Use of Computed Tomography in Archeology, a useful tool to explore.

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Aims and objectives

Along with Mexico's territory, there are more than 50,000 archaeological sites, which also can include ceremonial burials, and of course, they are very different in time and space. Those with full skeletons can be excavated and analyzed in situ, but those where the cremation is a main part of the burial ritual, there are ashes, bones, and offerings inside of ceramic vessels. The aim of the study is to develop CT protocols to help archeologist in the evaluation of ancient burial remains, specifically those where the excavation or micro-excavation could disrupt and harm the contents. Between the years of 2015 and 2016, a group of Mexican Archaeologist from INAH-Michoacan performed some archeological salvage works in Huetamo, a territory of the Rio Balsas basin. (figure 2) The site was named "The Tamarindos", from where 42 funerary urns were retrieved. (figure 3 and 4) They used traditional methods of micro-excavation in 8 of the urns, but despite the painstaking work, they concluded it was an insufficient method to gather data regarding the cremation process and the disposition of the bones, ashes, and offerings inside the urns without damaging the urns. The radiocarbon dating place them in the Postclassic period between 1300 and 1400 A.C.

The purpose of this study was to find a useful protocol to optimize the findings of value to the anthropologist and apply suitable filters for bone, metal, ceramics, and coral, and preserve the enviroment of each urn and its contents.

Images for this section:

Fig. 2: MAP OF MEXICO AND LOCATION OF THE ARCHEOLOGICAL SITE lOS TAMARINDOS, IN HUETAMO, MICHOACAN

Fig. 3: ACTUAL ARCHEOLOGICAL SITE WORKS AT "LOS TAMARINDOS". RETRIEVING OF THE FUNERARY URNS

Fig. 4: FUNERARY URNS RETRIEVED FORM "LOS TAMARINDOS" ARCHEOLOGICAL SITE

Methods and materials

We used a 16 slice CT and performed scans on 28 funerary urns, found in Los Tamarindos Michoacan and a skeleton with ornaments found In Tingambato Michoacan, Mexico in 2011. We first scanned a control random pot with a bamboo plant, using the regular ear soft tissue protocol shown in table 1. We obtained a bright image with low contrast that did not allow a distinction between components (figure 5).

Table 1. Soft tissue ear protocol

Thickness	7mm
Increment	7mm
Pitch	0.6
Filter (algorithm)	SB
Rotation	0.6
Kv	120
mAs	247

Then we used a modified protocol, shown in table 2, which provided us a clear image, with a contrast that allowed the distinction between different componentsin the pot. (figure 6).

We used this protocol to scan a control original pot which included micro-excavation known elements like soil, ashes, bones, and offerings such as shells, bells, rings, earrings, and other ornamental items. (figure 7).

Table 2. Modified sof tissue ear protocol

Thickness	3mm
Increment	3mm
Pitch	1
Filter (algorithm)	SB
Rotation	0.6
Kv	120
mAs	206

We obtained an automatic volumetric reconstruction of the control urn, which was coarse and with a lot of image noise(figure 8), thus we modified an ear reconstruction protocol

which allowed the differentiation between organic and inorganic compounds of the funerary urns to be used in multiplanar imaging and volumetric reconstructions (table 3)

Table 3. Modified dental reconstruction parameters

Filter(algorithm)	EA
Thickness	0.500mm
Increment	0.375mm

Images for this section:

Fig. 5: Clay pot containing pebbles, soil, bamboo plant. Scan obtained with soft tissue protocol.

