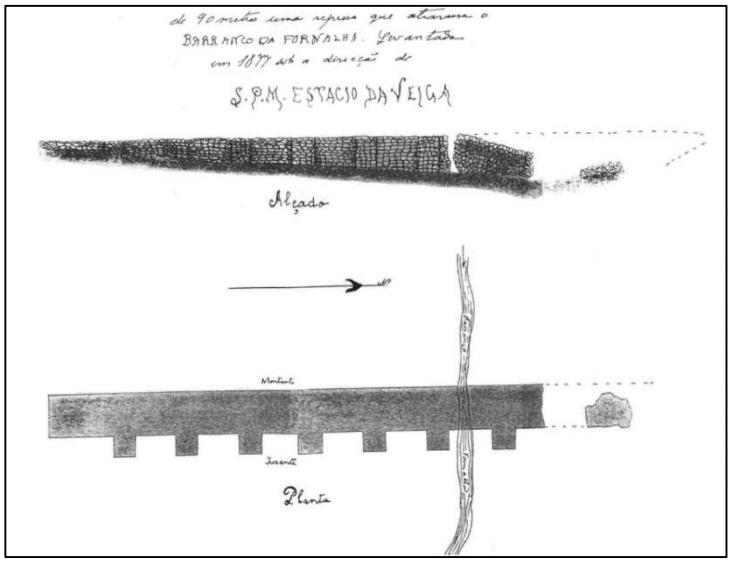

Figure 2. Dam of Álamo. Plan dressed by S. P. M. Estácio da Veiga in 1877 (files of National Archaeological Museum, Lisbon, cf. Santos, 1972, modified).

The dam would have stored approximately 2100 m^3 of water in the correspondent reservoir, which

would have had a 90 m-long (Quintela, Cardoso & Mascarenhas, 1986), but this estimative is conservative, since it hasn´t in account the severe siltation of the reservoir, that seemed much more reduced than it is in reality.

A hundred and twenty nine years after the Estácio da Veiga intervention, a field work program was set out, under the responsibility of one of us (J.L.C.) to recover as much information as possible about the roman dam with the aim of a valorisation project of this ancient hydraulic installation, performed by the local council of Alcoutim.

In this paper are presented the main results that were obtained from field work carried out in the two campaigns in the years of 2006 and 2007 and performed close to the upstream wall of the dam, which revealed the remarkable height of the construction (*circa* 7 m high, according to the surveys) as well as documenting some architectural features such as on the north side, the meeting point with the slope of the ridge, which was unknown till then.

MAIN RESULTS OF THE FIELD-WORK (2006/2007)

The investigation carried out during the two campaigns of 2006 and 2007, was undertaken at the request of the Portuguese Institute of Archaeology (IPA) to provide the appropriate archaeological field-work to enable the valorisation project of this classified monument.

With this in mind, three surveys were conducted in 2006, two close to the surface of the upstream wall and a third one at the meeting point with the slope of the left ridge, this last one located in a badly damaged area. The selection of those surveys was intended to provide a full documentation of the hydraulic structure.

In 2007, a last survey was open, adjacent to the survey 1, in order to attain the basement of the structure in the deepest sector of the ancient reservoir, in the central area of the valley (Fig. 3).

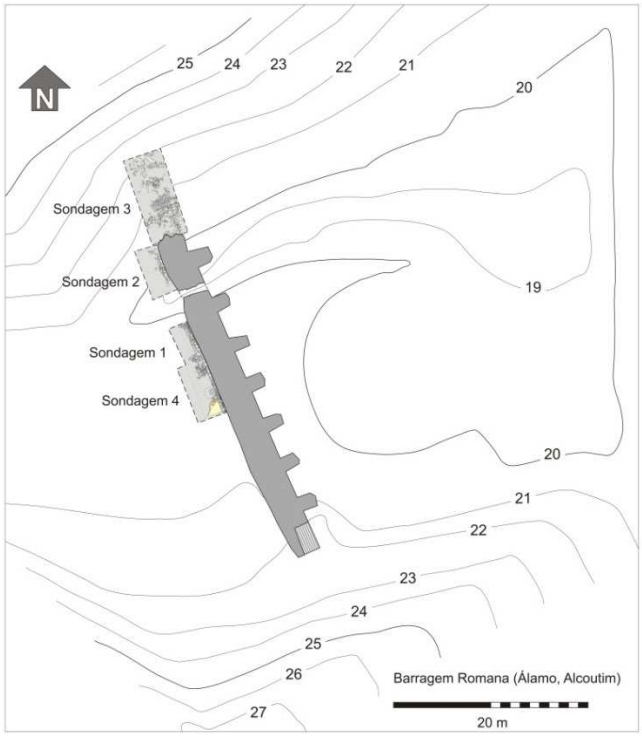

Figure 3. Dam of Álamo. General plan of the dam and location of the surveys.

