Mummification in the Mesolithic. New Approaches to Old Photo Documentation Reveal Previously Unknown Mortuary Practices in the Sado Valley, Portugal

Rita Peyroteo-Stjerna, Liv Nilsson Stutz, Hayley Louise Mickleburgh, João Luís Cardoso

SUPPLEMENTARY ONLINE MATERIAL

CONTENTS

Table S1. *Source material used for archaeothanatological analysis*

Individual (Site, Year, Skeleton)	**Source material**				**Observations**
	Block	Graphic documentation w/ human remains			
		Photographs	Drawings	Site plan	
ARA1962, 1A	yes	yes	n/a	n/a	Fragmented material. Archaeothanatology is limited.
ARA1962, 2A	n/a	yes	n/a	n/a	-
ARA1962, 3A	yes	yes	n/a	n/a	-
ARA1962, 4A	n/a	yes	n/a	n/a	-
ARA1962, 6A	n/a	yes	n/a	n/a	Partially preserved. Archaeothanatology is limited.
ARA1962, unknown 1 (5A?)	n/a	yes	n/a	n/a	-
ARA1962, unknown 2	n/a	yes	n/a	n/a	-
ARA1962, unknown 3	n/a	yes	n/a	n/a	-
PSB1960, III	n/a	yes	yes	yes	Partially preserved. Archaeothanatology is limited.
PSB1960, V	n/a	yes	yes	yes	Partially preserved. Archaeothanatology is limited.
PSB1960, VII-A	n/a	yes	yes	yes	Partially preserved. Archaeothanatology is limited.
PSB1960, VIII	n/a	yes	yes	yes	Partially preserved. Archaeothanatology is very limited.
PSB1960, XI	n/a	yes	yes	yes	Fragmented bones of one lower limb. Archaeothanatology is not possible.
PSB1960, unknown	n/a	yes	yes	yes	Only a few bone (?) fragments are preserved. Archaeothanatology is not possible.

ARAPOUCO 1962, PHOTOGRAPHIC DOCUMENTATION

Arapouco 1962, skeleton 1A

Figure S1. *Arapouco 1962, skeleton 1A (view one). The bone remains in the centre of the photograph match with the skeletal material from Arapouco preserved in one paraffin block at the National Museum of Archaeology, Lisbon (Figure S3). This correspondence allowed us to securely assign the photographs to the Arapouco series. The remains of an unidentified individual (unknown 1) are visible on the upper right corner of the photograph.*

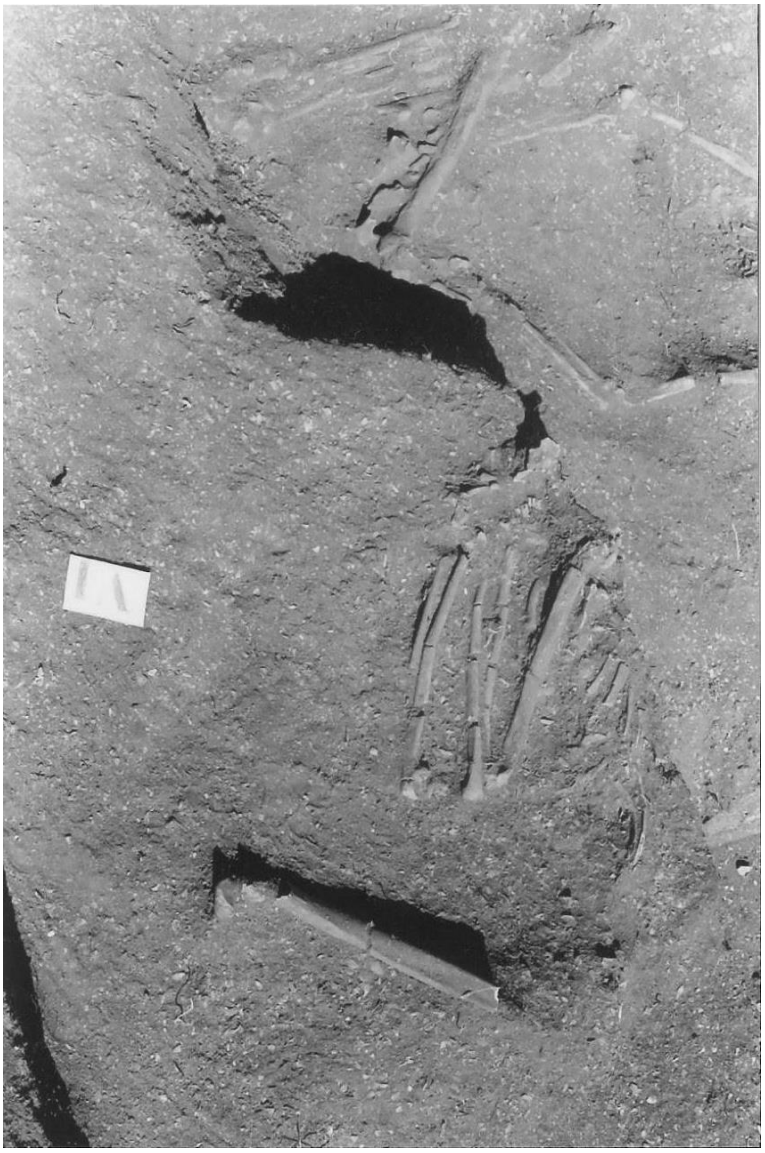

Figure S2. *Arapouco 1962, skeleton 1A (view two). One of the few photographs showing the identification number (1A) attributed during excavation. The remains of an unidentified individual (unknown 1) are visible on the upper part of the photograph.*