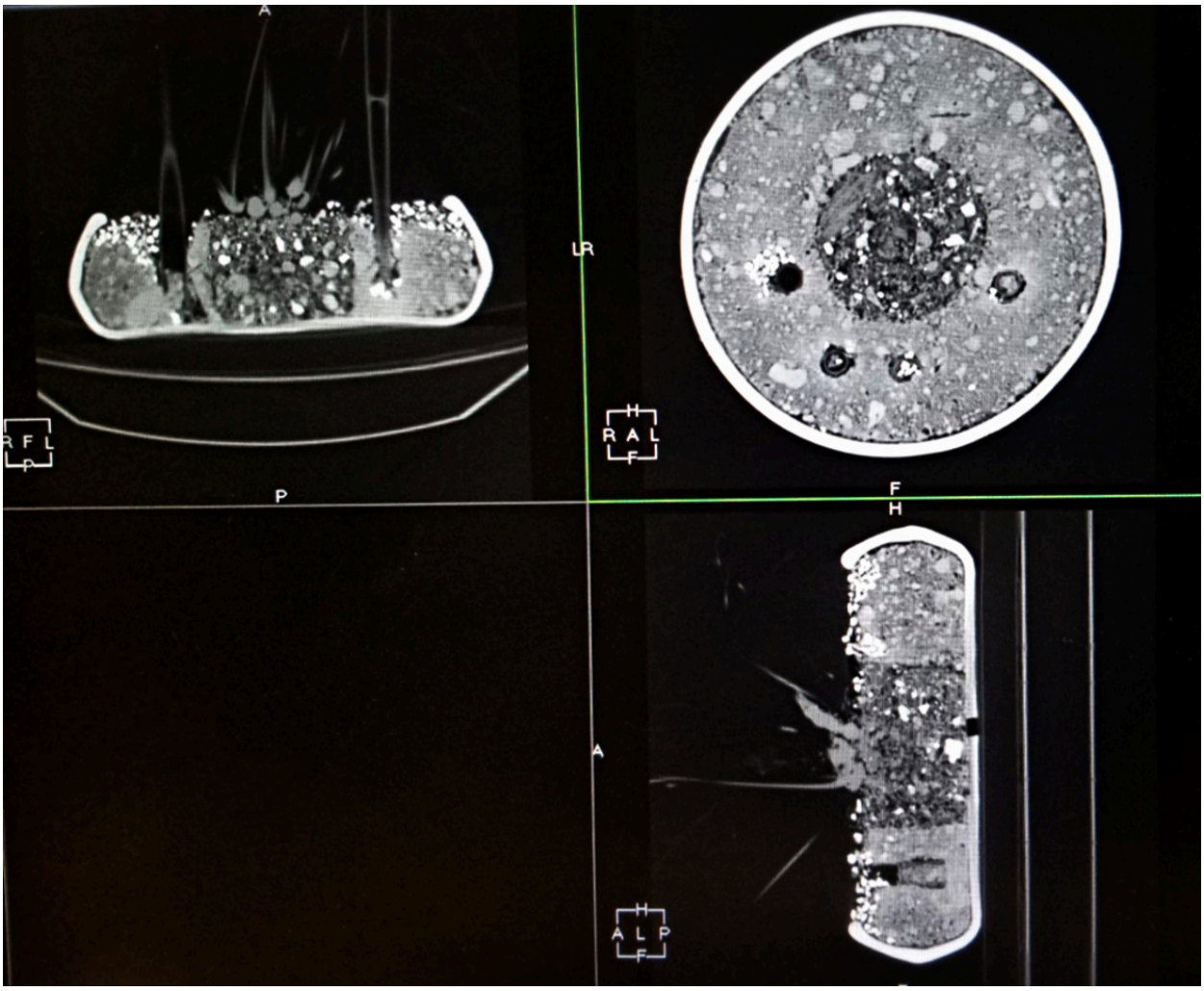

Fig. 6: Clay pot containing pebbles, soil, bamboo plant. Scan obtained with ear modified protocol