Preceding the excavations of the surveys, cleaning work of the total dam was made in order to provide new graphic representation of the monument, using innovative technology as the GIS (Geographic Information System). This permitted the documentation of the plan of the surface and elevations walls, made by Tavira's GAT, at the end of the field-work, using precise data generated by a local coordinate system, connected with geodesic reference of the official system WGS84.

One evidence that is observed only in the upstream side of the dam is the damaging of the *opus incertum* revetment of the nucleus of the structure provoking by the severe erosive action of the waves generated in the reservoir combined with the variation of the correspondent water level along the year (Fig. 4).

Figure 4. Partial view of Survey 1 (2006), showing the contrast between the conservation of the upper part of the upstream wall and the lower part, interred in the sediments accumulated at the bottom of the reservoir. Photo J. L. Cardoso.

Survey 1 - The survey section with 4 m length by 2 m in width (Fig. 5), was executed close to the surface of the upstream wall and reached 4.70 m in height, from the crown of the dam, in this sector. At that level the geologic substrate consist of schist and greywacke of the Upper Carboniferous as indicated in grey at that figure.

This survey did showed the good preservation of the dam upstream wall protected by the sediments, contrasting to the major erosion evident at surface height, which showed the antiquity of silting, as the two cross sections clearly shows (Fig 6 and Fig. 7). Although the dam wall revealed a homogeneous make-up of well-adjusted greywacke blocks (*opus incertum*), it did show a small longitudinal structural ledge (Fig. 8).

