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► To cite this version:

Géraldine Sachau-Carcel, Marcella Leone, Priscilla Munzi. Immobile after death? Taphonomic observations of a bone deposit exposed to nature for a year. FASE, Aug 2024, Amsterdam, Netherlands. hal-04871856

HAL Id: hal-04871856

<https://hal.science/hal-04871856v1>

Submitted on 7 Jan 2025

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IMMOBILE AFTER DEATH?

TAPHONOMIC OBSERVATIONS OF A BONE DEPOSIT EXPOSED TO NATURE FOR A YEAR

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INTRODUCTION

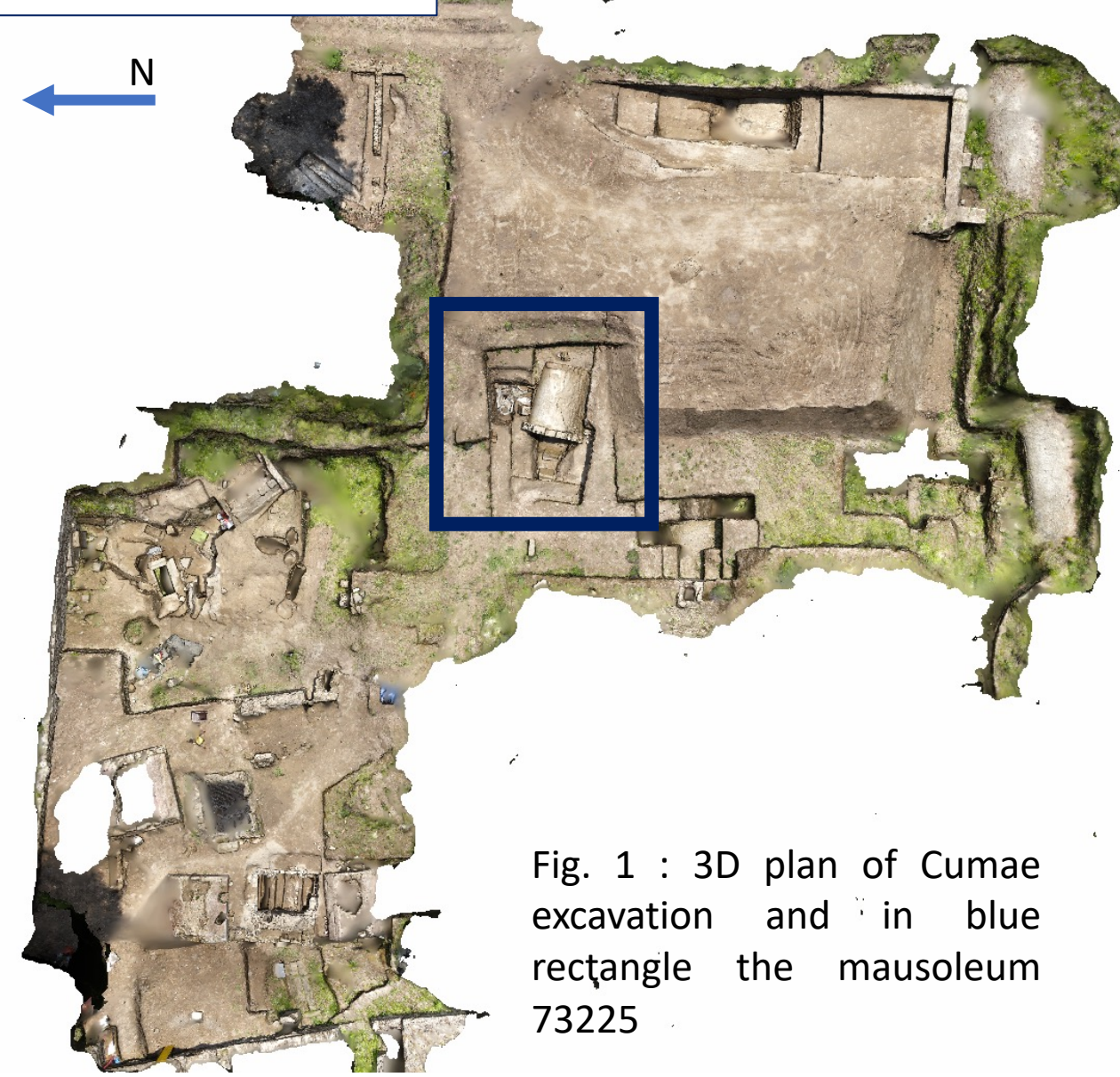


Fig. 1 : 3D plan of Cumae excavation and in blue rectangle the mausoleum 73225

At the Cumae site in Italy, each mortuary structure and burial site is photogrammetrically recorded from the moment it is discovered until it is completely excavated. The photogrammetry are produced with a precision of less than a millimetre, georeferenced and integrated into **the general 3D plan of the excavation** (fig. 1).

In June 2022, during the opening of the 73225 mausoleum, a deposit of bones was visible on the eastern bed. The mausoleum is in elevation with a vaulted roof preserved in stone and it is partially filled in between the funerary beds on the deposit is located. Two openings, one filled in to the north, linked to the pillage, and the other to the west, the entrance to the burial chamber (dromos), may have allowed sediment to infiltrate (fig.2).

The taphonomic analysis of the deposit between June 2022 and June 2023 was designed to show whether any elements had moved with the various submergences, and if so, which ones. The various funerary structures on this site were very often submerged.