Figure S3. *Arapouco 1962, skeleton 1A preserved in one paraffin block at the National Museum of Archaeology, Lisbon. Photograph by J. P. Ruas.*

Arapouco 1962, skeletons 2A and 3A

Figure S4*. Arapouco 1962. Skeleton 2A is visible on the right side of the photograph, lying on the left side of skeleton 3A visible on the left side of the photograph. The field labels in this photograph allowed us to identify unlabelled documentation.*

Arapouco 1962, skeleton 2A

Figure S5. *Arapouco 1962, skeleton 2A (view one). Bones of the feet from skeleton 3A are visible on the left side of the photograph. Bones from the lower limbs of unknown 1 are visible on the right side of the document.*

Figure S6. *Arapouco 1962, skeleton 2A (view two). The remains of 3A are visible on the left side of the document. Bones from unknown 1 are visible on the right side of the photograph.*

Figure S7. *Arapouco 1962, skeleton 2A (view three). Bone remains from unknown 1 are visible on the upper right side of the photograph, as well as from 3A on the upper left side of the document.*

Arapouco 1962, skeleton 3A

Figure S8. *Arapouco 1962, skeleton 3A is in the centre of the photograph (view one). The bone remains in the centre of the photograph match with the skeletal material from Arapouco preserved in one paraffin block at the National Museum of Archaeology, Lisbon (Figure S12). Skeletons 4A and 2A are partially visible on the lower left and lower right corners of the document, respectively.*

Figure S9. *Arapouco 1962, skeleton 3A (view two). Bone remains of 4A are visible on the lower left corner of the photograph. Skeleton 2A is partially visible on the lower right corner of the document.*

Figure S10. *Arapouco 1962, skeleton 3A (view three). The remains of skeleton 4A are visible on the lower left of the photograph. Bones from 2A are visible on the lower right corner of the document.*

Figure S11. *Arapouco 1962, skeleton 3A (view four). Skeleton 4A is visible on the upper left corner of the photograph. Skeleton 2A is partially visible on the lower left corner.*

Figure S12. *Arapouco 1962, skeleton 3A preserved in a paraffin block at the National Museum of Archaeology, Lisbon. Photograph by J. P. Ruas.*

Arapouco 1962, skeleton 4A

Figure S13. *Arapouco 1962, skeleton 4A (view one) with identification label attributed during excavation.*

Figure S14. *Arapouco 1962, skeleton 4A (view two). The cranial remains of skeleton 6A are visible on the left side of 4A, on the right side of the photograph.*

Arapouco 1962, skeleton 6A

Figure S15. *Arapouco 1962, skeleton 6A (view one) with identification label attributed during excavation. Skeleton 4A is partially visible on the upper right side of the photograph.*

Figure S16. *Arapouco 1962, skeleton 6A (view two) with identification label attributed during excavation. Skeleton 4A is partially visible on the upper right side of the photograph.*

Arapouco 1962, skeleton unknown 1 (5A?)

Figure S17. *This photograph shows the bone remains of an unlabelled skeleton, identified in this paper as unknown 1 (view one). Its relative position in relation to other identified skeletons suggests that these could be the remains of skeleton 5A. Skeleton 2A is partially visible on the lower left corner of the photograph.*

Figure S18. *Arapouco 1962, unknown 1 (5A?) (view two). Skeleton 2A is partially visible on the lower left corner of the photograph.*

Figure S19. *Arapouco 1962, unknown 1 (5A?) (view three). Skeleton 2A is visible on the lower left corner of the photograph. The distal portion of a femur of an unknown skeleton is visible on the upper left side of the document.*

Arapouco 1962, skeleton unknown 2

Figure S20. *This photograph shows the bone remains of an unlabelled skeleton, identified in this paper as unknown 2. We assumed it to be from Arapouco 1962 because this photograph is in the film with Arapouco human burials and no other sites were being excavated at this time.*

Arapouco 1962, skeleton unknown 3

Figure S21. *This photograph shows the bone remains of an unlabelled skeleton, identified in this paper as unknown 3. We assumed it to be from Arapouco 1962 because this photograph is in the film with Arapouco human burials and no other sites were being excavated at this time.*