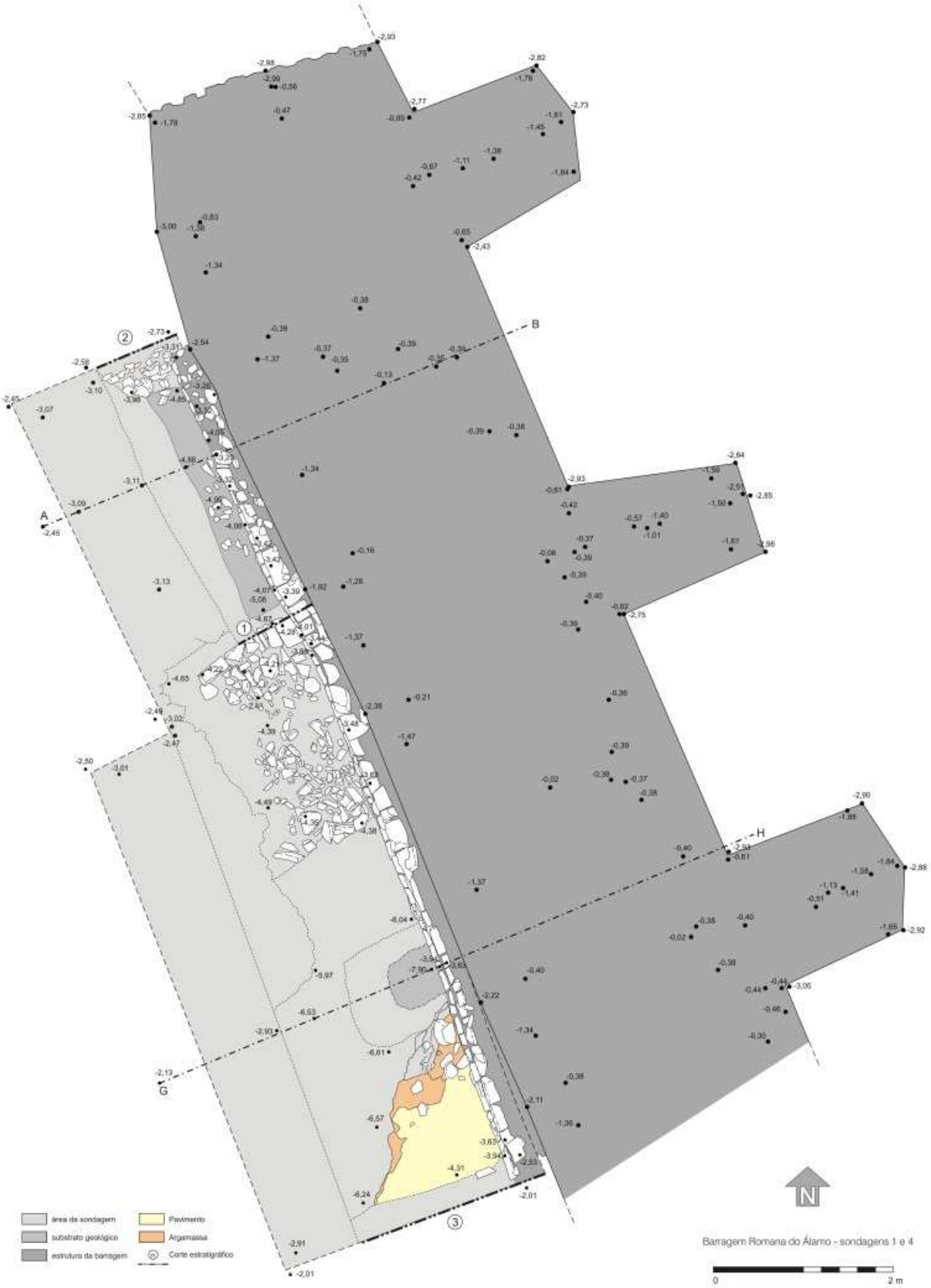

Figure 5. Dam of Álamo. Plan of Surveys 1 (2006) and 4 (2007) dressed by B. F. Ferreira under the supervision of J. L. Cardoso.

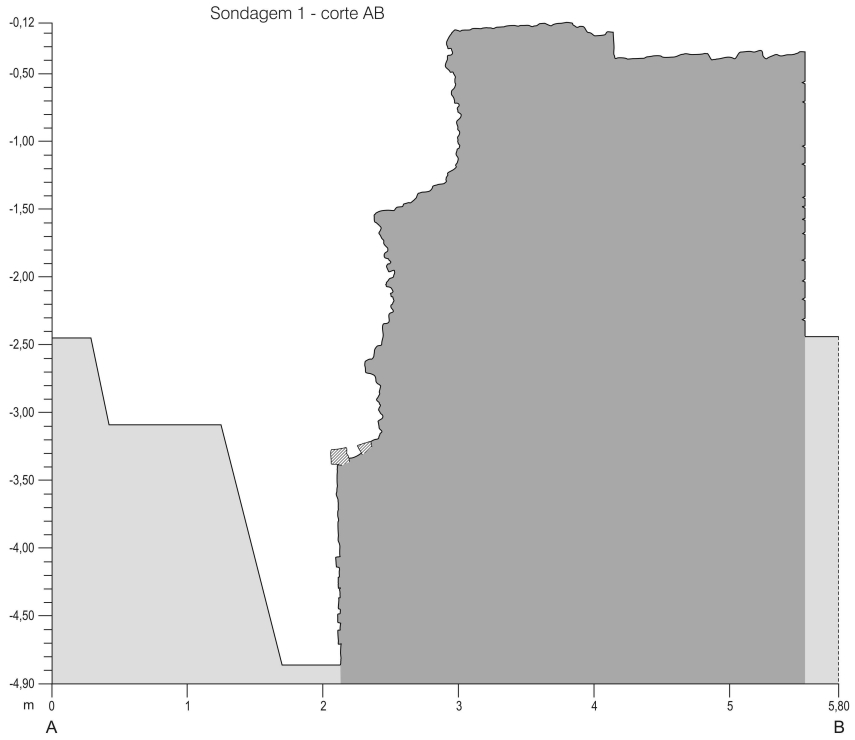

Figure 6. Dam of Álamo. Cross section AB of Survey 1 (2006) (see Fig. 5) dressed by B. Ferreira under the supervision of J. L. Cardoso.