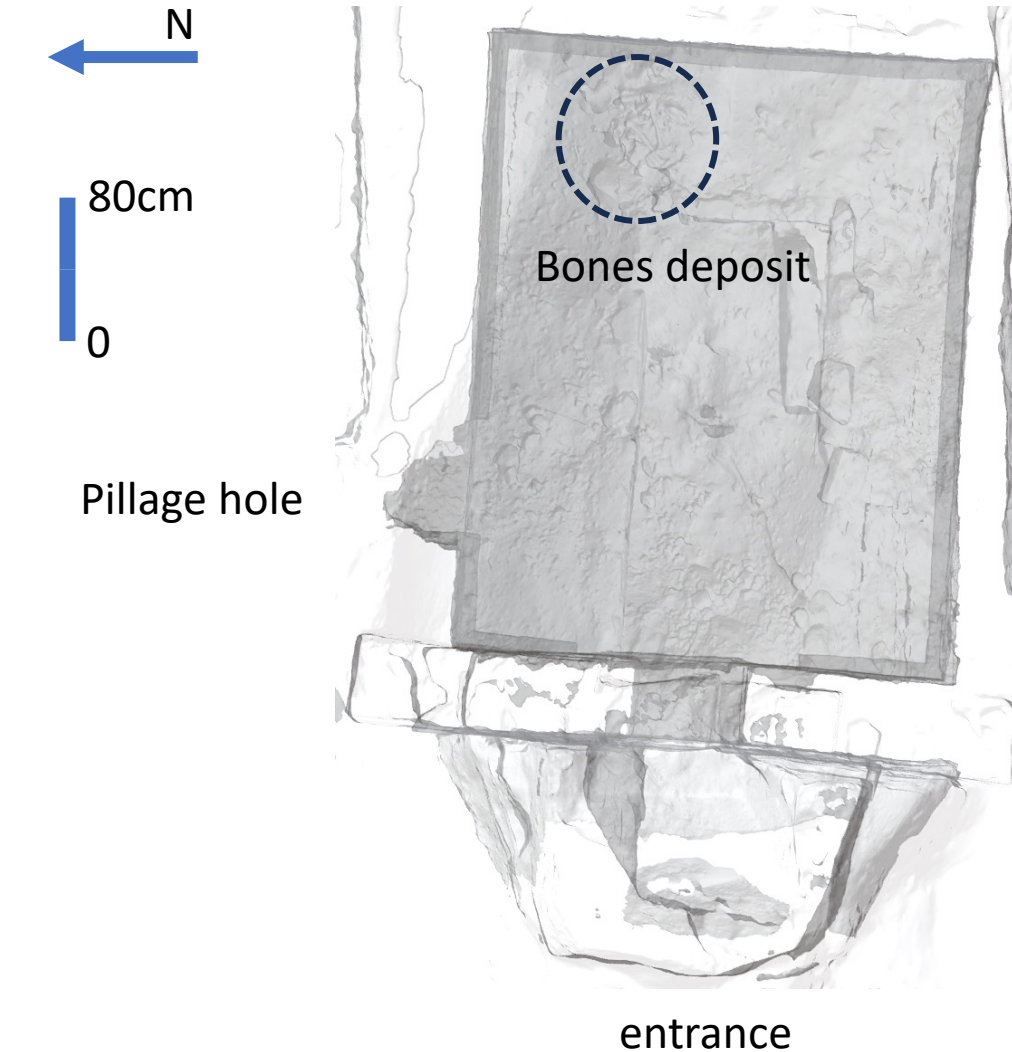


Fig. 2 : 3D plan of mausoleum 73225

MATERIELS AND METHODS

The bone deposit is made up of completely skeletonised remains of cranial elements, long bones and elements of belts, well preserved with a Minimum Number of Individuals at 2. This deposit shows no organisation or connection and its constitution results from the pillaging of the mausoleum, located stratigraphically in the 19th century. Smaller elements are either not present or under-represented, such as hands or feet, ribs and vertebrae, confirming that the initial deposits were reworked during the pillage.



Fig. 3: 2022 3D model of skeletal deposit (open of the mausoleum)



Fig. 4: 2023, first 3D model of skeletal deposit (non excavated)



Fig. 5: 2023, second 3D model of skeletal deposit (excavated)

In June 2022, the skeletal remains lay on the sandy sediment of the bed, some partially covered by brown sandy sediment (fig. 3). Nothing was excavated, only photogrammed. In June 2023, when excavations resumed, the mausoleum and some of the bones were underwater and covered in places by sediment (fig. 4). The skeletal remains is located at a depth below sea level and below the highest water table.

These levels were excavated and acquired in 3D (fig. 5). The second 3D model shows **three levels of intrusive sedimentary**, interspersed with a black level of accumulated degraded organic matter (mainly plant material), between 3 and 10 centimetres high (fig. 6).

The level of the water table in June 2023 was compared with the rainfall recorded in Naples from June 2022 to June 2023 (fig. 7), in an attempt to identify peaks that could lead to the rise of the water table (transport and suspension of sediments) and its fall (deposition of sediments), thus leading to the known sedimentation.

