STUDIES IN FUNERARY ARCHAEOLOGY:

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Henry Duday

THE ARCHAEOLOGY OF THE DEAD

Lectures in Archaeothanatology

Henri Duday

Translated by Anna Maria Cipriani and John Pearce

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Relationships between the internal and external environments of the corpse (I): the analysis of environmental conditions within the burial

This chapter shows how observations on the taphonomy of a corpse can provide us with useful information on the micro-environment in which a decay process takes place, and, indirectly, on burial architecture: the corpse may be buried either in a filled space or in a void.

4.1. Decomposition in a void

Let us begin with an example of a Middle Neolithic burial excavated at Villeneuve-Tolosane on the outskirts of Toulouse. The complex, 17 hectares in size, belongs to the middle Chasséen. During this period in the south of France, all the burials took place in earth graves. A burial is in an 'earth grave' when the corpse is placed either in an existing hole or in a pit cut into the ground for this purpose. The hole or pit is filled in afterwards immediately and the fill directly touches the body, its clothes or the shroud in which the corpse is tightly bound.

In this case the individual is lying in a pit on his left side in a crouched position (Figure 13). Since the connections that break down more rapidly are still preserved, this is a primary individual deposit. Wild boar canines and a vessel are present as offerings. The right ribs have fallen into the thoracic-abdominal cavity left free by the decomposition of the internal organs, while the left ribs have remained in their original position at the bottom of the pit. The vertebral column is slightly displaced: when excavated, it is generally found to be divided in segments (most commonly from two to five) of three or four vertebrae in strict connection. Between those segments, it is possible to observe a shift, rotation or change of angle at one of the inter-vertebral spaces. Save where the body is laid perfectly symmetrically on soft sediment, the vertebral column is subject to forces which exercise a double torsion. As long as ligaments hold, these forces do not generate any movement, but when the linkages break, one of the three types of displacements described above occurs in the space where the ligaments first yield. This movement absorbs the action of the forces on the vertebral column, unless another should happen a little further away at the intervertebral space which gives up second, and so on. David Persinotto, who is working on his Ph.D. dissertation at Bordeaux on corpse taphonomy, has showed the systematic occurrence of a displacement at the first or second lumbar vertebrae. At this point in front of the vertebral column is the transverse colon, containing faecal matter and bacteria which have been proliferating

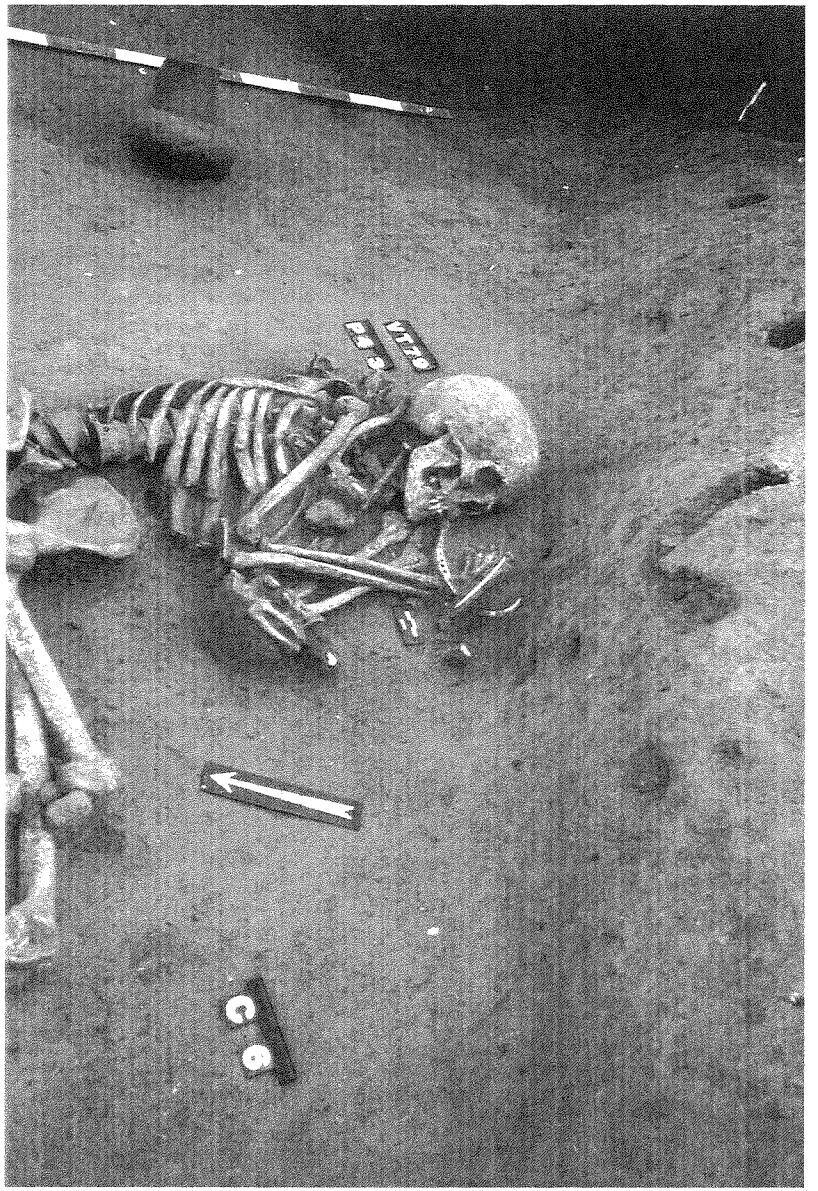

Figure 13. Villeneuve-Tolosane (Haute Garonne, France), burial P4–3, middle Neolithic (Chasséen culture). Excavation by J. Vaquer, J-P. Giraud and H. Duday.

since the moment of death. These attack tissues and rapidly cause a zone of precocious destruction.

The photograph further shows that the sacrum has fallen, dragging with it the L4 and L5 vertebrae, causing a very clear rupture at the space between L3 and L4. When the ligaments of the sacro-iliac joint came apart, the ligaments of L4–L5 and L5–S1 still held, whereas those of L3–L4 had already decayed. Here we see how excavation data may give us important information on the chronology of joint breakdown.

A few cervical and upper thoracic vertebrae have moved away from the space originally occupied by the corpse. There must have been a void since a vertebra obviously cannot move in the earth by itself. Many animal holes have been observed in the sides of the pit and although none have been found by the neck, a burrowing animal might have caused a disturbance. However even if a hole constitutes a void, this is of no archaeological interest because it does not provide us with any relevant information about the original structure of the tomb.

The upper part of the right limb is still in connection, while on the left, of the hand only the thumb and little finger remain in place, partly covered by the face. The central part of the carpal and the second, third and fourth metacarpals are connected, but away from the space originally occupied by the body, near the elbow. Since these joints break down more rapidly, the displacement should have taken place soon after deposition. During the initial phase of decomposition, there would have been a void around the corpse.

In conclusion, the displacement of skeletal elements proves the existence of an original void. Since this void provides information on the structure of the tomb and on the environment within the grave, it is necessary to demonstrate its existence at the initial phase of decomposition. This excludes the possibility of later re-working not related to burial practices.

In this case the causes of displacement are quite simple to explain. The upper part of the body leans slightly upwards on the side of the pit and, during decay, the cranial skeleton has slipped downwards towards the rib cage. It seems that the skeleton 'has no neck' (it is clear that at the same time the cervical and thoracic vertebrae shifted backwards). Moreover part of the left hand has slipped along the forearm bones during decomposition. Putrefaction in fact produces a rather viscous mass that may slide under the force of gravity. I have observed this mechanism in several cases, for example when corpses are buried on their back with their knees raised. Usually the patella does not fall vertically but after the quadriceps muscle is destroyed remains connected to the tibial tuberosity, through the patellar tendon. Then it slips towards the lower third of the leg, pulled by the fluid produced by decomposition.

'Archaeothanatology' therefore allows clues to be identified related to the presence of a void at the moment of burial. Archaeological observations, for example of traces of wood, nails or differences in fill would probably clarify what type of structure might have caused this void, coffin, burial chamber, wooden framework *etc* . However, a void can also be detected in the absence of architectonic elements. There are cases of individuals buried under covers of leather, a thick and rigid material that creates a void around the corpse, seen in the displacement of bones away from the space originally occupied by the body, since the cover decayed long after the corpse did.

Another example is a Middle Neolithic burial found at Berriac, near Carcassonne, in the south of France. Here grain storage pits were sometimes later used as graves. In our example the body was found laid on its back, with knees folded under its femora and an ox rib laid on its thorax (Figure 14). The head, that originally rested on the side of the pit, had fallen dragging with it the mandible, atlas and axis (in this case, the break is between C2 and C3) still attached to the base of the cranium; the first two cervical vertebrae had later fallen to the bottom of the pit, beneath the *foramen magnum*. This means that decomposition took place within a void and that a wooden cover which had closed the pit subsequently disappeared.