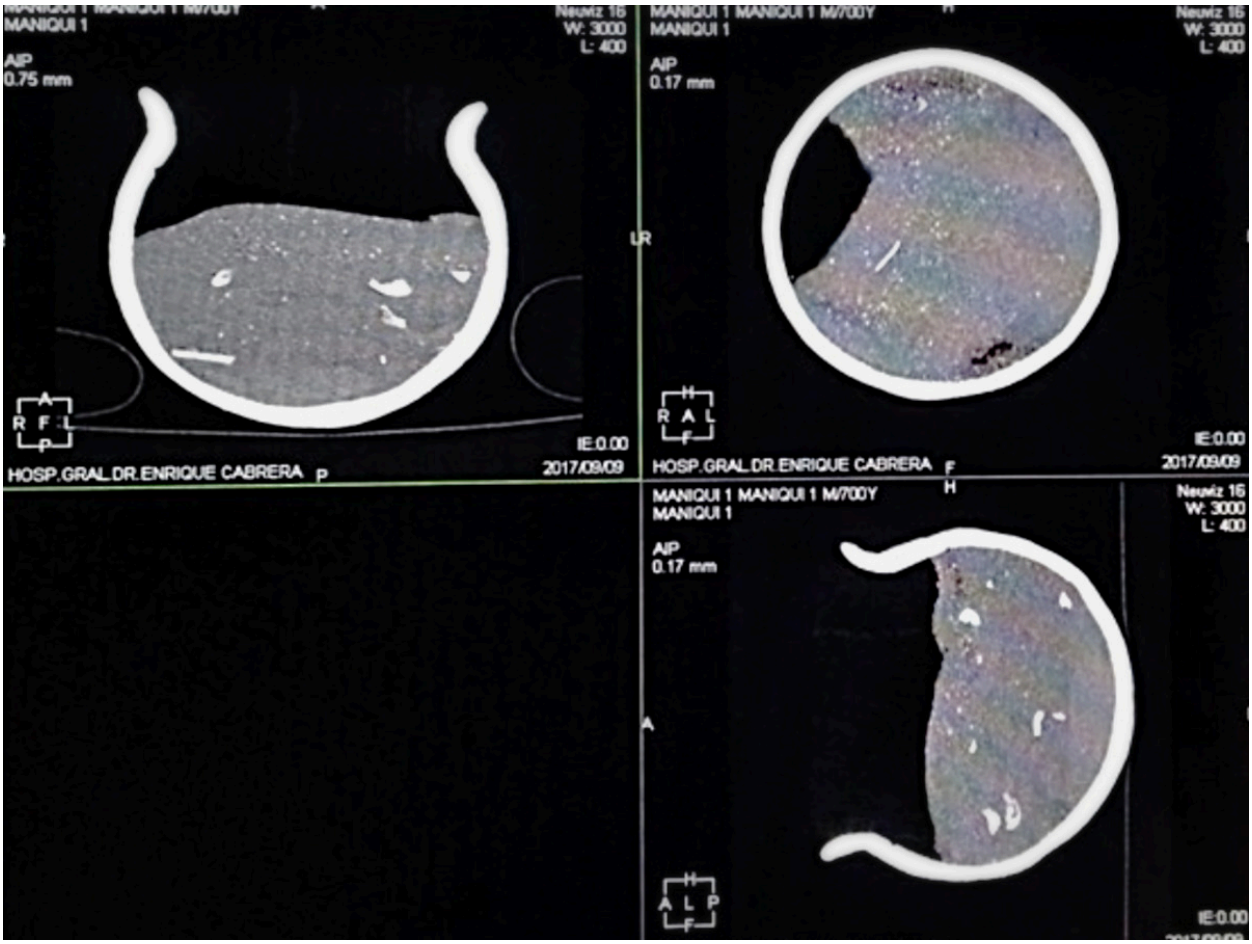

Fig. 7: Phantom urn made with an original ceramic pot, soil, ashes, shells, rings, bells and bones from other cinerary urns