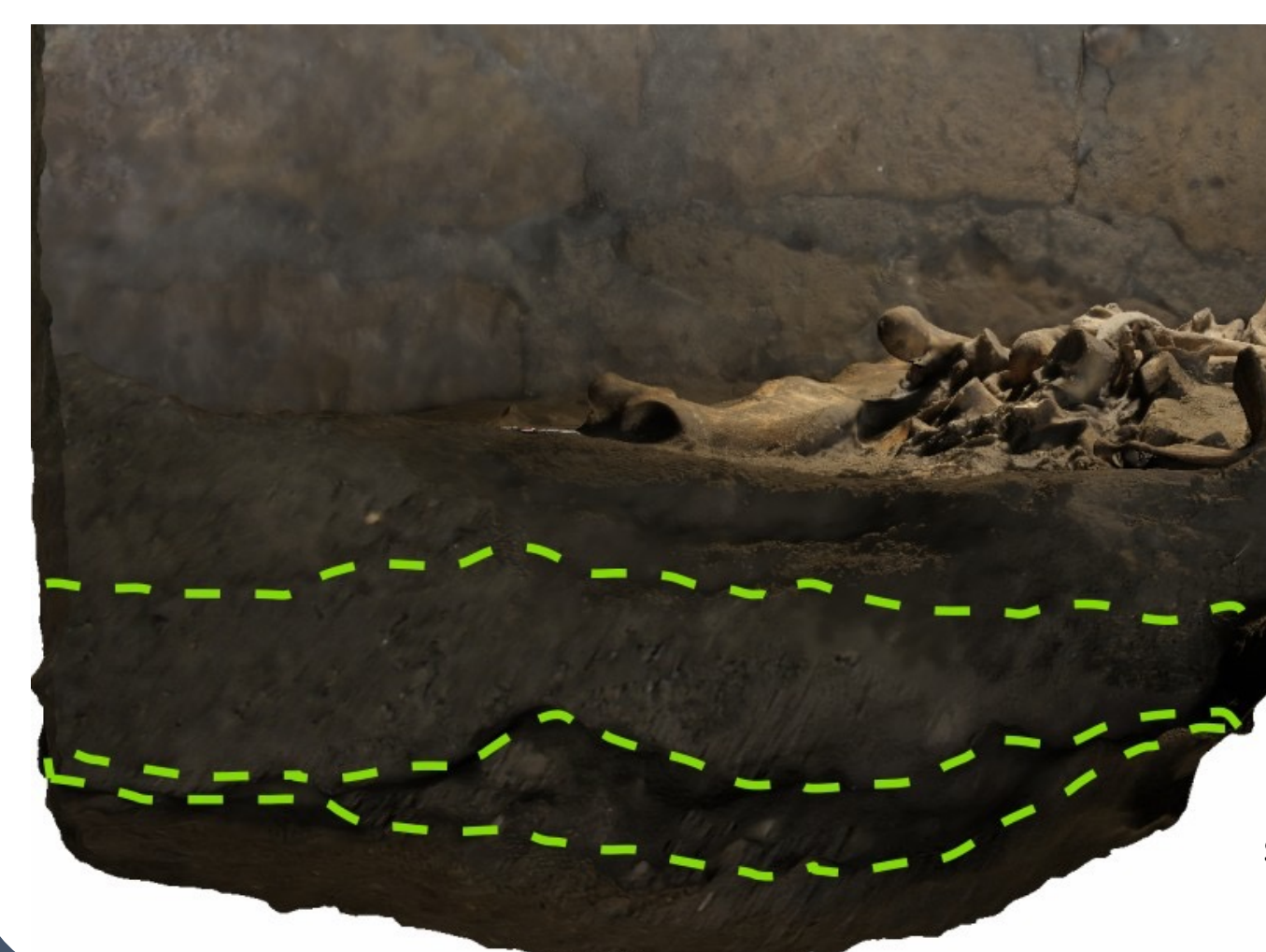


Fig. 6 : level of degraded organic matter (dotted line in green), separated different levels of sediment deposit during one year

By comparing the 3D models (CloudCompare software) between 2022 and 2023, we were able to discuss the height of the accumulated deposits in one year and study the behaviour of the bone deposit subjected to flooding and the different phases of sediment accumulation.