Displacements are linked to the effects of the force of gravity and depend on the position of the corpse at burial. When the body is laid on its back (as usually happens in Christian cemeteries as well as among other human groups) in a fairly wide space, the disappearance of ligaments is followed by the collapse and disarticulation of the pelvic structure. After the displacement of the coxal bones, a lateral rotation of the femora occurs, with the heads still engaged in the hip joint, along with the falling of the patellae away from the knees (Figure 15). It is therefore very important to record the exact position of the patella during excavation.

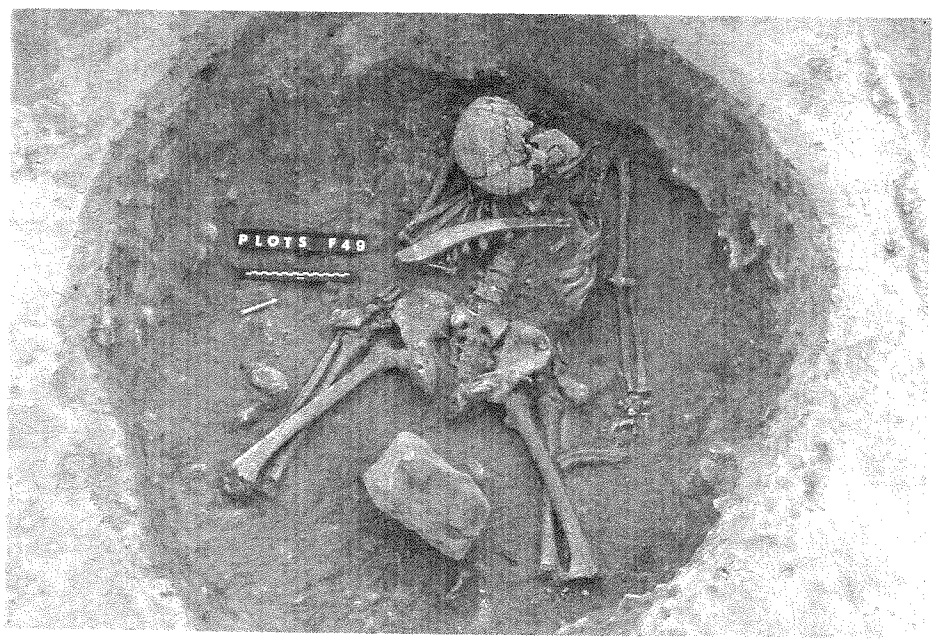

Figure 14. Les Plots at Berriac (Aude, France), middle Neolithic (early Chasséen phase). Excavation by J. Vaquer and H. Duday.

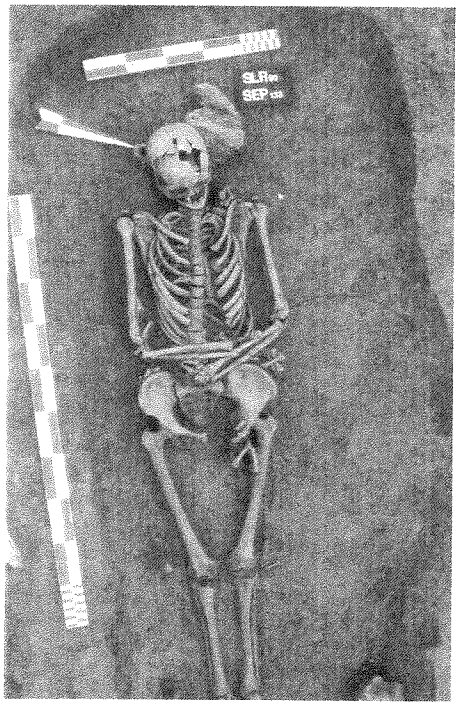

Figure 15. Serris, Les Ruelles (Seine-et-Marne, France), burial 133, early medieval. Excavation by B. Foucray, F. Blaizot, F. Gentili and H. Guy.

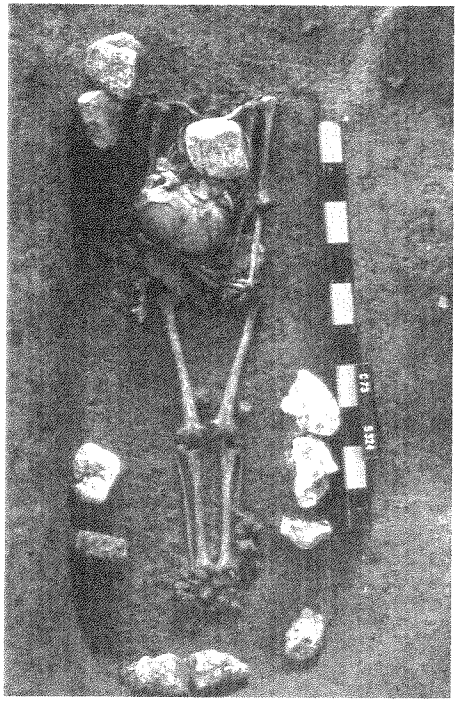

Figure 16. Cemetery of Saint Cheron at Chartres (Eure-et-Loir, France), burial 324, 4th–5th century AD. Excavation by D. Joly and P. Courtaud.

There are multiple potential causes of alteration to the original deposit. To the action of gravity we could add, for example, a partial collapse of the coffin, as in the case of a fifth century AD burial found at Chartres (Figure 16). The skeleton is in a wooden coffin (which is different to the bier: the latter transports the corpse from home to the place of burial). A displacement of the foot bones can be observed; the right patella has fallen outside the knee because of gravity, while the left has fallen inside because of the medial rotation of the femur. The cranio-facial region has been pushed forward onto the torso by the collapse of the wooden wall behind the head.

A medieval burial at Serris-les-Ruelles provides another example (Figure 17). There are important disassociations in the area of the head, with an upwards displacement of the cranio-facial region, mandible, upper and middle cervical vertebrae (the series has turned but remained connected), scapulae, clavicles, left humerus and some upper ribs. The upper part of the body has generally preserved its original position, but with some disjunctions in the vertebral column (there is a widening of the intervertebral space

between L2 and L3) and especially of the bones of the right forearm. The radius has rotated (with the distal end by the elbow and proximal end seemingly in articulation with bones of the right wrist). The leg bones (tibiae and fibulae) and those of the feet have kept their anatomical connections, but there is an important overlap at the knees: the patellae have retained their relationship with the tibiae but not the femora. The overall impression is that the skeleton has been divided into four separate blocks: (1) the head, the neck and the upper part of the thorax, (2), the remainder of the thorax and the first two lumbar vertebrae, the left forearm and the left hand (the latter situated a little above and within the right elbow), (3) the last three lumbar vertebrae, pelvis and thighs, with the right forearm and the right hand which lies on the left hip and (4) the legs and feet. These indications suggest that the base of the coffin split along three fracture lines that were more or less perpendicular to its longitudinal axis, perhaps because wooden beams had been positioned under the coffin. The other parts then slipped one over the other like tectonic plates (for a detailed analysis of the collapse of a wooden container, see Duday *et al.* 1990).

On the same site, another burial (Figure 18) shows a large zone of disconnection in

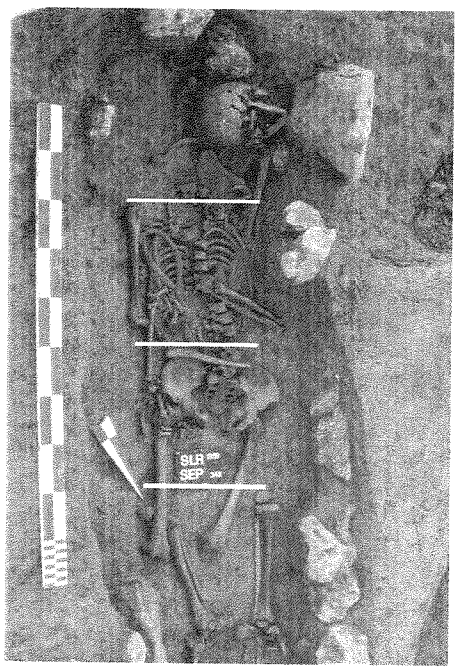

Figure 17. Serris, Les Ruelles (Seine-et-Marne, France), burial 342, early medieval. Excavation by B. Foucray, F. Blaizot, F. Gentili and H. Guy.