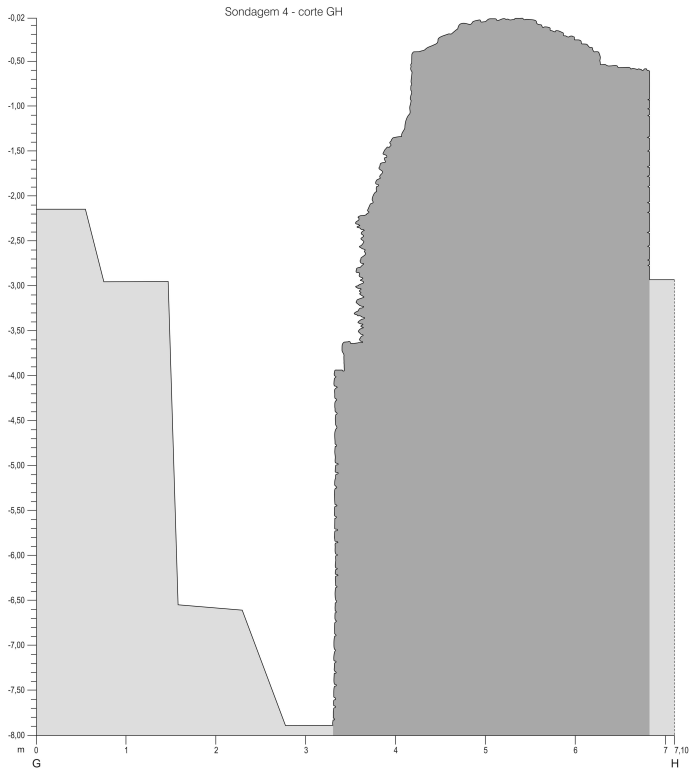

Figure 7. Dam of Álamo. Cross section GH of Survey 4 (2007) (see Fig. 5) dressed by B. Ferreira under the supervision of J. L. Cardoso.

Figure 8. Dam of Álamo. Partial view of the upstream wall, observed in Survey 1 (2006), with a small longitudinal step. Photo A. Gradim.

The Fig. 9 corresponds to a cut made on the sediments accumulated against the upstream wall, shows very well the importance of them, with 2.30 m in height in this dam sector, also registered in the stratigraphic cut (Fig. 10). So the bottom part of the sedimentary accumulation is mostly filled by fine sediment laid down at the bottom of the old reservoir, followed by layers with increasingly abundant rough greywacke blocks, partially as a result of the erosive action of the waves against the upper stream wall of the dam, combined with the variation of the water level in the reservoir. This layer of blocks seems to set the time when the structure was abandoned; but along all the sedimentary sequence we can observe large blocks, detached from the wall of the dam, due to the above mentioned actions, during its utile life. Of course, it must be also in mind the contribution of blocks from upstream, carried by the flash flooding of the river, which is known to flood at certain periods of the year, according to its torrential regime, typical Mediterranean.

Figure 9. Dam of Álamo. Stratigraphic cross section 2 of Survey 1 (2006) (see Fig. 5). Note the existence of a mortar covering partially the wall of the dam, protected by sediments. Photo A. Gradim.