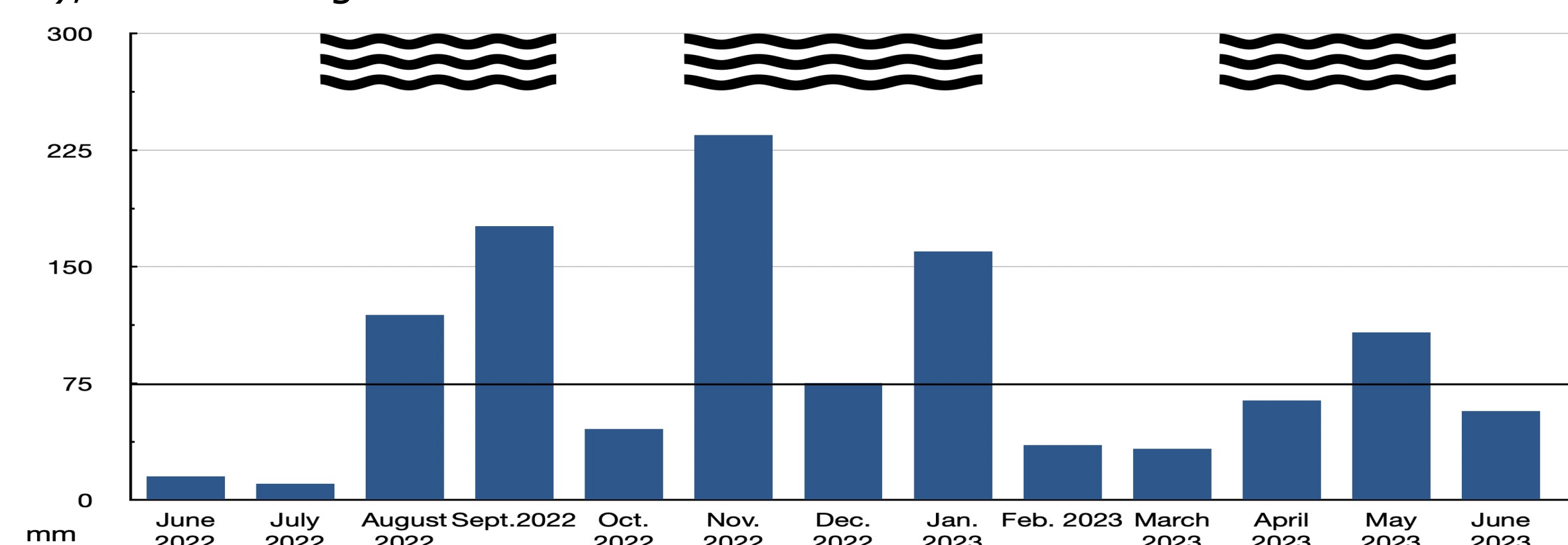


Fig. 7: Cumulative rainfall (source: ARPAC) of Pozzuoli (15 km east of Napoli) in millimetre by month, with in black waves the three probable moments when the phreatic zone may have risen inside the mausoleum