POÇAS DE S. BENTO 1960, DRAWINGS

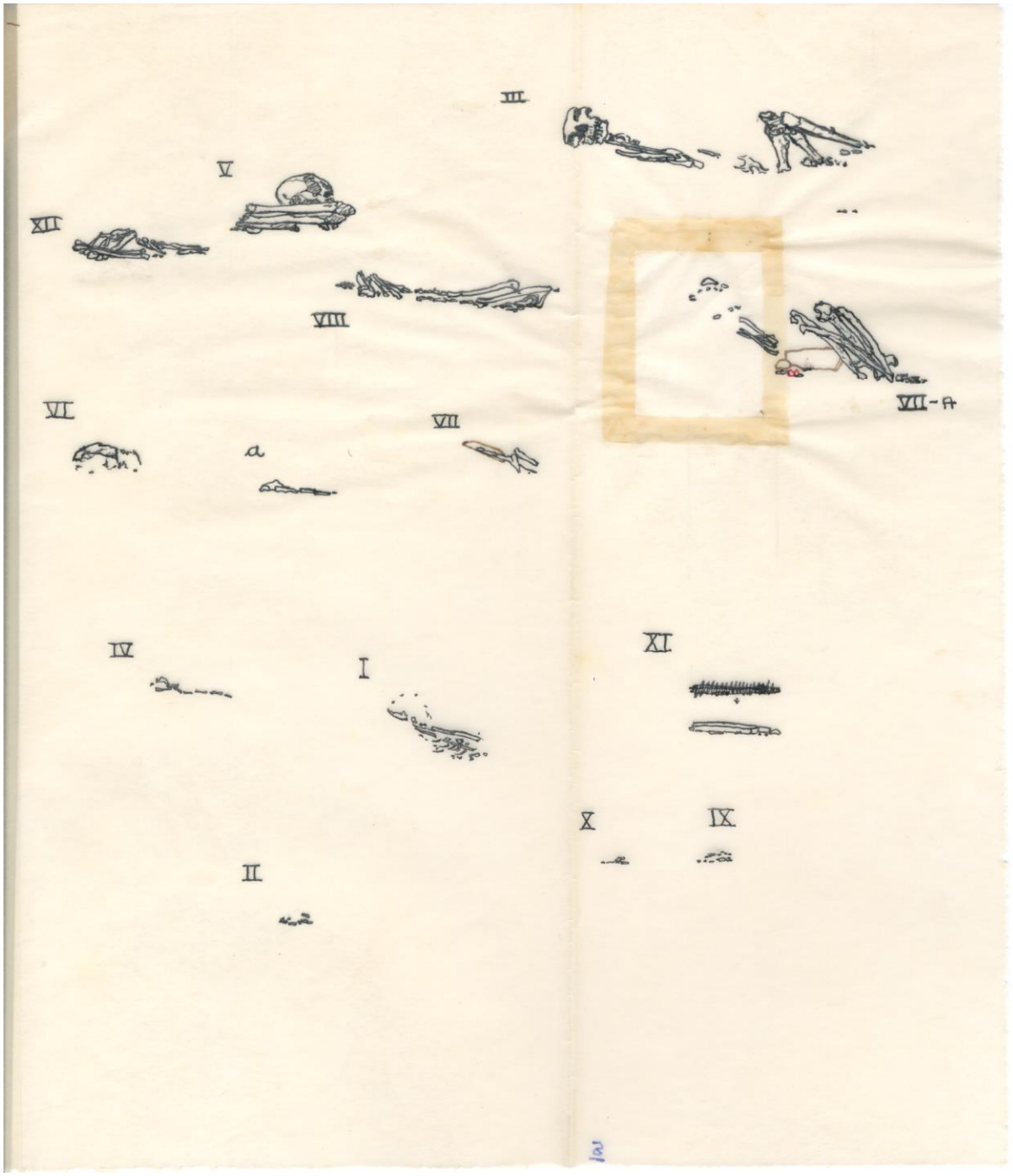

Figure S22. *Poças de S. Bento 1960. Sketch with human remains (I to XII) and animal bones (a) in profile view. Individuals VI, V, a, VIII, III, XII are in profile C-D and X, IX, II, IV, I, VII, VII-A, XI are in profile A-B in the site plan (Figure 2). Original drawing by Dario de Sousa in the archives of the National Museum of Archaeology, Lisbon.*

POÇAS DE S. BENTO 1960, PHOTOGRAPHIC DOCUMENTATION

Poças de S. Bento 1960, skeleton V

Figure S23. *Poças de S. Bento 1960, skeleton V. The cranial fragments of skeleton III are visible on the upper right side of the photograph. Archive drawings at the National Museum of Archaeology, Lisbon indicate that these remains were excavated at a depth of 150 centimetres from the modern surface.*

Poças de S. Bento 1960, skeletons V, III, VIII

Figure S24. *Poças de S. Bento 1960. These two photographs show the remains of three individuals (views one and two): skeleton V on the left side of the photograph, skeleton III on the right side of the photograph, and skeleton VIII partially covered by the deposition of III. These skeletons were excavated at a depth of 150-160 centimetres from the modern surface layer, according to drawings in the archive of the National Museum of Archaeology, Lisbon.*

Figure S25. *Poças de S. Bento 1960. This photograph shows the remains of three individuals (view three): skeleton V on the left side of the photograph, skeleton III in the centre of the document, and skeleton VIII partially covered by the deposition of III.*

Figure S26. *Poças de S. Bento 1960. Skeleton III is visible in the centre of the photograph. The remains of skeleton VIII are visible in the centre of the photograph and are in close proximity with the lower limbs of III. This proximity was represented slightly differently in the site plan (Figure 2) on the right. See also Figures S24, S25 and S33. Skeleton V is partially visible on the upper side of the photograph.*