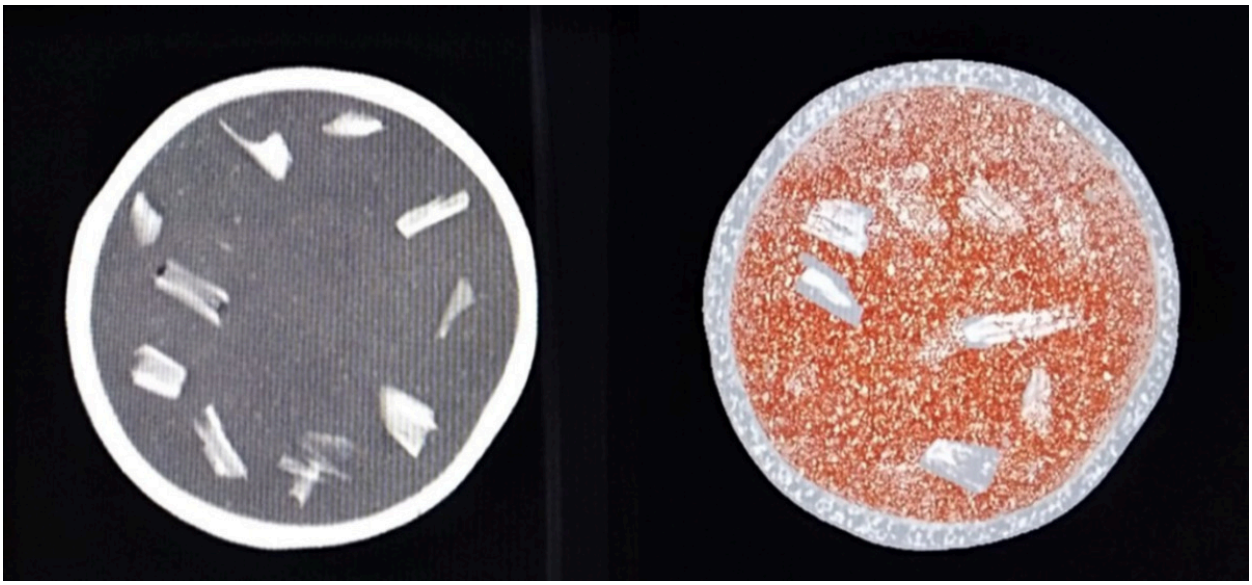

Fig. 8: Axial view of the control urn with volumentric reconstruction

Results

With the preloaded protocol, we found that the slices were very thick, the filter was not suitable and that results in a loss of information, thus not proper images could be obtained. With the modified protocol we obtained images with very good definition and low artifacts, (figure 9) that allowed the visual analysis of the contents and general and individual 3D reconstruction of most the findings. (figure 10)

We achieved a good technique that allows the gathering of useful information for the archeology team. It was possible to differentiate between the several compounds in each urn. We found metal pieces (jewelry) and bone fragments of different sizes and densities that vary depending on the temperature and time they were exposed during the cremation process. (figurs 11 and 12). This gives the archeologist and anthropologist important information about the process of cremation and urns contents without damaging them or their components

It was also very useful to perform 3D reconstructions with good saturation and definition thru developing a gallery to get the best images and differentiate the components of each urn. (figure 13)

Images for this section:

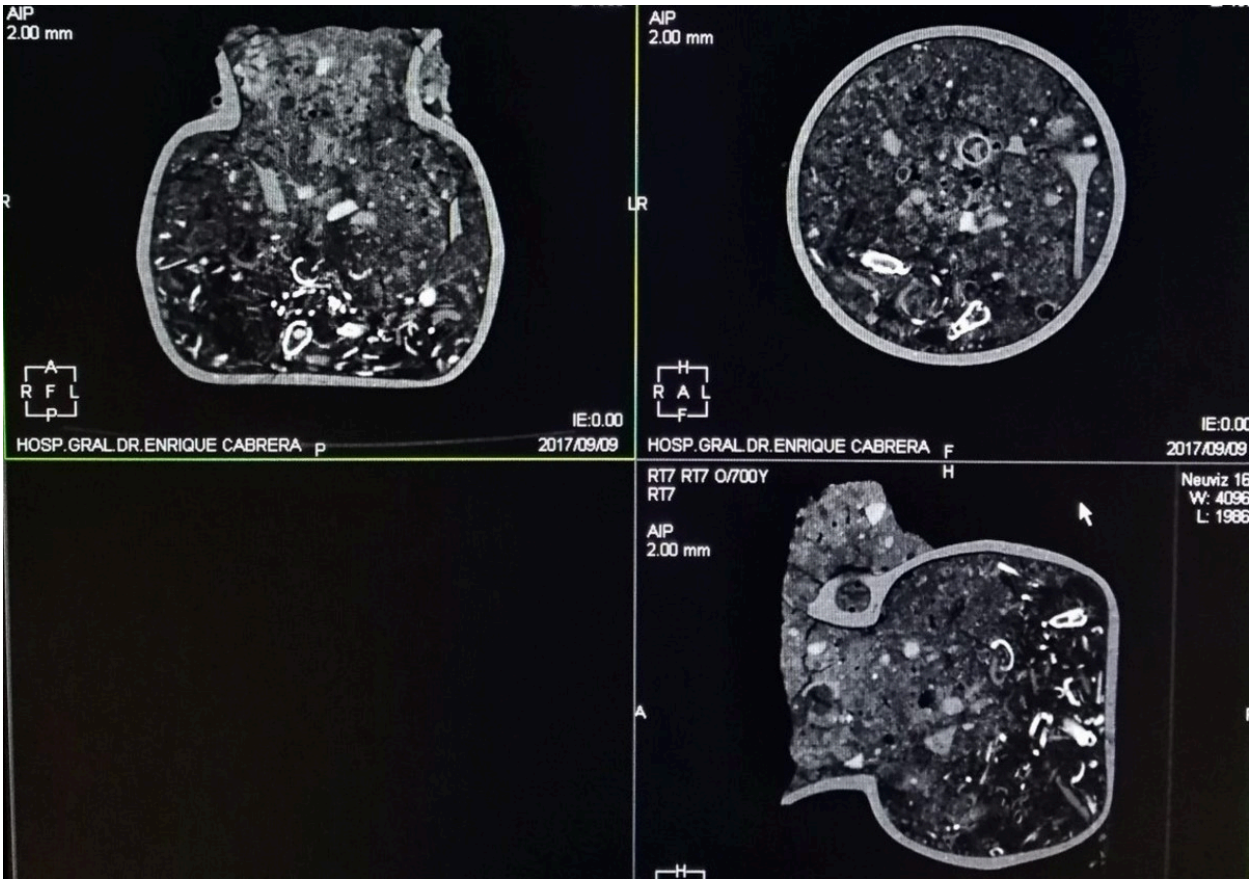

Fig. 9: Scan obtained with modified protocol and fine modifiedreconstruction protocol that shows the different contents within the urn. We identified many large bone fragments, rings, bells and it is appreciated the difference between deposition soil and ashes.