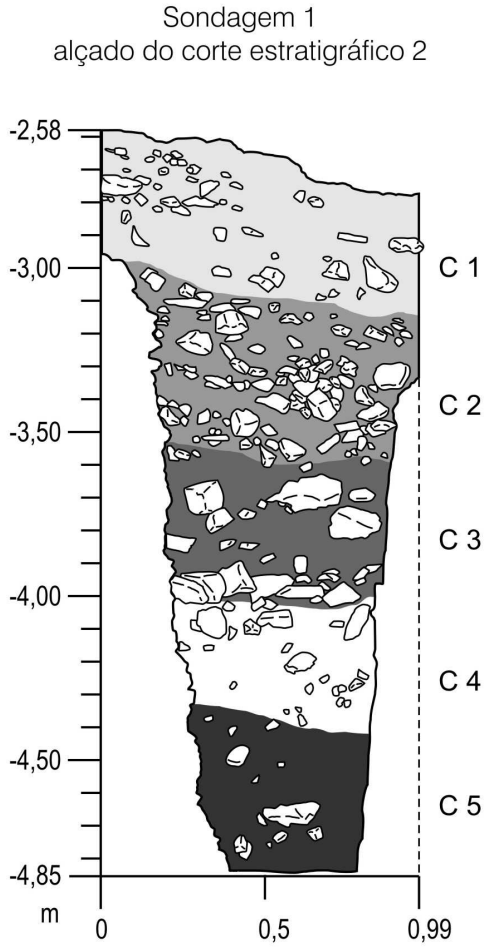

Figure 10. Dam of Álamo. Stratigraphic cross section 2 of Survey 1 (2006) (see Fig. 5). Legend: Base (C5)– the oldest deposit corresponds to essentially fine sediments at the bottom; Middle (C4/C3) – the large amount of blocks of greywacke of considerable dimensions, as well as its horizontal disposition, indicate that they would have fallen from the upstream wall of the structure, corresponding to its covering at the top; Top (C1/C2) – Evidence of the quick silting of the old reservoir through the effect of torrential water discharges of Barranco da Foupana, as indicates the existence of schist fragments and greywacke arbitrarily oriented in the level. The C1 corresponds to the modern soil. Dressed by B. Ferreira under the supervision of J. L. Cardoso.

At the southern survey limit, noticed a perpendicular alignment of blocks related to a probable platform built in the central part of the dam. It's possible that this structure, without any structural function due to its position in the structure, eventually related to a direct access to the water. The epoch of their construction is relatively recent in the general sequence of the use of the dam, since it is founded in sediments accumulated at the bottom of the reservoir (Fig. 11).

Survey 2 – this survey was implanted in a section of the dam that collapsed, in order to find out the causes of this occurrence. This happened most probably due to excavation under the foundation due to the erosive action of the water line that currently passes through the fissure of the wall (Fig. 12).

This survey covers an area approximately 2,5 m in length and 2 m in width (Fig. 13), having reached at its deepest point, about 4 m lower than the crown of the structure and 2,20 m lower than the level of the ground; the geologic substrate consist of schist and greywacke of the Marine Carboniferous. All these layers correspond to the silting up of the old reservoir.

The observed filling level at Survey 1, was here slightly smaller, which indicates that the bottom of the old reservoir, corresponding to the geologic substrate was nearly flat. This probably happened due to human intervention, since the valley present V cross section. In conclusion, it is possible that the geologic basement of the dam would have been regularized, in order obtain a flat surface in order to facilitate the building operations.

Unfortunately it wasn't possible confirm the cause of the dam wall collapsed, since near the upstream wall the considerable accumulation of blocks as a result of erosion (Fig.14), also represented in the plan, prevented the direct observation of the state of the structure's foundation. We can provisionally conclude, based on the observation of a small section in the excavated area close to the fissure in the wall, where currently the water line passes through, that the cause of the collapse was due to the water line undermining the foundation structure.

Figure 11. Dam of Álamo. View of the platform observed in the middle of the upstream wall. Photo J. L. Cardoso.

Figure 12. Dam of Álamo. Collapsed section of the dam. Photo J. L. Cardoso.