Figure S27. *Poças de S. Bento 1960. Skeleton V is visible on the upper part of the photograph. Skeleton III is partially visible on the lower part of the document.*

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Poças de S. Bento 1960, skeleton VII-A

Figure S28. *Poças de S. Bento 1960, skeleton VII-A (view one). This is the only grave known from the Sado Valley Mesolithic burial sites with stone elements shown in the photographs.*

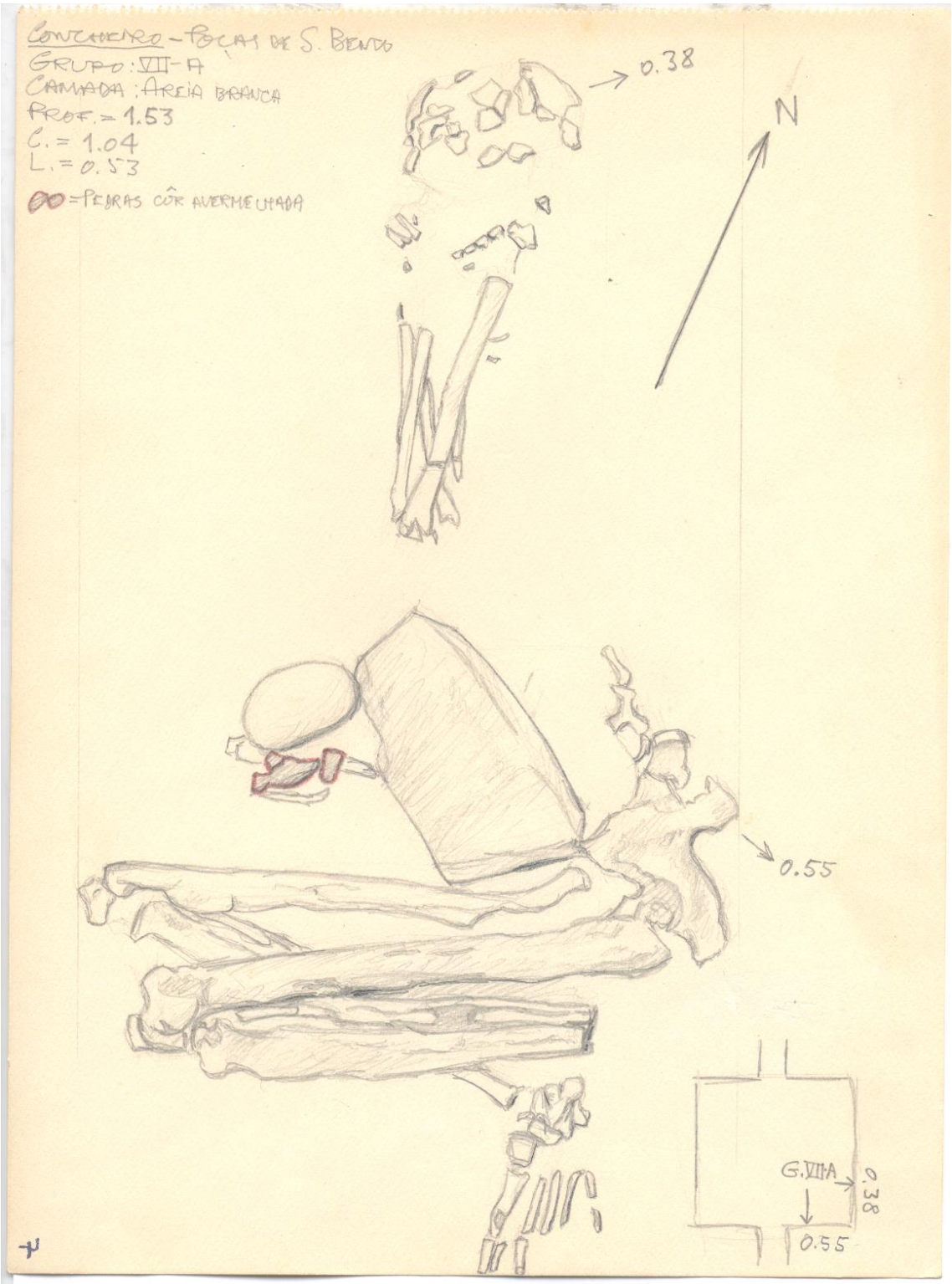

Figure S29. *Poças de S. Bento 1960, skeleton VII-A. These remains were excavated on the white sand (areia branca) at a depth of 153 centimetres from the modern surface. Red stones (pedras de cor avermelhada) were found near a large round stone and highlighted in the drawing. Illustration by Dario de Sousa, 1960, National Museum of Archaeology, Lisbon.*

Figure S30. *Poças de S. Bento 1960, skeleton VII-A (view two). A concentration of fragmented remains are visible in front of VII-A but their identification is unclear (see Figure S31).*