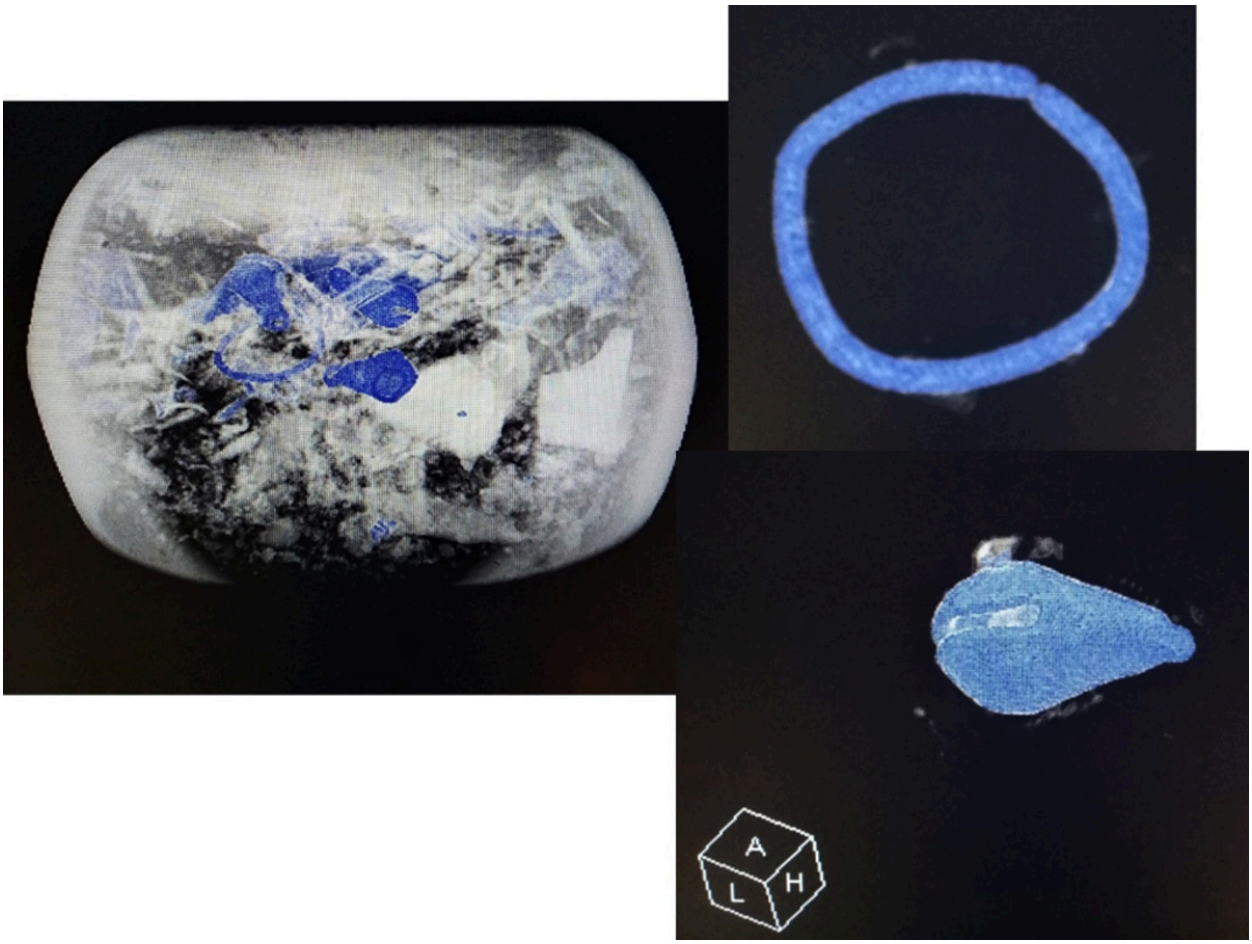

Fig. 10: Volumetric reconstruction of one urn containing metal offerings. Ring and a bell. individual volumentric reconstruction of the metal artifacts with high detail.