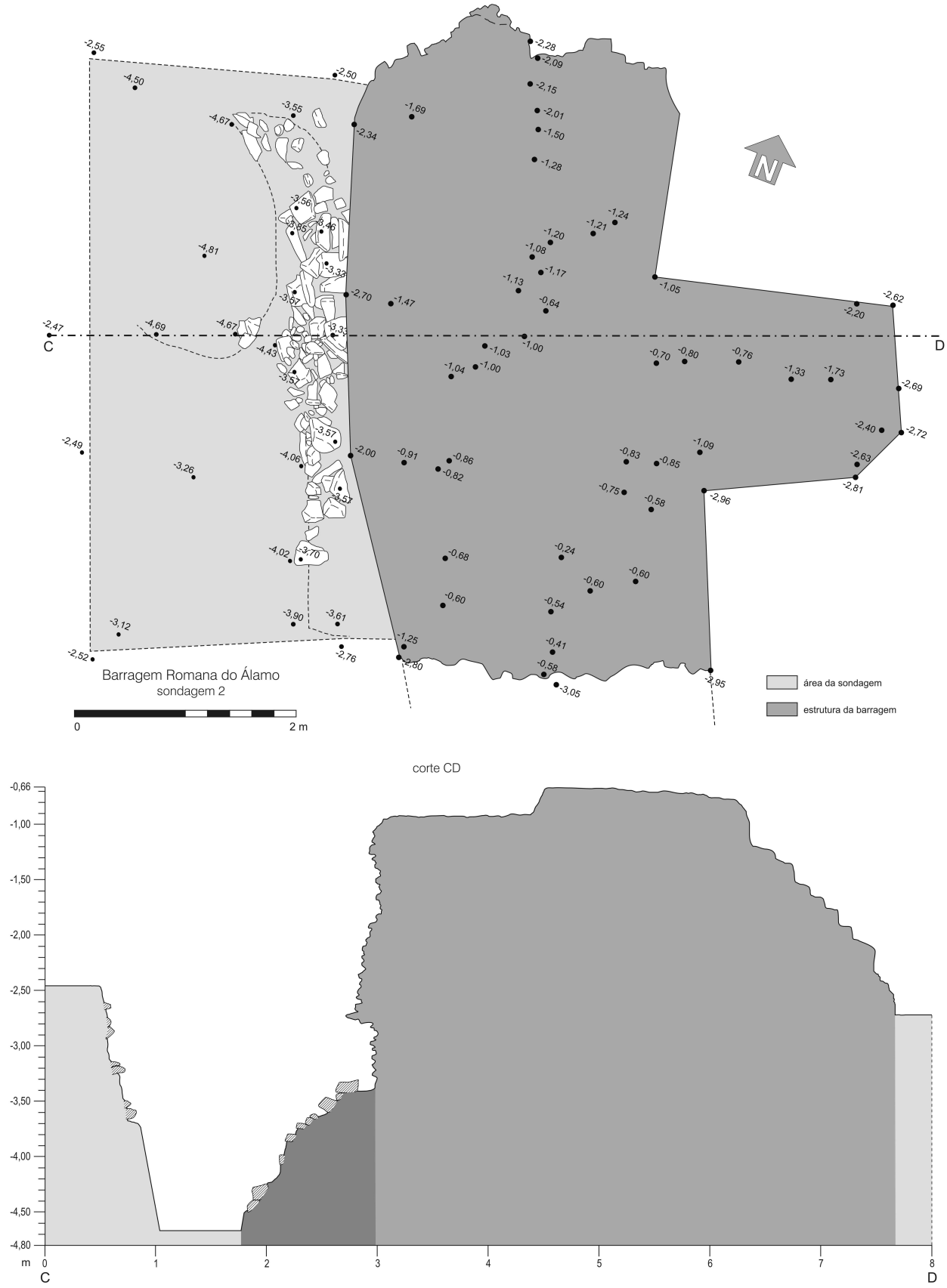

Figure 13. Dam of Álamo. Plan and cross section of Survey 2 (2006). Detail of the blocks in the base of the wall in result of the erosion of the upstream wall. Dressed by B. Ferreira under the supervision of J. L. Cardoso.

Figure 14. Dam of Álamo. Detail of Survey 2 (2006). Note the existence of fine sediments under the basement of the collapsed section of the wall by the waters of the Ribeira da Foupana that currently crosses the structure through the existent fissure. Photo J. L .Cardoso.

Survey 3 – this survey was applied to the alignment of the dam with its meeting point at the slope of the left ridge (Fig. 15). This location was aimed at identifying the rest of the structure not visible at the original surface of the ground but signalled by Estacio da Veiga in 1877 (see Fig. 2). It was essentially an excavation in extension of an elongated rectangle, 9 meters long by 4 meters wide. All the aims were accomplished as it allowed us to observe a specific area covered with a sandy mortar embedding some greywacke blocks of the same type as the ones used at the nucleus of the dam (Fig. 16). According to this it can be concluded that this sector, in grey at Fig.15, it's what's subsist of the left foundation of the dam, that allows one to determine that its length would have been about 10 meters more than the current one, totalizing 50 meters long (Fig. 3).

Survey 4 – this survey was performed in 2007, with the main propose to determine the maximum height of the dam, since it corresponds to the central area of the river valley, where the sediment thickness reaches its maximum. It was executed close to the surface of the upstream wall and in the continuity of survey 1, reaching a length of approximately 7.0 m and a width of 3.20 m (Fig. 17).