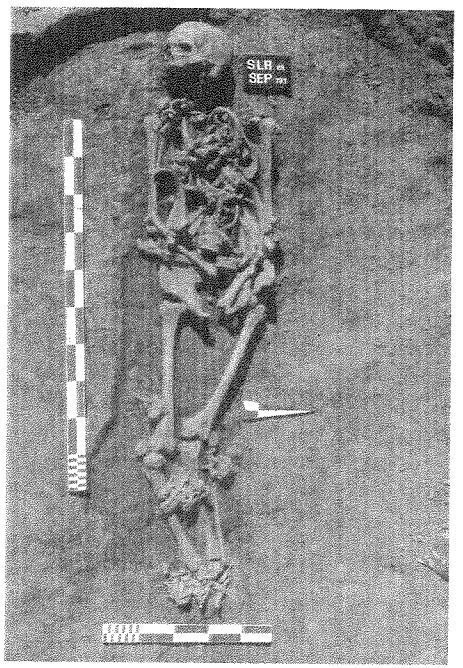

Figure 18. Serris, Les Ruelles (Seine-et-Marne, France), burial 783, early medieval. Excavation by B. Foucray, F. Blaizot, F. Gentili and H. Guy.

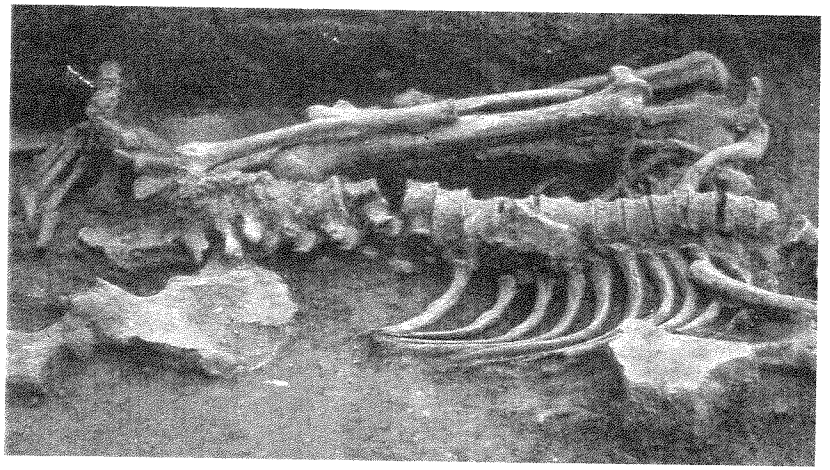

Figure 19. Cemetery of Saint-Cheron at Chartres (Eure-et-Loir, France), 4th–5th century AD. Excavation by D. Joly and P. Courtaud.

the area of the thorax; the last two lumbar vertebrae and the sacrum have moved about 50 cm. towards the knees. These anomalies are probably due to fluctuation of the water table and micro-currents within the burial which have floated and moved the smallest bones. Obviously this can only happen in a void.

Some displacements may be due to human intervention long after the inhumation. An example is given by a fifth century AD burial from Chartres in the cemetery of Saint Cheron (Figure 19). The bones of the upper part of the left limb had been moved towards those of the right one. They are certainly still within the volume originally occupied by the corpse, but the left humerus and the left ulna have rotated, making them pass temporarily into the space outside this original volume. This disturbance was caused by the excavation of a later pit which cut the side of the coffin. Rather than throwing them away the bones were replaced in the position described.

Whatever their cause, all these displacements suggest that a void existed at the moment of burial.

4.2. Decomposition in a filled space

This section discusses a middle Neolithic burial found at Berriac, near Carcassonne (Figure 20). It is a primary burial, with the individual laid prone, the head turned to the left and the right hand holding the right knee (Figure 21). The bones of the hand are connected and the distal phalanges of the fingers are pushed straight into the ground, against the upper part of the right tibia. Generally, if a bone is in potential disequilibrium in relation to the space occupied by the body, it will fall into this space when decay of the soft tissue frees it. If this does not happen, something has prevented its fall.

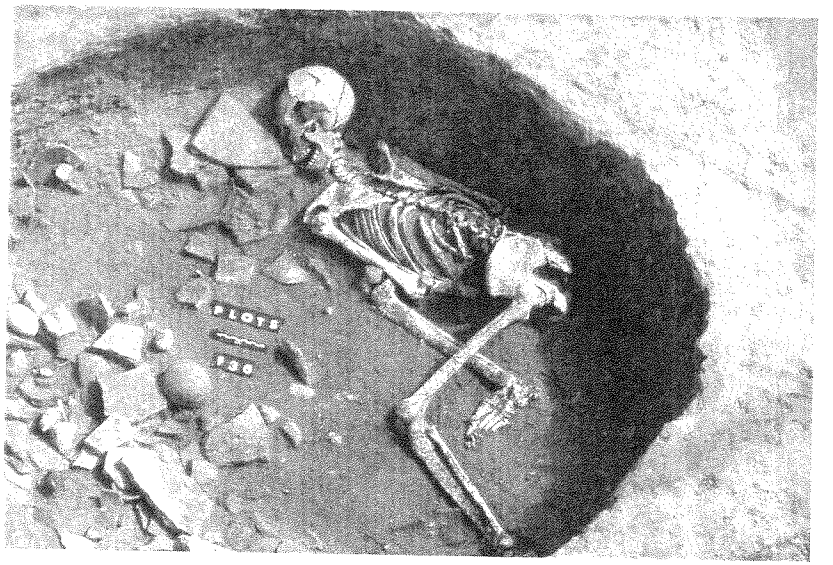

Figure 20. Les Plots at Berriac (Aude, France), burial F36, middle Neolithic (early Chasséen phase). Excavation by J. Vaquer and H. Duday.

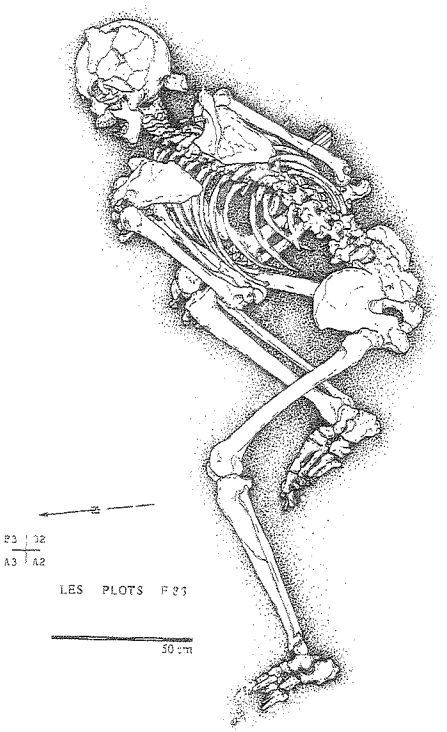

Figure 21. Les Plots at Berriac (Aude, France), burial F36, middle Neolithic (early Chasséen phase). Excavation by J. Vaquer and H. Duday, plan by H. Duday.

This would demonstrate the existence of an obstacle that provides some support. The archaeological observations may allow us to identify that element, which could be:

- the edge of the pit (not the case here);
- a border in perishable material in contact with the corpse at some distance from the edge of the pit (but in this burial the effect caused by the obstacle can be observed at a distance from the line that joins the outermost points of the skeleton, the face, the left shoulder and the left foot);
- the pit fill (the bones are prevented from falling beyond the space occupied by the corpse because this space is already filled).

In this case, it is likely that the earth was in contact with the corpse and served as an obstacle to prevent the bones from falling. This would then be a burial in a filled space.

These obstacles have effects of two different sorts:

- a 'supporting' effect, which we have just described (a burial is defined as in a 'filled space when the grave fill provides the obstacle, supporting the bone),
- a 'linear delimitation' effect, seen when all the bones on one side of the corpse are aligned against a physical limit, for example the side panel of a coffin, the edge of a pit, the base of a wall *etc.*

The demonstration of the existence of an obstacle is not therefore sufficient in itself to prove that a burial is in a filled space. An early medieval burial at Serris-les-Ruelles gives an example (Figure 22). The corpse is supine and the pubic symphysis has not separated, the femora are in an anterior position and the patellae are at the distal extremities of the two femora. The body has been buried in a particularly narrow pit. The characteristics of the grave cut here prevent the displacement of the bones. A narrow container may both delimit and hold the burial, so that the bones line up against the side and remain in equilibrium.

A 'supporting' effect can be observed even when decomposition has undoubtedly taken place in a void. In a 17th century AD samurai cemetery in Japan, some tombs have the shape of small circular chests (Figure 23), buried with a void within and a wooden cover above. The wood is very well preserved due to the permanent humidity. The corpse was buried in a sitting position inside the container: at the bottom were the pelvis, which has opened, and the lumbar vertebrae, as well as the head, which has fallen, and the scapula showing its posterior aspect. The lower limb bones however have remained in their vertical position, leaning against the wall.

4.3. The Grotte de Foissac: some observations on taphonomy in an underground environment

In 1965 cavers exploring a network of unknown galleries in the Grotte de Foissac in the south of France came across the bed of a subterranean stream which they decided to follow. They reached the original entrance of the cave, the surface of which was covered with intact Neolithic vessels, arrow heads, foot and hand prints *etc.* In order to reach the site, now visited by many tourists, a shaft had to be dug.