RESULTS

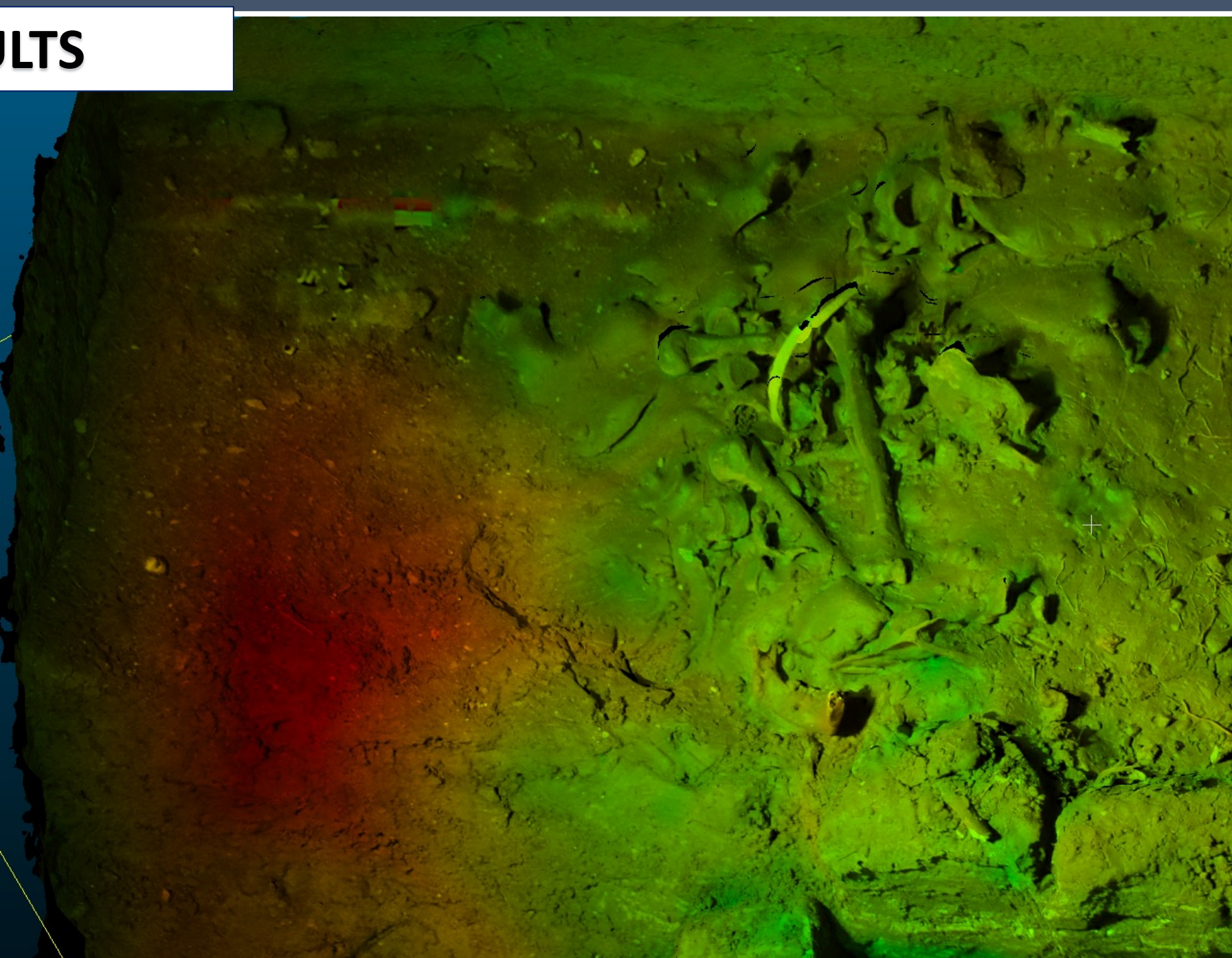


Fig. 8: comparison between 2022 and first model 2023

An irregular sedimentary deposit is visible on the bones of around 8 millimetres (fig. 8). The sediment (very fine and homogeneous) was probably deposited during the last flooding. Another levels of sediment accumulated just near the wall (in red) measure 22 centimeters.

Comparison of the 3D models shows that the bones like humerus, acquired first in 2023 **are in the same place as those visible** when the mausoleum was opened in 2022.

The analysis between the models shows that the presence of **several floods** over the past year **has not altered the position of the bone deposit**.