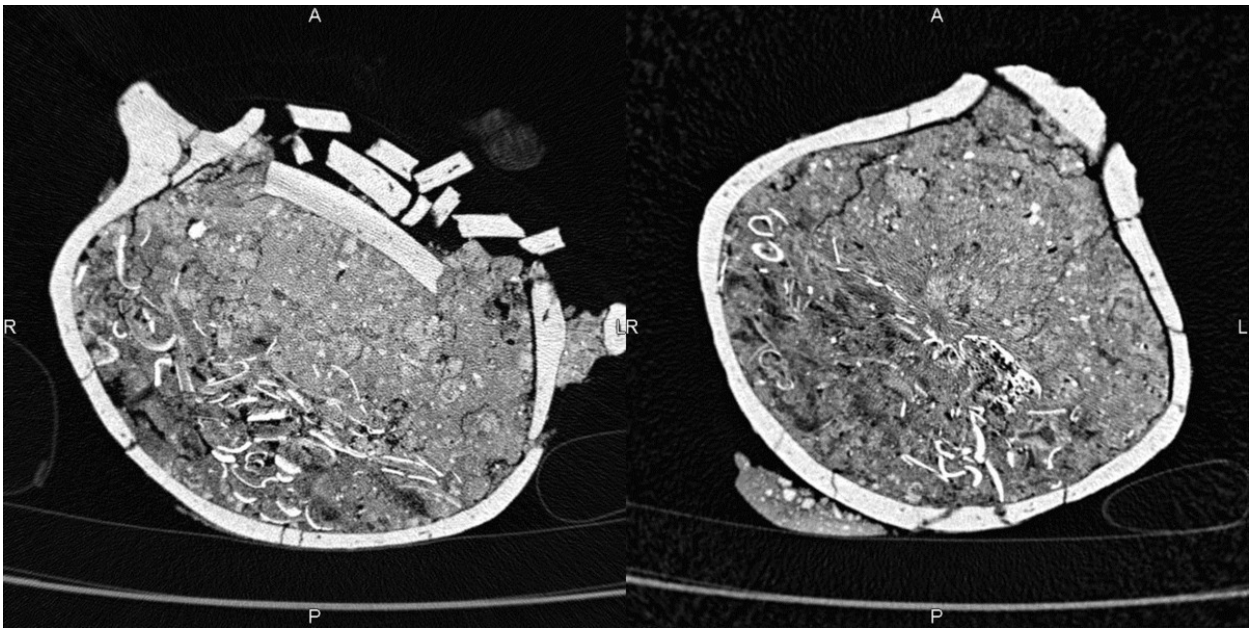

Fig. 11: Sagital view of two urns containing bones, ashes and metal

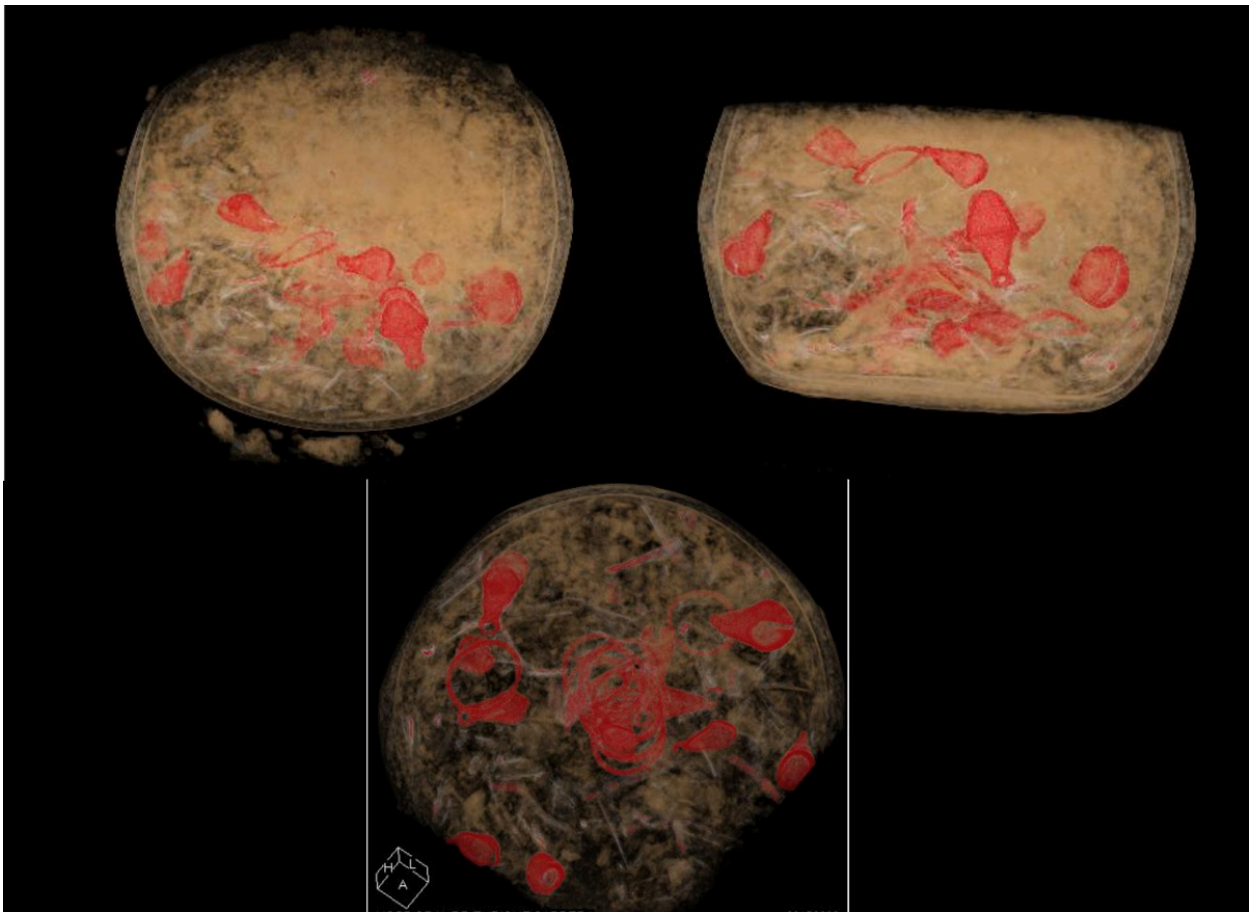

Fig. 12: Volumetric reconstruction portraying many metal offerings distributed withing the ashes. This type of reconstruction allows the investigators to know the type of offering and thus the origin of the person p.e. priest or governors.