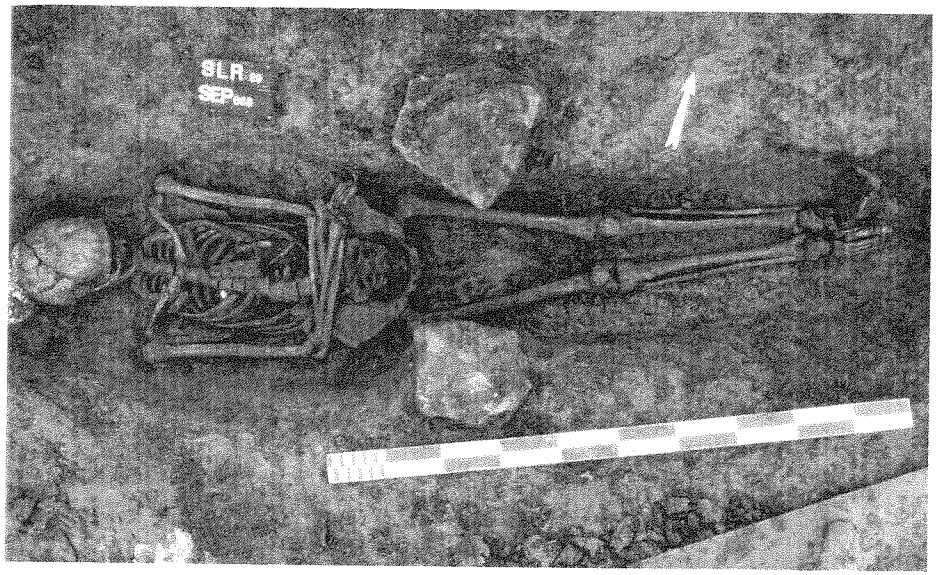

Figure 22. Serris, Les Ruelles (Seine-et-Marne, France), burial 688, early medieval. Excavation by B. Foucray, F. Blaizot, F. Gentili and H. Guy.

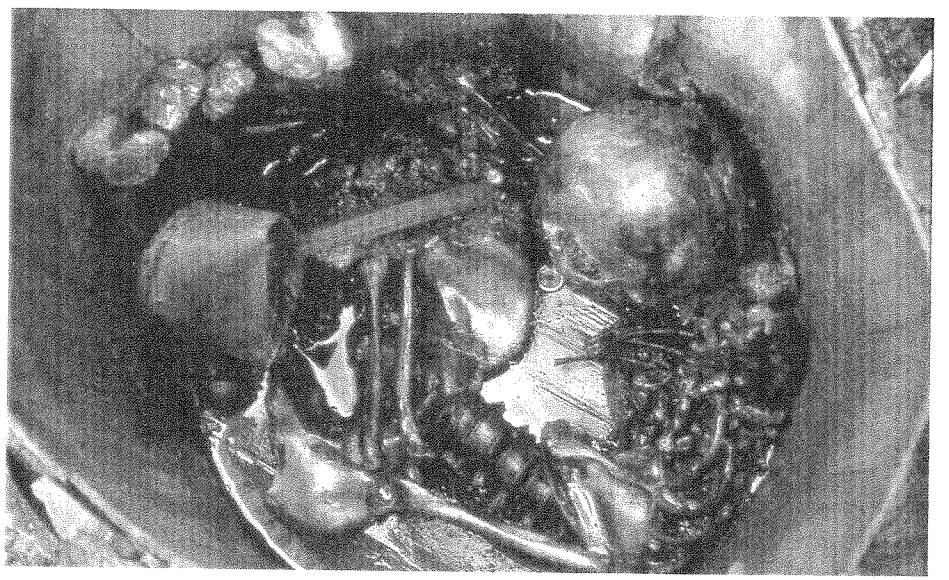

Figure 23. Sendaï (Japan), Samurai cemetery, 17th century. Photograph by T. Nara.

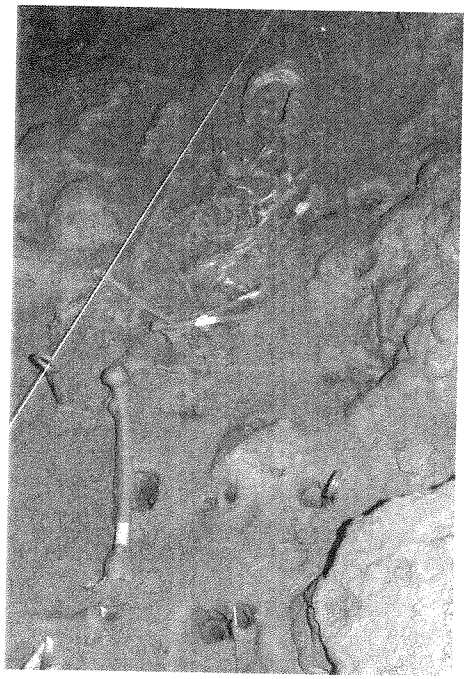

Figure 24. Grotte de Foissac (Aveyron, France), burial 1, Eneolithic. Excavation by H. Duday, photograph by F. Rouzard.

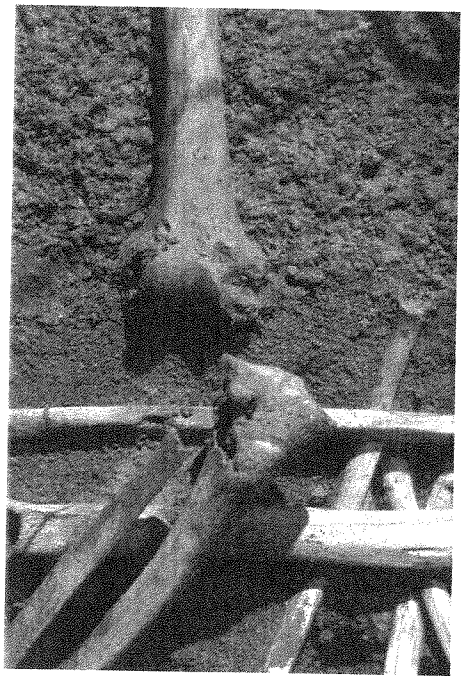

Figure 25. Grotte de Foissac (Aveyron, France), burial 1, Eneolithic. Excavation by H. Duday, photograph by F. Rouzard.

About 4500 years ago, the cave was a clay pit, with platforms to facilitate extraction of the clay. On these platforms skeletons have also been found. The clay has preserved everything, impressions of basketry, of a stick with a rope knotted around it, tool marks and, against the wall, a child's footprint. The burials were found on the platforms cut into the clay along the shore of the stream, placed on the surface and not in pits. During floods, water mixed with soil covered the bones. Drops of water, falling from stalactites, then washed the bones of the clay which had encased them.

In one sector of this site, the skeleton of an old woman was found (Figure 24), mostly with anatomical connections preserved but with some disturbance. Animal bones present included a pig's rib cage placed under the left leg of the skeleton which was laid on its back. During decomposition the head moved upwards and backwards, the upper limbs were partially dissociated and the foot bones disappeared.

At the proximal extremity of the right tibia and fibula, an osteolytic lesion, whose surface is slightly porous, could be an osteitis. The other fibula shows an eroded zone, black in colour, in a position corresponding to the zone of erosion on the woman's right leg (Figure 25). This spatial indication shows that the alteration of the bones depends on

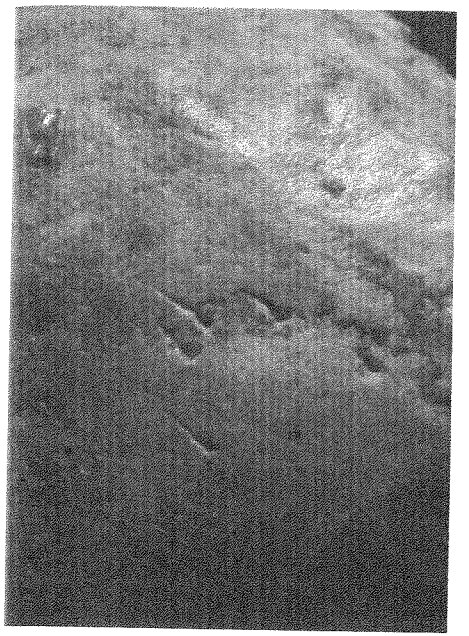

Figure 26a. Grotte de Foissac (Aveyron, France), burial 1, Eneolithic. Claw marks on the parietal-temporal region. Excavation and study by H. Duday, photograph by F. Rouzard.