Due to the possibility of collapse of the cut, excavated without planking, which reached the maximum depth below the current ground level of 5.75 m, the geological substrate was attained only in a limited area, covered by fine clay sediment with greenish colour that was the first to accumulate at the bottom of the old reservoir (Fig. 18).

Figure 15. Dam of Álamo. Plan and cross section Survey 3 (2006). In the middle of the excavated area, is conserved blocks cemented by sandy-chalky mortar that corresponds to the basement of the structure. Dressed by B. Ferreira under the supervision of J. L. Cardoso.

Figure 16. Dam of Álamo. Survey 2 (2006), evidencing the regularization of the geologic basement over which the dam was built. Note the remains of the foundation layer of the structure corresponding to blocks of greywacke cemented by a sandy-chalky mortar. Photo J. L. Cardoso

Figure 17. Dam of Álamo. Detail of the upstream wall built with isometric blocks of greywacke (*opus incertum*), observed at Survey 4 (2007). Note at the bottom the geological substratum. Photo A. Gradim.

Figure 18. Dam of Álamo. Partial view of the excavation field season of 2007 (Survey 4). Photo A. Gradim.

The cross section perpendicular to the dam and the survey shows the small structural ledge observed at the upstream wall of the dam, already noted in Survey 1, corresponding to a constructive element extending over the whole length, perhaps related with the building technique made of successive horizontal layers made of blocks cemented by a sandy-lime mortar. Bearing in mind that the height of the dam in this sector above current ground level is about 2 m, it can be concluded that the present minimum height of the dam is 6.50 m.
We also managed, with the enlargement of survey 1, to ended the excavation of the wall identified in 2006, that would delimit a possible platform, built in the middle of the dam at a time when the old reservoir was already much silted, as proves the foundation level of this structure, on previously sediments accumulated in the bottom of the reservoir.

At the South end of this survey, it was identified a regular flat surface, consisting of thin whitish mortar, involving small blocks of greywacke, leaning the upstream wall of the dam, superimposed by another more yellowish layer (Fig. 19). It's hard to know the exactly purpose of these two floors, made in different times and over natural surface deposits meanwhile accumulated at the bottom of the old reservoir, what proves that, just like the above mentioned platform, are related to secondary use of water storage in the old reservoir.

Sediment samples were also collected for their later paleo-environmental analysis.

Figure 19. Dam of Álamo. Partial view of two layers of mortar, in the middle of the ancient reservoir near the upstream wall, made over the deposits accumulated at the bottom of the reservoir. See Fig. 5. Photo J. L. Cardoso.

ARCHAEOLOGICAL MATERIALS

In this first study we would like to underline, in the range of roman materials, the existence of amphorae, common ceramics vessels and construction materials which will be treated in specific work to be published at a later date with Prof. Carlos Fabião, to whom we would like to thank for the classifications made available to us. These materials have been collected in the deposits accumulated along the use of the reservoir, as a result of the habit to thrown inside the reservoir the discarded pieces, along materials originating from up-stream, carried by flash flooding, in spite of not showing much wear.

The amphorae include Italic, African and Baetican productions, in addition to regional productions. The oldest date back to the 1st century BC and is represented by a handle of a Dressel I, an italic

production dating most certainly before the construction of the dam. In fact, it's just with the 3rd century AD that amphorae materials appear more abundant, reaching in the 4th/5th centuries AD its greatest frequency, being represented by Almagro 51 C amphora, most certainly an Algarve production or even local production, as proved by the presence of an annealed rim fragment, suggesting the existence of a nearby production centre.

It's interesting to note that chronological differentiated productions such as amphorae Keay 16 / Beltrán 2 and Almagro 51 C that were recovered in the same sedimentary layer, evidence that there was a mix of materials at the bottom of the old reservoir at any given moment of the process of silting up as a result of anthropic action and/or of natural agents.

In addition to amphorae, several common ceramic vessels were also recovered, including some of Baetican productions, a fact that also applies to the construction materials, especially *tegulae* with characteristic yellowish pastes from that geographic area. It's true that the presence of these constructions materials can easily be explained by their use as ship ballast which would have been sailed up the Guadiana River to the place where they would be reused, as was the case of the *villa* of the Álamo, functionally associated with this dam.