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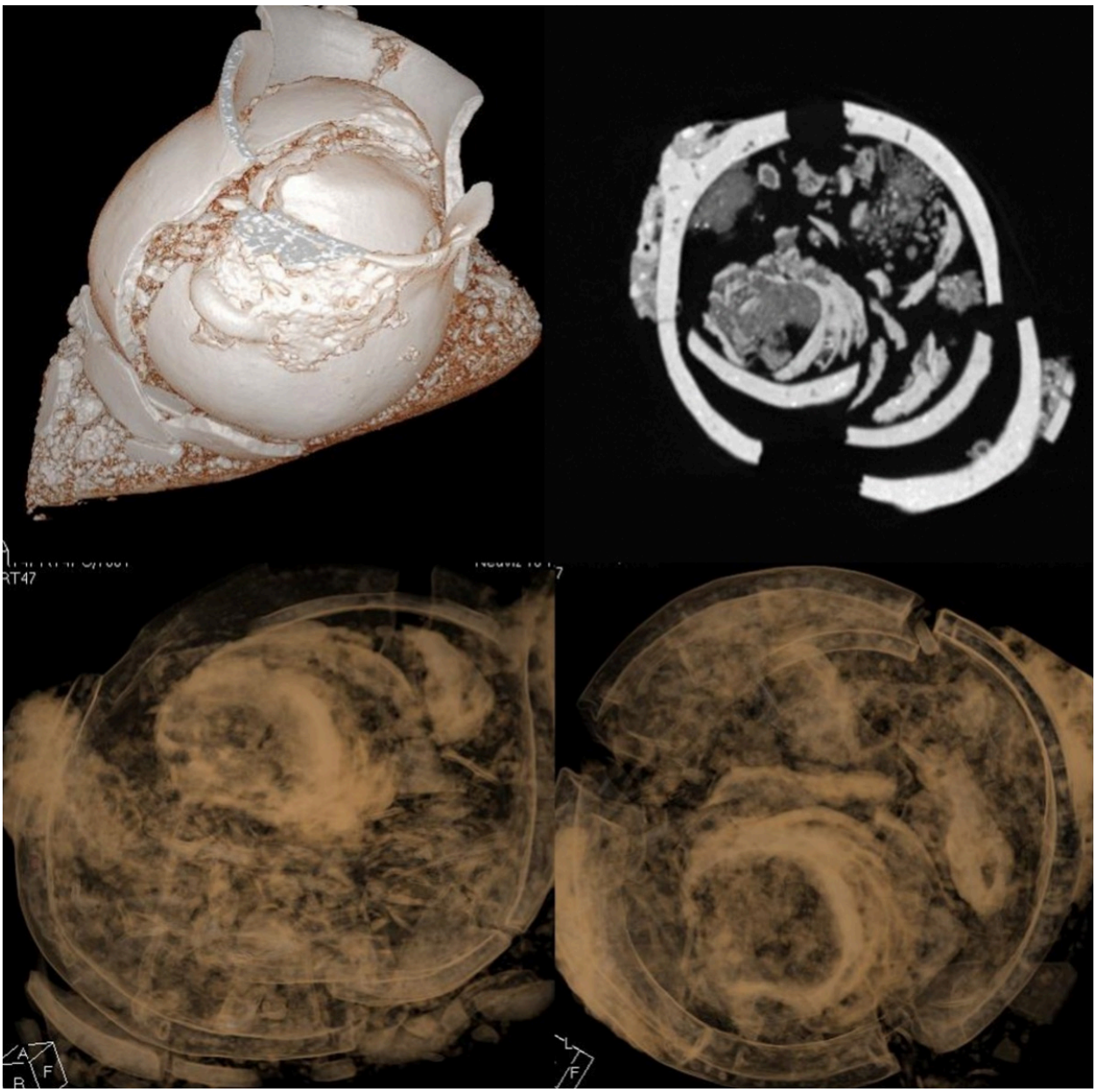

Fig. 13: 3D reconstruction of one of the urns, which had a cover. The volumetric reconstruction and modified gallery pictures shows a small thorax probably belonging to a stillborn, and some other fragments of bones, that were thought to belong to the mother.

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Conclusion

The present work provided very important information about the microenviroment of the urns, their composition and helped the archeologist and anthropologist better understanding of the culture related to the findings.

The analysis of human remains via internal and surface documentation using X rays methods has demostrated valuable benefits like exposing, comparing, reconstructing and sharing information. 3D imaging techniques mantain respect to the actual remains as they are noninvasive, limit handling, and therefore reduce further destruction to them.

The use of appropriate CT protocols as a very useful tool in archeology, can allow a better understanding of the findings where excavation and micro-excavation could be deleterious and harmful, as well as for a better understanding of the composition of the materials of the findings, so it can be shared with different experts to improve the knowlege within the ethics of bioarcheology.

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