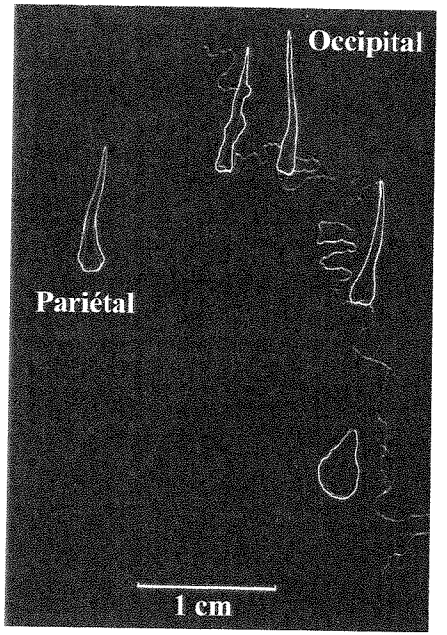

Figure 26b. Grotte de Foissac (Aveyron, France), burial 1, Eneolithic. Drawing of claw marks by H. Duday.

the position in which the corpse was laid and is not a pathological lesion. This alteration has been caused by the water falling from the stalactites above and the black colour is due to deposition of manganese.

There are also disturbances to the torso and the head. Some vertebrae have shifted, paradoxically moving in a direction opposite to that of gravity. On the cranium there are five deep comma-shaped marks, corresponding to the left front paw of a small animal, a mustelid, perhaps a skunk (Figure 26). The displacements are therefore taphonomic and due to the passage of the skunk. The cranio-mandibular dissociation is not to be interpreted here as evidence for a headrest.

In another, higher area, above the flood level, was the burial of a seven-eight year old child. The head was detached from the bones and fresh fractures were visible on the skeleton. Beside the skeleton were some small clay blocks and many bones were displaced. The child was crouched on its back, with the knees folded up to the thorax, so that the tarsal bones were found by the pelvis (Figure 27). The mandible is complete, but the left mandibular condyle has broken and is by the right shoulder. The right ribs are in position, while three left ribs, apparently in relation with each other, have

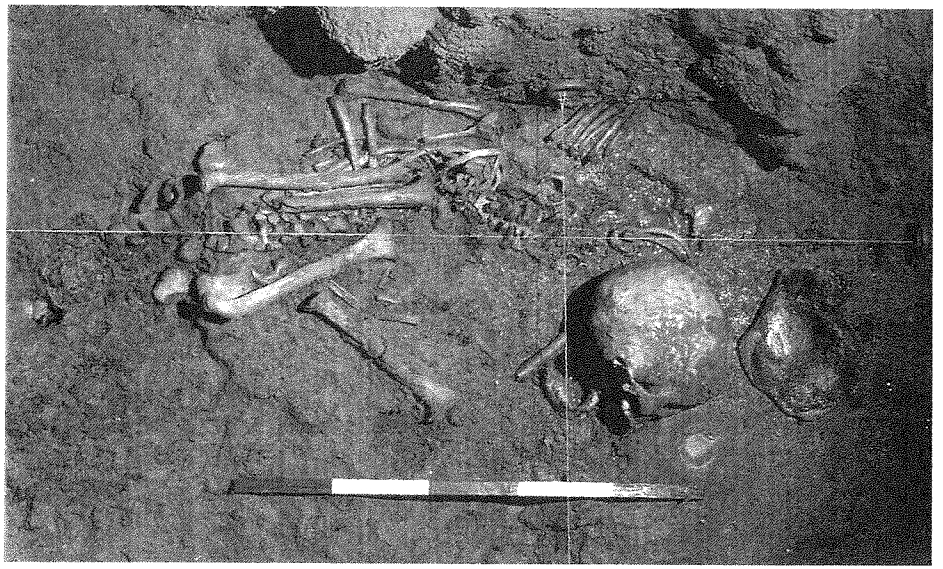

Figure 27. Grotte de Foissac (Aveyron, France), burial 1, Eneolithic. General view after excavation.

shifted towards the side of the platform, but not down the slope, as might be expected. A metatarsal was found behind the lumbar vertebrae and as excavation continued, four foot phalanges were found. The child was probably deposited in a sitting position, with his back resting against the wall. After an early stage of decomposition, some bones, including those of the distal area, became detached from the skeleton.

Lecture 5

Relationships between the internal and external environments of the corpse (II)

5.1. 'Verticalization' of the clavicles

This topic can be introduced with the example of another medieval burial found at Serris-les-Ruelles (Figure 28). It is a primary deposit in a void of a body with its connections that break down more rapidly still preserved. The left patella has fallen outside the knee, and the foot bones and some cervical vertebrae have been displaced. The 'verticalization' of the clavicles can be observed, with their lateral extremity pushed upwards and the medial downwards. This position is a consequence of transversal compression at the shoulders and can only occur when the body has been placed in a very narrow coffin or has been wrapped in a shroud (a double effect of 'linear delimitation' can be seen at a certain distance from the edges of the pit, on the right side of the skeleton).

The clavicles also become vertical or shift to a very oblique position in 'anthropomorphic' tombs dug into rock or clay. The corpse lies in a pit cut to its shape and the grave narrows

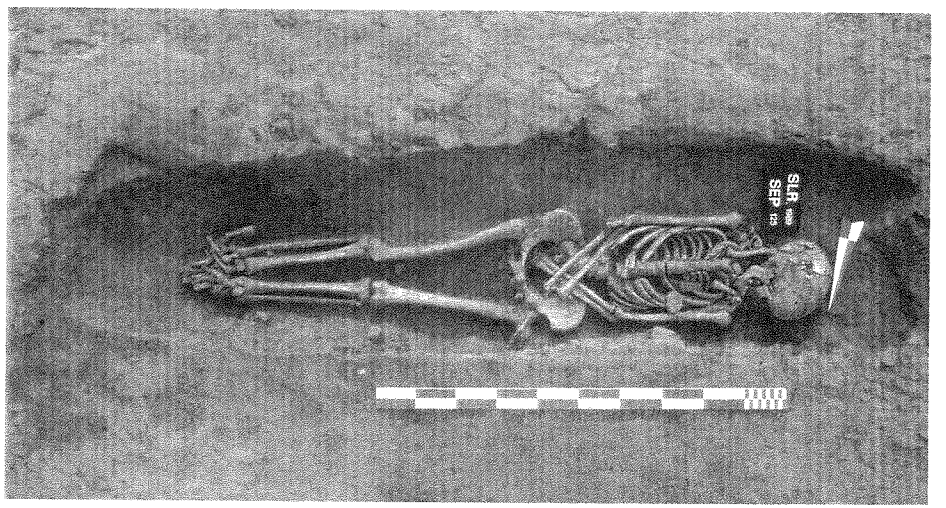

Figure 28. Serris, Les Ruelles (Seine-et-Marne, France), burial 125, early medieval. Excavation by B. Foucray, F. Blaizot, F. Gentili and H. Guy.

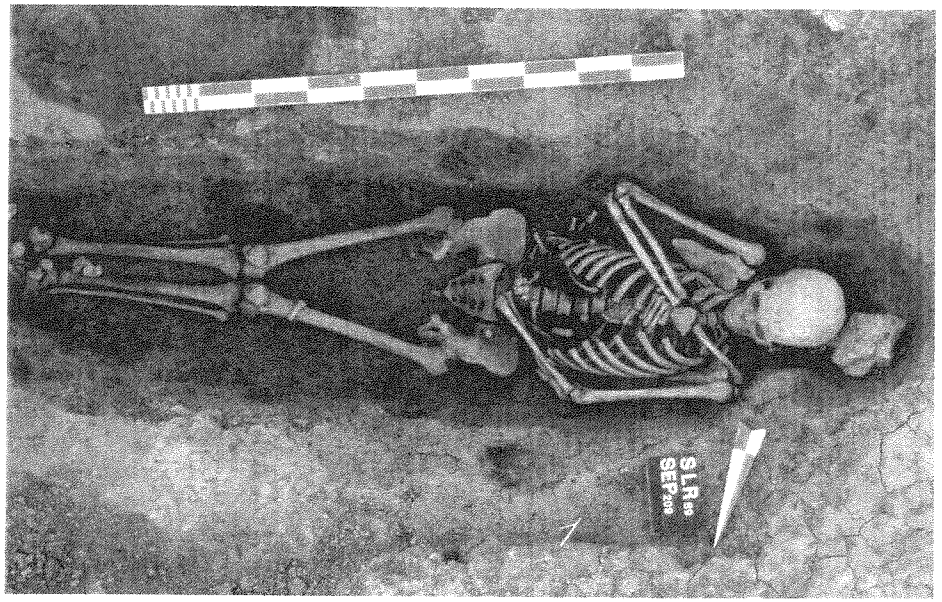

Figure 29. Serris, Les Ruelles (Seine-et-Marne, France), burial 209, early medieval. Excavation by B. Foucray, F. Blaizot, F. Gentili and H. Guy.

at the neck to a niche for the head. The shoulders are pushed forward since they lie where the pit narrows for cutting the niche for the head, which is often slightly higher than the bottom of the pit (Figure 29).

The 'verticalization' of the clavicles simply indicates that the shoulders were pushed upward, forward, and towards the interior of the space occupied by the body. The observations made during excavation give information on the mechanism for this and on the taphonomic dynamics. To interpret them correctly, the archaeological information concerning the characteristics of the pit should be carefully considered.