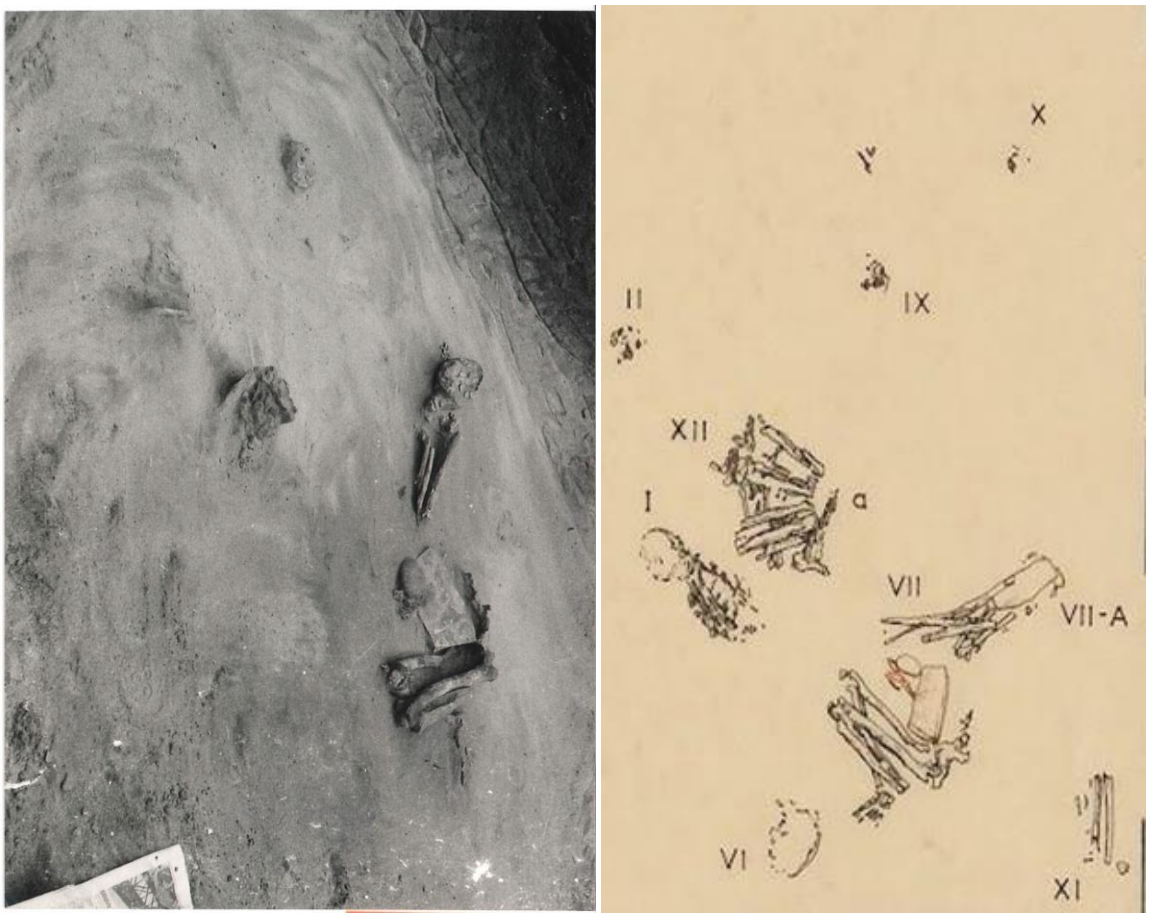

Figure S31. *Poças de S. Bento 1960. A concentration of fragmented remains are visible in front of VII-A but their identification is unclear when comparing with the site plan (Figure 2) on the right.*