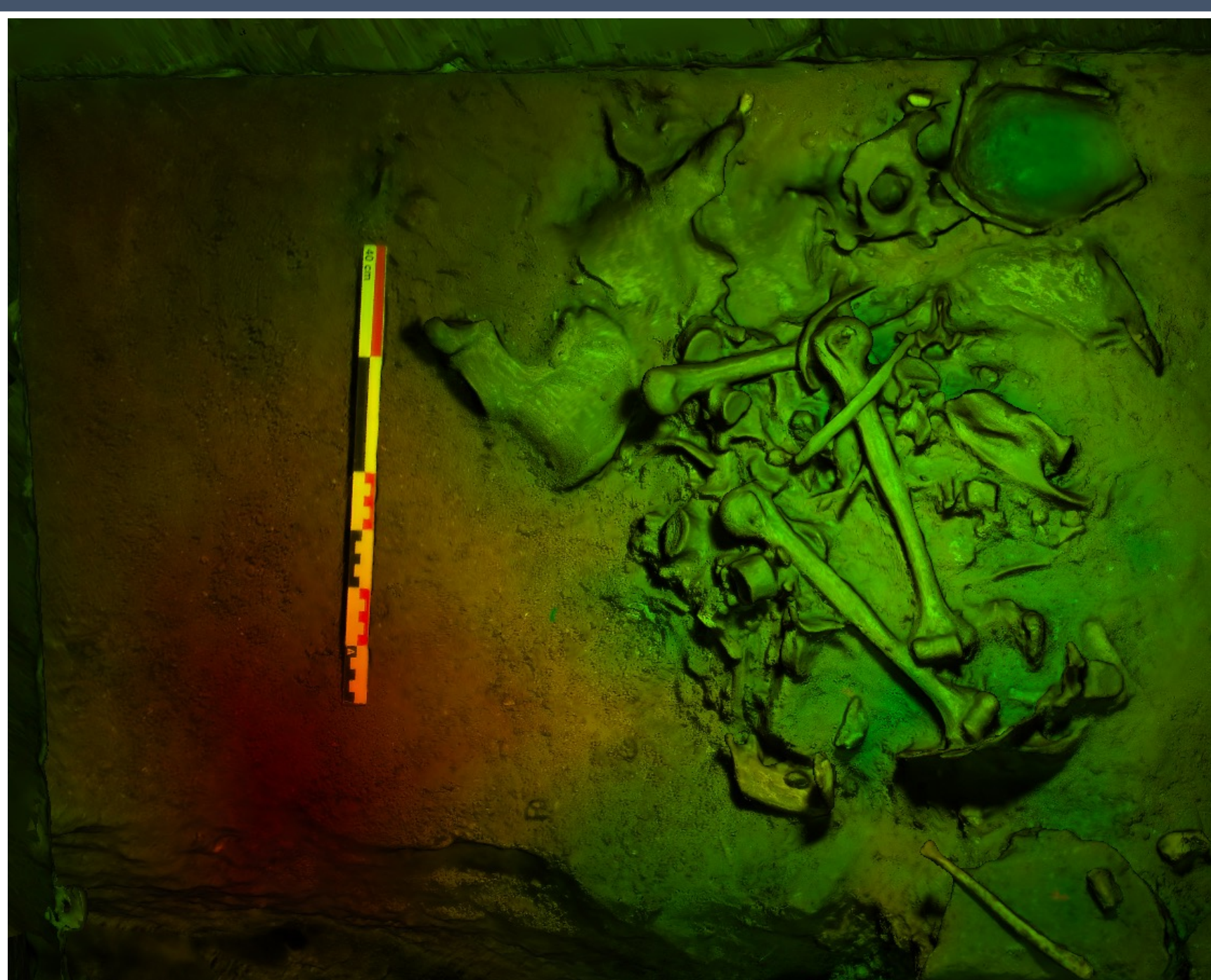


Fig. 9: comparison between 2022 and excavated model 2023

The comparison between 2023 and 2022 shows that **the bones are immovable**, the bones have not been washed away or floated away. No translation is visible. Only the prominent ribs appear to have been displaced, either as a result of preservation, the flotation or excavation link to the compact sediment that covered the bones, (fig. 9 and fig 10). Bones in balance stay in balance: the fibula on the stone edge of the bed, the calvarium against the eastern wall. The fibula, although in the same localisation, has changed orientation from lateral to posterior.