5.2. Voids that form around the corpse

Let us now examine burial 175 of the fourth century BC necropolis at Aleria in Corsica, a site already discussed in relation to the arrangement of grave goods. This tomb does not seem to have been robbed in antiquity; the door of unfired brick was still closed when the tomb was found. This closed off access to the burial chamber, which was formed by a ledge on each side where the corpses were placed and a central pit where grave goods were laid (Figure 30). Sand has infiltrated to cover the skeletons and protect them when the tomb ceiling collapsed. One individual has a bronze brooch on its chest, beads, a scarab made of glass paste near the right elbow and a bronze ring on a phalanx

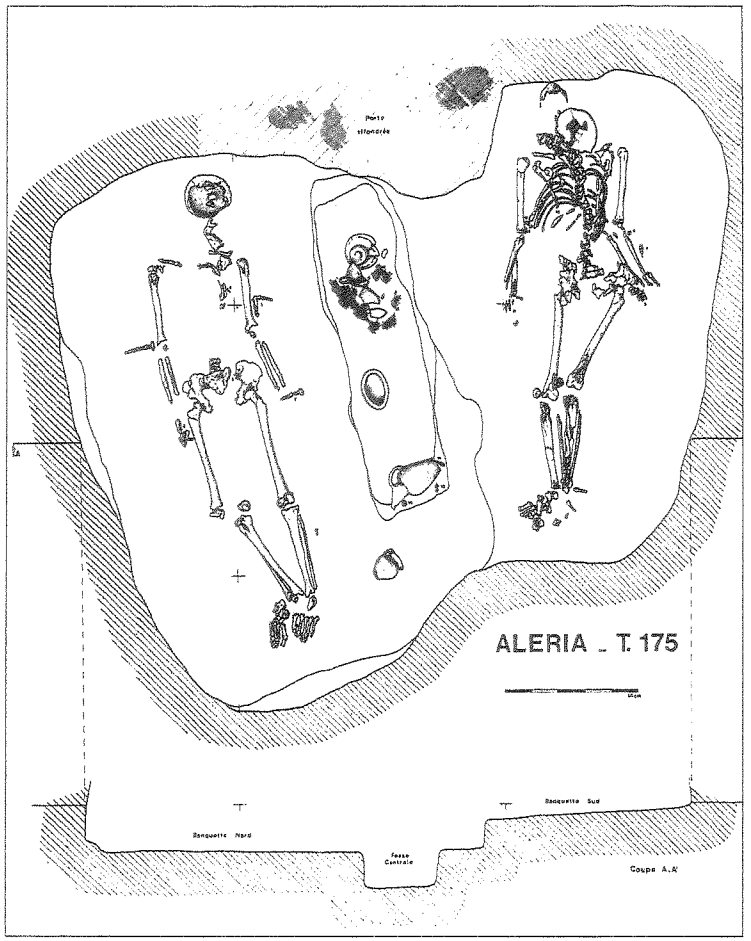

Figure 30. The pre-Roman necropolis of Aleria (Corsica), burial 175, 4th century BC. Excavation by J. Jehasse and H. Duday, plan by H. Duday.

on the left hand. This burial is of interest not only for its rich grave goods, but also for what has happened to the head. The mandible is in a vertical position against the side of the chamber. The cranio-facial region with the atlas connected to the occipital has fallen to the left of the neck, while the vertebral column, still in connection up to the axis, has leaned towards the right (Figure 31). This is the typical position taken up by the bones when a perishable element that supports the head decomposes (for example a cushion or small wooden structure, like a headrest). A supporting element can leave traces among the bones only if made of material that decays after the ligaments of

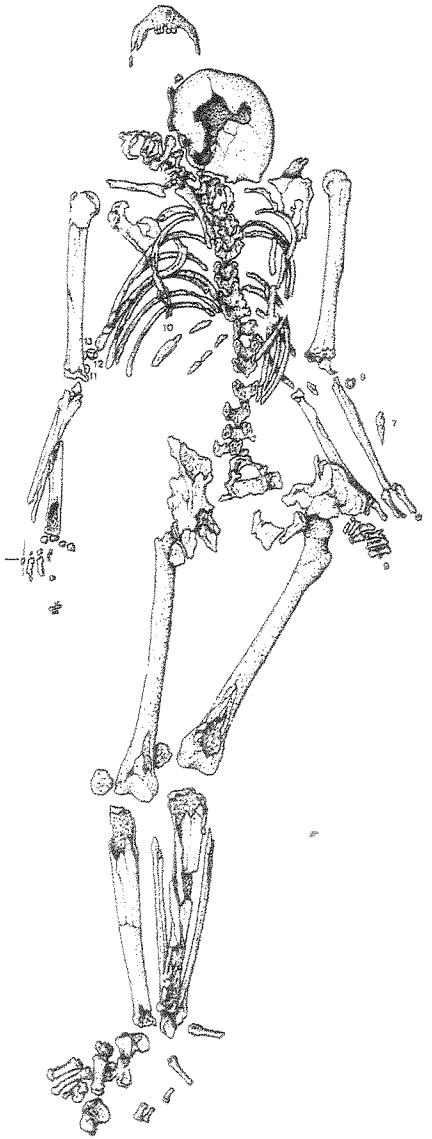

Figure 31. The pre-Roman necropolis of Aleria (Corsica), burial 175, 4th century BC detail. Excavation by J. Jehasse and H. Duday, plan by H. Duday.

the temporo-mandibular and cranio-vertebral joints have decomposed.

A similar situation can be seen in a fifth century AD burial in the St Cheron cemetery at Chartres (Figures 32 and 33). The corpse was put in a coffin (whose nails have been found *in situ*) inside a very narrow pit. The corpse was laid on its back with limestone blocks placed beneath, one below the upper part of the thorax and head and the other beneath the feet. The head has rolled against the side of the pit, detaching itself from the vertebral column, and the cervical vertebrae have been scattered, while the mandible is on the same side as the cranio-facial region, from which it is nevertheless separated. The organic matter produced by the decomposition of the corpse soaked the wooden coffin and caused its destruction. The collapse of the base of the coffin, held up by the limestone blocks, has caused the displacement of the bones. The elements from the central part of the body have fallen to the bottom of the pit, while the extremities have remained in an elevated position where they came to rest on the blocks. From above the tomb looks the same as in the previous case, even if the changes undergone by the skeleton are different, as shown by the different levels of the individual bones. In the tomb at Aleria, all the bones are on the same level (the ledge), while here the bones of the head, neck and feet are elevated in relation to the rest of the skeleton.

In a medieval burial in the cemetery of Saints-Côme-et-Damien at Montpellier, in the south of France, a hyperextension of the head can be seen with an exaggerated opening between the occipital and the atlas and between the atlas and axis (Figure 34). The cause is a hole made by an animal that passes just behind

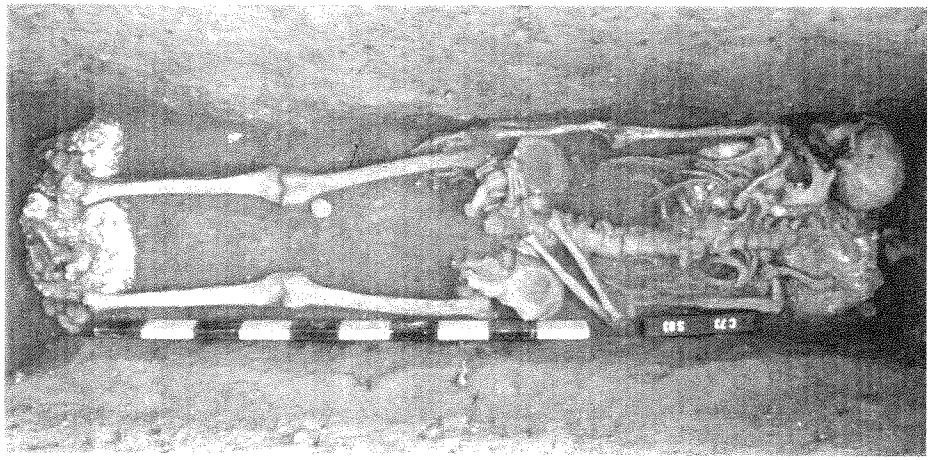

Figure 32. Cemetery of Saint-Cheron at Chartres (Eure-et-Loir, France), burial C73, 4th–5th century AD, general view. Excavation by D. Joly and P. Courtaud.