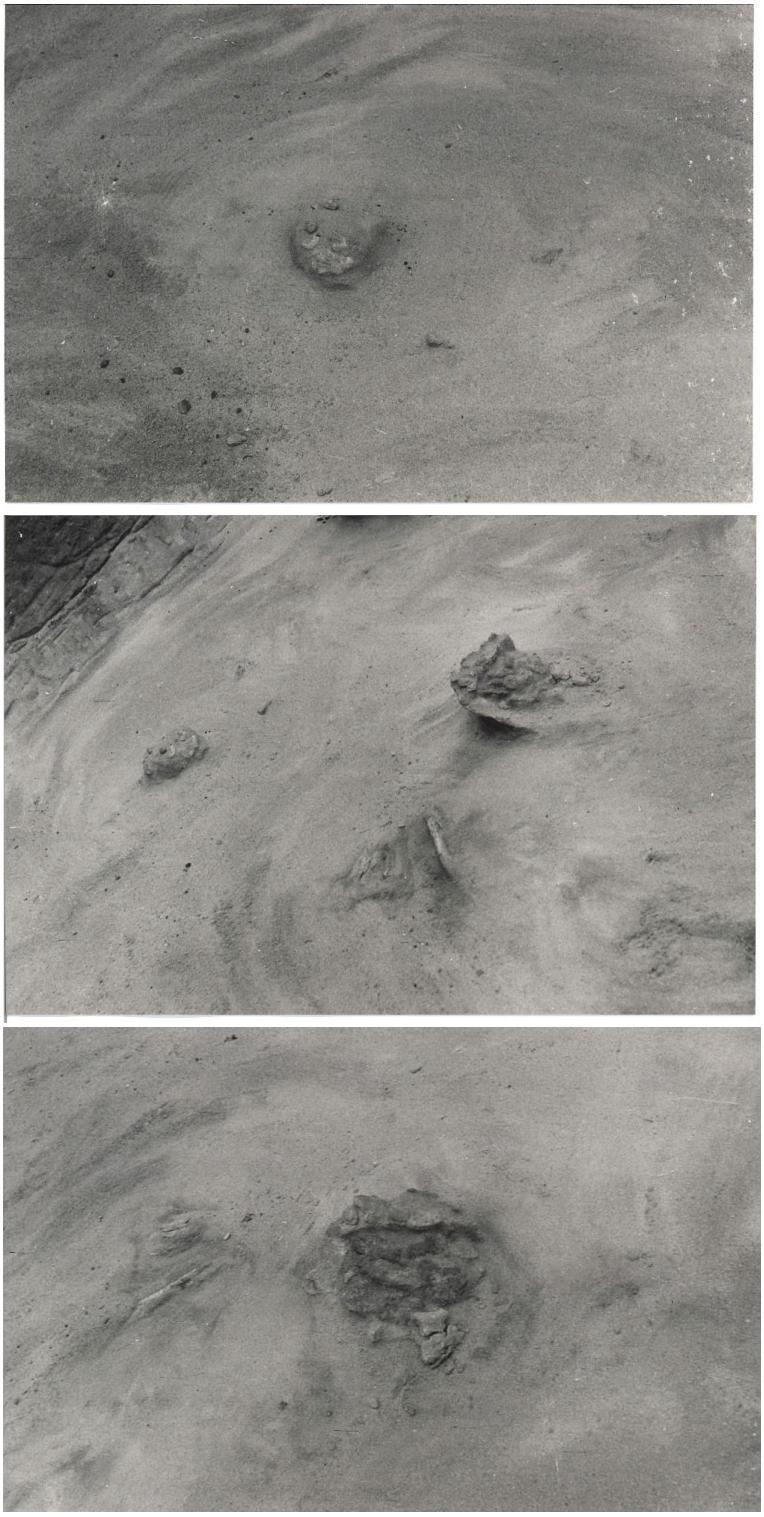

Figure S32. *Poças de S. Bento 1960. Unidentified concentration of fragmented bone (?) remains in front of skeleton VII-A (see Figures S30 and S31).*

Poças de S. Bento 1960, skeleton VIII

Figure S33. *Poças de S. Bento 1960, skeleton VIII, after lifting the bones of skeleton III (view one). The archive documentation at the National Museum of Archaeology, Lisbon, indicates that these remains were excavated 160 centimetres from the modern surface of the site.*

Figure S34. *Poças de S. Bento 1960, skeleton VIII, after lifting the bones of skeleton III (view two).*

Poças de S. Bento 1960, skeleton XI

Figure S35. *Poças de S. Bento 1960, skeleton XI. These remains were excavated in the white sand at a depth of 165 centimetres from the modern surface, according to documentation at the National Museum of Archaeology, Lisbon.*

Poças de S. Bento 1960, skeleton XII

Figure S36. *Poças de S. Bento 1960, skeleton XII (view one). The human remains laid near fragmentary animal bones and were excavated in the white sand at a depth of 170 centimetres from the modern surface, according to documentation at the National Museum of Archaeology, Lisbon.*

Figure S37. *Poças de S. Bento 1960, skeleton XII (view two).*

Figure S38. *Poças de S. Bento 1960, skeleton XII (view three)*

Table S2. *Summary of the nature of the deposits and the space of decomposition of the human remains in the grave features.*

Individual	***Nature of the deposit.* Arguments**	***Space of decomposition.* Arguments**
ARA, 1A	*Probably primary.* The preservation of the skeleton and labile articulations is poor. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.	*Filled.* Maintenance of bones in original unbalanced position: patella is in a semi-suspended position.
ARA, 2A	*Probably primary.* The labile articulations are poorly preserved and unclear in the documentation. However, the skeleton is well articulated and the general anatomical integrity of the body has been maintained.	*Filled.* Maintenance of bones in original unbalanced position: no collapse of the left os coxae. No movement outside initial volume of the cadaver.
ARA, 3A	*Primary.* Maintenance of labile articulations: most metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.	*Filled.* Maintenance of bones in original unbalanced position: limited collapse of the os coxae. No movement outside initial volume of the cadaver.
ARA, 4A	*Primary.* Maintenance of labile articulations: most metatarsals and phalanges of the right foot. Maintenance of the general anatomical integrity of the body.	*Filled.* Maintenance of bones in original unbalanced position: limited collapse of the os coxae and of bones of the right foot; the bones of the right foot are rotated. No movement outside initial volume of the cadaver.
ARA, 6A	*Probably primary.* The preservation of the skeleton and labile articulations is poor, but the general anatomical integrity of the body has been maintained.	*Probably filled.* Maintenance of bones in unbalanced position: left ribs are slightly verticalized and rotated forwards, but their order has been maintained.
ARA1962, unknown 1 (5A?)	*Primary.* Maintenance of labile articulations: most metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.	*Filled.* Maintenance of bones in original unbalanced position: limited collapse of bones of the feet; the bones of the right foot are rotated. No movement outside initial volume of the cadaver.
ARA1962, unknown 2	*Primary.* Maintenance of labile articulations: right hip joint. Maintenance of the general anatomical integrity of the body.	*Filled. Mixed?* Maintenance of bones in original unbalanced position: the right patella is suspended on the distal end of the right femur. No movement outside initial volume of the cadaver. Movement at the level of the feet suggests empty space in this area.