CONCLUSIONS

The archaeological surveys carried out in 2006 and in 2007 on the Roman dam of Álamo, related to the water supply of the *villa* of the same name situated downstream, as had already been concluded by Estácio da Veiga, resulted from the public initiative of Alcoutim council's, which aims to enhance the cultural and touristic significance of this important monument. This initiative had the main purpose to define not only the history and characteristics of the structure, but also to guarantee the protection of the archaeological areas interested by the project.

As to the characterization of the structure and its "useful" lifetime, the surveys were an important contribution to this effect. Thus, it was found that the height of the dam, contrary to what one would have assumed from the observation of the terrain, had reached more than twice the existing known height before the excavations (about 7.90 m), in the most central area of the valley, where the substrate would have presented the maximum depth.

The remarkable amount of sediments accumulated in the bottom of the old reservoir, is related to the bad conservation of the upper part of the upstream wall, contrasting with the excellent preservation of the opposite wall, should bear testimony to the erosion due to conjoint action of waves and seasonal change level of the water in the reservoir. This is proven by the fact that all surveys clearly shows that the upstream wall appears perfectly preserved below the current ground level, corresponding to the maximum level attained by the sediments in the old reservoir.

The causes of the collapsing of a section of the dam located at the north end, were investigated by conducting the Survey 2. However, it has not been possible to extend this up to the geological basement, having come across deep blocks resulting from the collapse of the wall, which it was necessary to preserve. Anyway, the observation of this sector, along the fissure produced in the structure, leads to the conclusion that the most likely cause of the collapse was the excavation under the foundation structure due to erosion of the crossing of the waters of the watercourse which today still takes advantage of this fissure to cross through this artificial barrier.

In survey 1 and 4 was identified, at about 2 m depth, the remains of an orthogonal wall to dam. This wall, devoid of any structural functions, would support a platform built in an advanced epoch of the

use of the dam, because it´s foundation is made on sediments accumulated before in the bottom of the reservoir. This is the same case of two horizontal layers of mortar observed at the same depth from the surface, also observed in the central section of the dam.

Survey 3 has confirmed the existence of the left meeting point of the dam, although it is a reduced small extension of its foundation, directly based on the geological substrate, consisting of schist and greywacke of the Upper Carboniferous, previously regularized.

The collection of Roman ceramic fragments, among them amphorae, are due to throwing into the old reservoir, objects already out of service. The typological study of the amphorae will allow us to date the construction of the dam, perhaps in the 1st century AD as well as its period of operation, that lasted till the 4/5th century AD, in the same way that the systematic collection of sediment samples will enable the study of the vegetation cover at the time, both through pollen analysis, and the identification of vegetables macro-remains.

With the conclusion of these limited surveys, it was demonstrated that this is an exceptionally important roman hydraulic structure, in excellent state of conservation, justifying fully its cultural recovery, as it is the wish of the municipality of Alcoutim. In fact, with circa 7,90 m height his is one of the higher known dams of this typology on the Roman world, with buttresses downstream; only the Olisipo dam, of the same type, is similar in height, with circa 8 m height (Fernández Casado, 1983; Quintela, Cardoso & Mascarenhas, 1986; Cardoso, 1990).

REFERENCES

Cardoso J. L. 1990 Barragens romanas do Algarve. Encontro de Arqueologia do Algarve (Faro, 1990). Faro: Delegação Regional da Secretaria de Estado da Cultura, p. 85-107.

Cardoso J. L. and Gradim A. 2011 Dez anos de trabalhos arqueológicos em Alcoutim. Do neolítico ao Romano. Lisboa, Câmara Municipal de Alcoutim.

Fernández-Casado C. 1983Estudio conjunto sobre la presa romana Consuegra. Revista de Obras Publicas. Madrid. Julio.

Gradim A., Cardoso J. L. Catarino H. 2011 Guia do Núcleo Museológico de Arqueologia, Lisboa, Câmara Municipal de Alcoutim.

Quintela A. C., Cardoso J. L., Mascarenhas J. M. 1986 Aproveitamentos hidráulicos romanos a sul do Tejo. Lisboa: Direcção-Geral dos Recursos e Aproveitamentos Hidráulicos.

Santos M. L. (1971; 1972) Arqueologia romana do Algarve. Vols. 1 e 2. Lisboa: Associação dos Arqueólogos Portugueses.