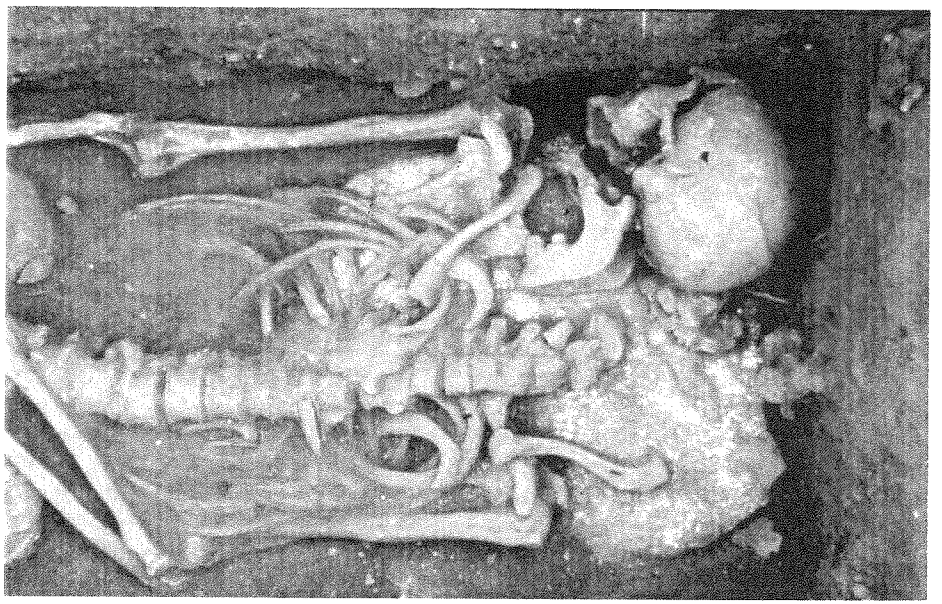

Figure 33. Cemetery of Saint-Cheron at Chartres (Eure-et-Loir, France), burial C73, 4th–5th century AD, details of thoracic region and upper limbs. Excavation by D. Joly and P. Courtaud.

Figure 34. Cemetery of Saints-Côme-et-Damien at Montpellier (Hérault, France), Middle Ages. Detail before the removal of the cranio-facial region. Photograph by E. Crubézy.

Figure 35. Cemetery of Saints-Côme-et-Damien at Montpellier (Hérault, France), Middle Ages. Detail after the removal of the cranio-facial region. Photograph by E. Crubézy.

the head (Figure 35). The hole has collapsed and pulled the head into it. Even if the disassociation between vertebrae and cranium can be seen from above, measurement of their relative depth reveals that the occipital is lower than the rest of the skeleton.

These considerations concern the displacement of the bones towards voids which are created during the 'history' of the burial. The discussion may sometimes be more complex but also richer in information in those cases that imply later human interference. In a burial in the cemetery of Saint Cheron, Chartres, the individual is supine and while the original anatomical logic is preserved, the skeleton is extremely compressed transversally on the median line through the burial (Figure 36). The femora are behind the coxal bones on the median line; the right femur appears in anterior view, while the left is in posterior view and their heads touch. The vertebrae are in front of the ribs which are oriented downwards and towards the interior of the burial and converge on the median line. The upper limbs can be found under the skeletal elements of the torso, at a greater depth (Figure 37).

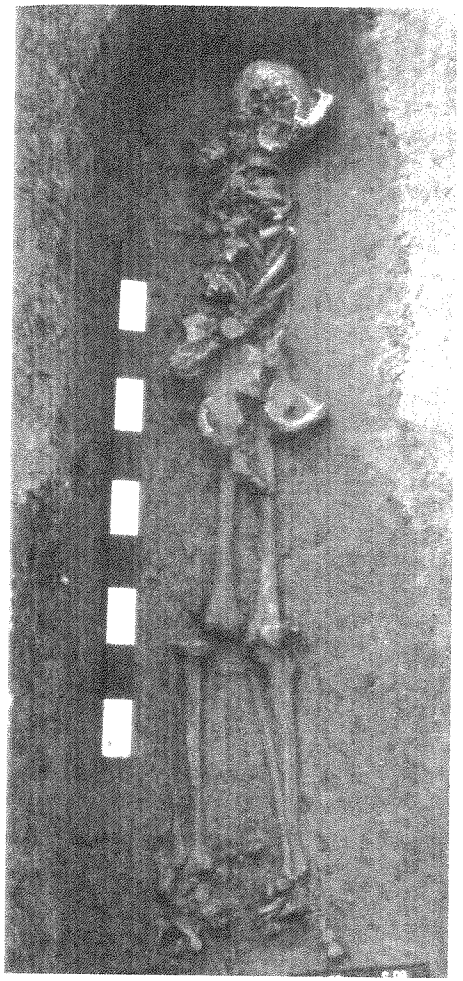

Figure 36. Cemetery of Saint-Cheron at Chartres (Eure-et-Loir, France), burial 98, 4th–5th century AD, first excavation layer. Excavation by D. Joly and P. Courtaud.

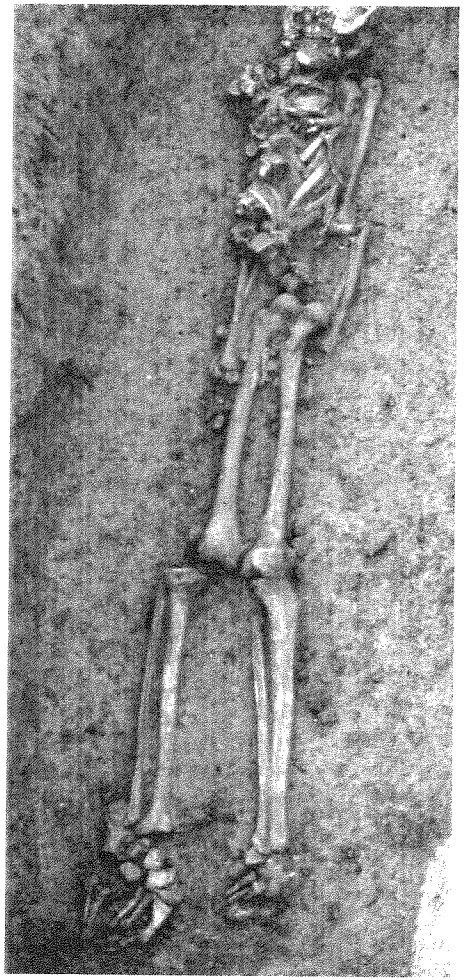

Figure 37. Cemetery of Saint-Cheron at Chartres (Eure-et-Loir, France), burial 98, 4th–5th century AD, second excavation layer. Excavation by D. Joly and P. Courtaud.

This would seem to be a case of an anomalous disturbance but is actually the natural evolution of a primary burial of a body laid on its back in a V-section coffin. As decomposition frees the bones, they move toward the median line of the burial, moving down the slope. The scapulae are freed faster than the ribs, so that the upper

limbs slip behind the thorax. The heads of the femora, having joints that break down more rapidly, move out of the hip joints and pass below the coxal bones toward the median line; during this movement the left femur has rotated. We know that rib joints disassociate quite fast because of the decomposition of the rib cartilage. They are followed by the destruction of the joint between the rib head and the vertebral bodies, so that only the joint between the costal tubercle and the transverse processes of the vertebra remains connected. At this point the rib cage flattens, a phenomenon we have already discussed. Usually, when a corpse lies on a flat surface, the ribs rest on it and spread symmetrically in relation to the vertebral axis, while the sternal extremities are displaced. When the container has a V-section, the sloping support causes the anterior part of the rib to be pulled backwards and to the middle and finish behind the vertebral column (an inversion of the normal relationship between ribs and vertebrae).

These mechanisms are known thanks to the observations made by François Lambach in his study of protohistoric burials at Nordhouse (Alsace), where many individuals were buried in tree trunks dug out in U- or, rarely, V- shaped sections. Since the wooden containers were well preserved, in the second case he could observe the pulling backwards and towards the median axis of the coffin of the bones freed by decomposition of the ligaments. In a V-section coffin, a particular space develops during the decomposition of the corpse. This space becomes accessible only when the bones are freed from the ligaments.

Lambach's observations have made it possible to understand this type of burial and interpret others. The observations made during excavation provide substitutes for experiments and help us to understand corpse taphonomy. The displacements reveal an interaction between the corpse during its decomposition and the structure that contains it. This might initially be a V-shape, but sometimes it could be a flat support which has later split in two parts along its longitudinal axis. These two sections then slope towards the median line. If this break occurs quite early, then the bones freed by putrefaction are under the same mechanical conditions as those observed when the container was originally V-shaped in section.

5.3. The filling of the internal volume of the corpse

A corpse ready to be buried still has internal organs and muscles. The 'soft parts' which characterize the primary deposit disappear and are replaced by the fill which is found when the burial is excavated. It is important to examine this 'transubstantiation', the apparent transformation of flesh into fill, which clearly constitutes the main difference between the time of burial and of excavation. Paradoxically the archaeological literature seems to overlook this process completely. When does the filling of the internal volume of the corpse occur and what are its causes?