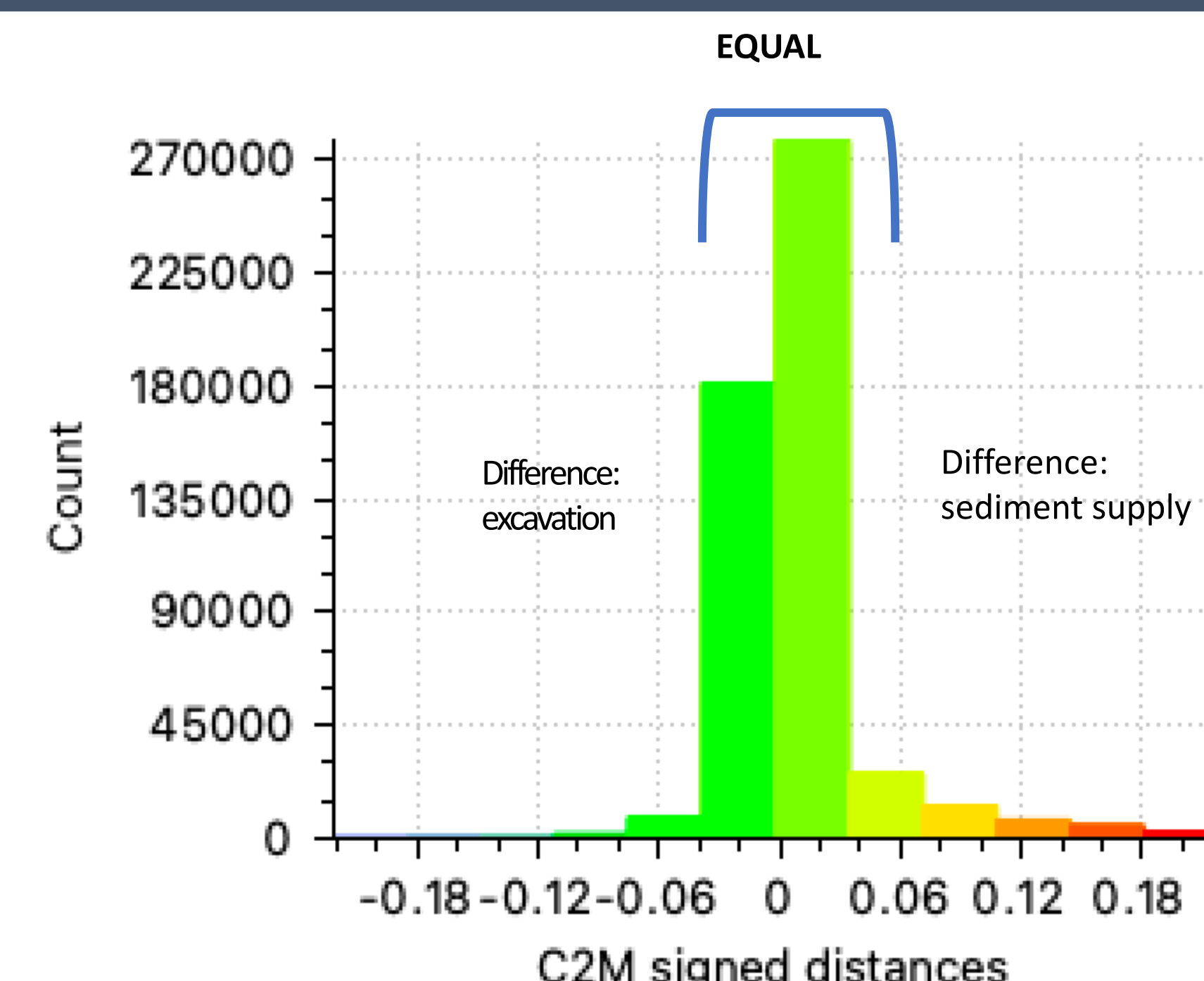


Fig. 10: equivalent number of vertices between the 2022 (reference) and excavated 2023 3D models in meters.

The very short acquisition time makes of photogrammetry an indispensable tool for accurate anthropological surveying, and enables the development of additional analysis that would be impossible without the virtualisation. **Quantifying the volume of sediment** deposited on the bones or inside the mausoleum could be one of the developments to answer specific questions such as the time required to fill an initially empty decomposition space. another important contribution of this study is that a pile of bones in an empty but covered space, subject to rising water tables, **can be the subject of a classic taphonomic study** since the majority of the bones have not moved.