ARA1962, unknown 3	*Primary.* Maintenance of labile articulations: metatarsals and phalanges of the right foot. Maintenance of the general anatomical integrity of the body.	*Filled.* Maintenance of bones in original unbalanced position: limited *(if any)* collapse of the right os coxae and bones of the feet. No movement outside initial volume of the cadaver.
PSB1960, III	*Probably primary.* The preservation of the skeleton is poor. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.	*Unknown.* Although there is no clear movement outside the initial volume of the cadaver the poor preservation and unclear documentation does not allow an unambiguous interpretation.
PSB1960, V	*Probably primary.* The preservation of the skeleton is poor. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.	*Unknown.* Although there is no clear movement outside the initial volume of the cadaver the poor preservation and unclear documentation does not allow an unambiguous interpretation.
PSB1960, VII-A	*Primary.* Maintenance of labile articulations: metatarsals and phalanges right foot. Maintenance of the general anatomical integrity of the body.	*Filled.* Maintenance of bones in original unbalanced position: no collapse of the left os coxae; the patellae are in a semi-suspended position. No movement outside initial volume of the cadaver.
PSB1960, VIII	*Probably primary.* The preservation of the skeleton is poor, but the labile articulations of the foot (which was rotated) seem to have been maintained. The overall position of the bones suggests that the general anatomical integrity of the body has been maintained.	*Unknown.* Although there is no clear movement outside the initial volume of the cadaver the poor preservation and unclear documentation does not allow an unambiguous interpretation.
PSB1960, XII	*Probably primary.* The labile articulations are poorly preserved and unclear in the documentation. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.	*Unknown.* Although there is no clear movement outside the initial volume of the cadaver the poor preservation and unclear documentation does not allow an unambiguous interpretation.

Table S3. *Summary of the reconstruction of the initial position of the cadaver in the grave features. The initial position of the limbs is indicated as -R or -L and refers to the right or left limb when their positions are different. Rotation -R or -L indicates the rotation of the skeletal element(s) towards the right or the left side.*

Individual	**Initial position of the cadaver in the feature**			
	Head	**Trunk**	**Upper limbs**	**Lower limbs**
ARA1962, 1A	n/d	On the right	In flexion	Partially preserved. Probably in flexion. Rotation-prob. R
ARA1962, 2A	Rotation-L	On the back	In semi-flexion	Hip and knee joints: in flexion Rotation-R Feet towards buttocks Clumping
ARA1962, 3A	Rotation-L	On the back	In flexion-R In semi-flexion (90 degrees)-L	Hip and knee joints: in flexion Rotation-R Feet towards buttocks
ARA1962, 4A	Rotation-R and downwards	On the back	In hyperflexion-R In flexion-L	Hip joints: in flexion Knee joints: in flexion Rotation-R Feet towards buttocks Clumping
ARA1962, 6A	Rotation-R	On the back	Partially preserved. Humeri are placed laterally to thoracic cage	n/a
ARA1962, unknown 1 (5A?)	No rotation (?)	On the back	In semi-flexion In moderate abduction	Hip joints: in flexion Knee joints: in flexion

				Rotation-R Feet towards buttocks
ARA1962, unknown 2	Rotated slightly upwards and backwards	On the left	In flexion-R Clumping	Hip and knee joints-R: in flexion (left not visible) Rotation-L Feet towards buttocks Clumping
ARA1962, unknown 3	Rotated-L	On the back	In hyperflexion-R In flexion-L	Hip and knee joints: in hyperflexion Lower limb-R: rotation-R Lower limb-L: rotation-L Feet rotated inwards towards buttocks Clumping “Square shaped burial”
PSB1960, III	On the right. No rotation.	On the right	In flexion	Hip and knee joints-R: in flexion Hip joint-L: in flexion Knee joint-L: in semiflexion
PSB1960, V	On the left. No rotation.	On the left	In flexion-R or L?	Hip joints: in flexion Knee joint(s): in flexion (at least one)
PSB1960, VII-A	On the right. Rotation?	On the right	In flexion	Hip joints: in flexion Knee joint-R: in semiflexion Knee joint-L: in flexion Foot-R in extension and rotated downwards
PSB1960, VIII	n/a	On the right	Probably in flexion	Hip joints: in flexion Knee joints: in flexion Clumping?

PSB1960, XII	No rotation?	On the back	In flexion-R In abduction	Hip and knee joints: in hyperflexion Lower limb-R: rotation-R Lower limb-L: rotation-L Clumping “Square shaped burial”

Table S4. *Summary of the key observations used in the reconstruction of the grave features. Observed pressures on the body are presented in a number sequence. The arguments supporting these observations are indicated by the same number in the respective column.*

Individual	**Pressures**	**Arguments**
ARA1962, 1A	1. Wall-effect, lower end; 2. Weight of sediment from above. Design of the grave feature.	1. Alignment of right leg; 2. Visible by the even levelling and flattening of the bones in a horizontal plane.
ARA1962, 2A	1. Bilateral compression; 2. Wall-effect, lower end. Design of the grave feature and possible light wrapping. *Cuvette* shaped pit.	1. Alignment of the upper limbs, involving right arm, and left shoulder girdle and arm. Pattern enhanced on the left side could be explained by a sloping floor causing a transfer of body weight towards the left side. This movement would explain the dislocation observed at the level of the right shoulder girdle. 2. Alignment of the lower limbs and constraint effect towards legs forcing feet towards buttocks.
ARA1962, 3A	1. Bilateral compression; 2. Wall-effect, lower end. Design of the grave feature. *Cuvette* shaped pit.	1. Towards shoulder girdles involving the arms as well. Pattern enhanced by the sloping characteristics of the floor of the grave, slightly more elevated on the lateral sides than on the centre of the feature. 2. Alignment of the lower limbs and constraint effect towards lower limbs forcing feet towards buttocks.
ARA1962, 4A	1. Wall-effect, upper end (?); 2. Wall-effect, right side; 3. Wall-effect, lower end. Design of the grave feature. *Cuvette* shaped pit.	1. Rotation forwards and downwards of the head. 2. Providing support for the head, upper and lower limbs. Constraint effect towards the right shoulder. Alignment of the upper right limb. 3. Alignment of the lower limbs and constraint effect towards lower limbs forcing feet towards buttocks.
ARA1962, 6A	1. Bilateral compression. Probably design of the grave feature. *Cuvette* shaped pit.	1. Towards shoulder girdles and arms.
ARA1962, unknown 1 (5A?)	1. Wall-effect, right and lower end;	1. Alignment of lower limbs;

	2. Weight of sediment from above. Design of the grave feature.	2. Visible by the even levelling and flattening of the bones of the feet in a horizontal plane.
ARA1962, unknown 2	1. Wall-effect, right side; 2. Wall-effect, left side; 3. Overall constraint effect. Design of the grave feature and possible light wrapping.	1. Alignment of right clavicle, vertebral column and pelvic girdle 2. Alignment of lower limbs and constraint effect towards legs forcing feet towards buttocks. 3. Hypercontracted skeleton.
ARA1962, unknown 3	1. Overall strong lateral pressure and compressing effect. Design of the grave feature. Pre-burial treatment of the body including desiccation and tight wrapping.	1. Constraining the movement of the bones and maintaining these clumped together; 2. Hypercontracted skeleton.
PSB1960, III	No particular pressures.	-
PSB1960, V	1. Wall-effect, lower end (?).	1. Alignment of the lower limbs (one tibiae is missing).
PSB1960, VII-A	No particular pressures.	-
PSB1960, VIII	1. Wall-effect, lower end. Design of the grave feature.	1. Alignment of the lower limbs
PSB1960, XII	1. Overall strong lateral pressure and compressing effect. 2. Weight of sediment from above. Design of the grave feature and possible pre-burial treatment of the body including desiccation and tight wrapping.	1. Constraining the movement of the bones and maintaining these clumped together; Hypercontracted skeleton. 2. Visible by the even levelling and flattening of the bones in a horizontal plane.

Figure 9. *Extended description. Experimental burials of a fresh body (top row) and a desiccated body (bottom row).*

*The **top row of images** illustrates the experimental burial of a fresh body in flexed supine position, unclothed directly in the soil. Top left: initial body position upon burial of the freshly deceased individual. Top middle: the position of the skeleton upon excavation after 2 years and 2 months. Top right: indication of the relation between the initial body position and the final position of the bones. Joint disconnections can be seen at the ankles and mandible, as well as the left hip socket. Movements of bones can be observed mostly in the lower limbs, including downward movement of the tibiae and fibulae, and the closing of the intersegmental angle of the right lower limb. The cervical vertebrae were uncovered in perfect anatomical relation, although there was slight downward movement of the cranium and mandible into the space left by decomposition of the soft tissues of the throat. Some small bones of the left hand (intermediate and distal phalanges) have fallen into the void created by the decay of soft tissue of thigh/buttock. The ribs have flattened downward somewhat, but there is no splaying. Slight opening of the pelvis at the pubic symphysis has occurred, due to the lateral space created by decomposition of the thighs/buttocks.*

*The **bottom row of images** illustrates the experimental burial of a desiccated body after 7 months of guided natural mummification and trussing during the first 3 weeks. Bottom left: the initial body position upon burial of the mummified individual. Bottom middle: the position of the skeleton upon excavation after 3 years and 2 months. Bottom right: indication of the relation between the initial body position and the final position of the bones. Displacements of the right fibula, cervical vertebrae, mandible (not present in images) and left foot are related to the disturbance of these shallow laying areas by a small animal. Movements of bones related to decomposition of the remaining desiccated soft tissues can be observed in the lower left limb, including downward movement and inward rotation of the tibiae and fibulae as the volume of the abdomen decreased. Related joint disconnections can be seen at the left hip socket, as well as of some ribs in the upper thorax. The small bones of hands and right foot were found in strict anatomical relation and connection with their respective limbs. The slight opening of the pelvis at the pubic symphysis is related to the lateral space created by decomposition of the remaining desiccated soft tissues of the left thigh.*