5.3.1. The chronology of filling the volume freed by the decay of soft tissue

5.3.1.1. Delayed filling

Generally the filling is staggered over time, as the various examples discussed earlier testify, in particular the flattening of the rib cage or the separation at the inter-vertebral

spaces (see for example Figure 13). The decay of the thoracic (lungs, heart) and abdominal organs (liver, spleen, stomach, and bowels) frees a space which lasts for a certain time. The bones are subject to various forces (for example gravity, torsion of the vertebral column *etc*) and when freed by the breakdown of ligaments, move under the action of these forces. The sediments later invade the interstitial spaces and block the bones in their new position. They will only be freed by further disturbance, for example excavation.

A little known consequence of the delayed filling of the volume freed by the decay of soft tissue is the closing of the intersegmental angles of the body, *i.e.* the angles which are created by the different segments of the limbs, like the arm and forearm (elbow) or thigh and leg (knee). For example, in the Chalcolithic burial chamber of Devois de l'Etang in the lower valley of the Rhône, a corpse was found crouched in a particularly contracted position (Figure 38). Many archaeologists interpret skeletons in this position

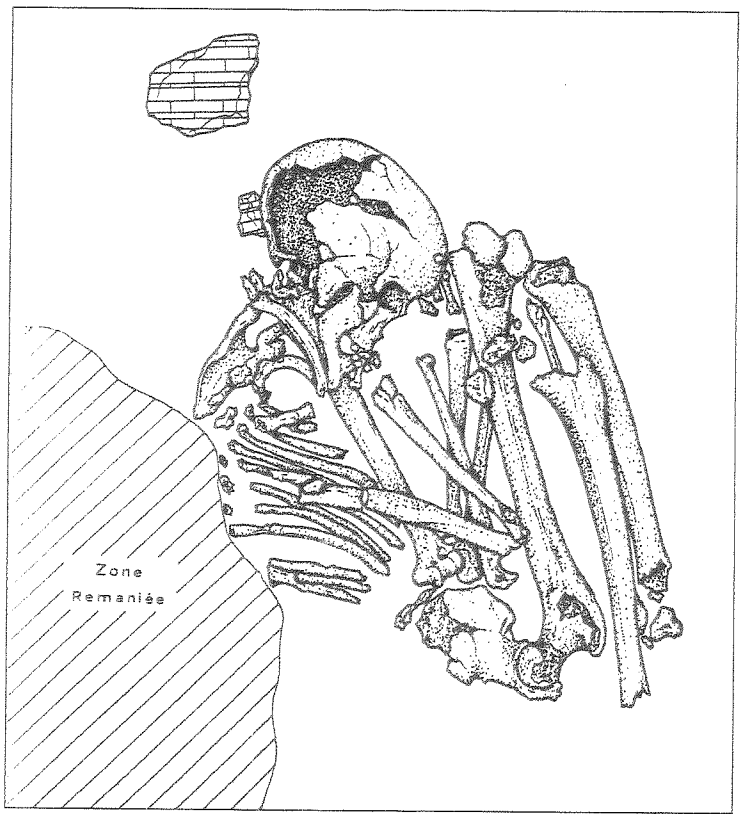

Figure 38. Burial chamber at Devois de l'Etang at Laudun (Gard, France), Chalcolithic. Excavation by A. Colomber, J. Coularou, X. Gutherz, A. Raux and H. Duday, plan by H. Duday.

as evidence for corpses having been buried in bags or tightly bound. This is possible but difficult to prove. When a corpse is buried in the earth, the sediment around it exerts pressure and gradually, as muscles and ligaments progressively decay, closes the intersegmental angles between the bones. Obviously this phenomenon does not occur when the joints are extended or lightly flexed.

5.3.1.2. Progressive filling

Let us take the example of a fifth century BC skeleton of an eight to ten year old boy, a primary burial found at Coteau de Montigné, in the west of France (Figure 39). Two small fragments of the base of the cranium have been displaced from the space originally occupied by the corpse, but they cannot be considered proof that decomposition has taken place in a void, since a burrowing animal has made a hole beneath the head. The rib cage has partly retained its original volume. A difference of four to seven cm. in depth was measured between the anterior-lateral and posterior extremity of the ribs. Flattening of the pelvis was also not noted. At this age, the coxal bone comprises three independent bones, ilium, ischium and pubis, linked by cartilage that naturally decays during decomposition of the corpse, when each of these bones would go its own way. In child burials these bones usually fall within the pelvic basin, but in our example they have been found in their original position (the pubic symphysis is still tightly connected). The hands, too, are in their original position. The right hand lies at a level which corresponds to the forward part of the abdomen, where it had been laid when the body was buried. The left hand lies in a place corresponding to the super-lateral part of the left hip, with the first two fingers passing forward and inside the anterior-super iliac crest. Although these bones were potentially in disequilibrium with respect to the internal space of the corpse, they maintained their original position exactly. This occurred because the volume left by decay of the soft tissue had been progressively filled with sediment.

The filling of spaces with sediment can therefore be either deferred, *i.e.* staggered, or progressive, *i.e.* when it replaces the organic elements little by little as these decompose. The former case is more common.

5.3.2. The mechanisms of filling the volume freed by the decay of soft tissue

Three mechanisms have been identified in the process of filling. The first is the force of gravity: the sediment that has built up above the corpse falls into the spaces left empty by the disappearance of the soft tissue. The second is the increase in volume of clay sediment when wet, as Michel Pichon, engineer at the Institut National de Recherche en Archéologie Préventive, suggested to me: decomposition fluids from the corpse soak the sediment and, if clay, this expands to fill the empty spaces. The third is disturbance caused by the actions of small animals, particularly earthworms. While digging tunnels they swallow the soil and later expel it. Such animals particularly seek out humid areas where the sediment is rich in organic matter, like those near burials.

Worm action may radically change the sediment near the tomb. When excavating a burial, one of the first tasks is the identification of the edges of the burial pit. If the tomb has been excavated in rock and filled with earth then this is easy, but if the burial

has been made in an alluvial deposit and has been filled with the soil excavated when it was dug then it is more problematic. Often archaeologists interpret as pit fill a zone where the sediment is darker, softer, and lumpier than usual (they sometimes call this 'organic' sediment). In such cases I have often noticed that the pits seem very large compared to the skeletons. Archaeologists often think they have completed excavation when they have recovered the skeleton and the grave goods. However if they continue to excavate they may notice the presence of this sediment for some centimetres beneath the level of the skeleton. This is because the sediment interpreted as pit fill is soaked with decomposition fluids which worms have then worked in all directions. As a result the size of the pit and in particular its depth may be overestimated. This may be misleading for the identification of intersections between tombs or circulation spaces around them.

We turn now to cases where it has been possible to identify a progressive filling of the volume left by the decomposition of soft tissue. The first example is a Neolithic burial from Djibouti in eastern Africa (Figure 40). Since the sediments of this area comprise very fine powdery sands, tiny vacuum pumps were used in excavation. This was the burial of a young woman, laid on her left side in a contracted position. With the head turned towards the left, her face rested on the bottom of the pit. Inside the mandible is the hyoid bone. This is a U-shaped bone, lacking in real joints and suspended among the muscles, attached to the body through the greater horns. In adults of advanced age it is a single bone, whereas in children and in young adults it is formed of three portions linked by cartilage. After the disappearance

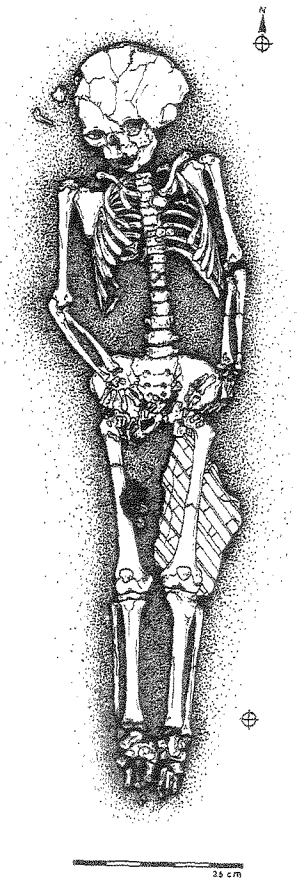

Figure 39a. Funerary circle at Coteau de Montigné, Coulon (Deux-Sèvres, France), burial P9, 5th century BC. Excavation by J-P. Pautreau and H. Duday, plan by H. Duday.

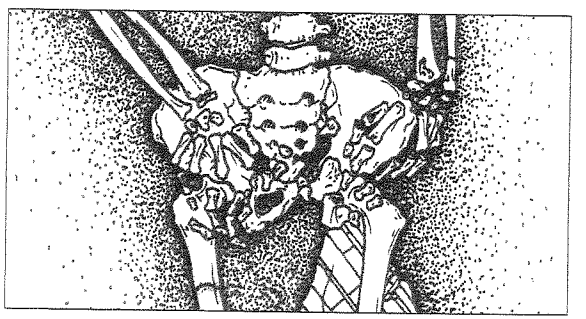

Figure 39b. Details of abdominal region and hands.

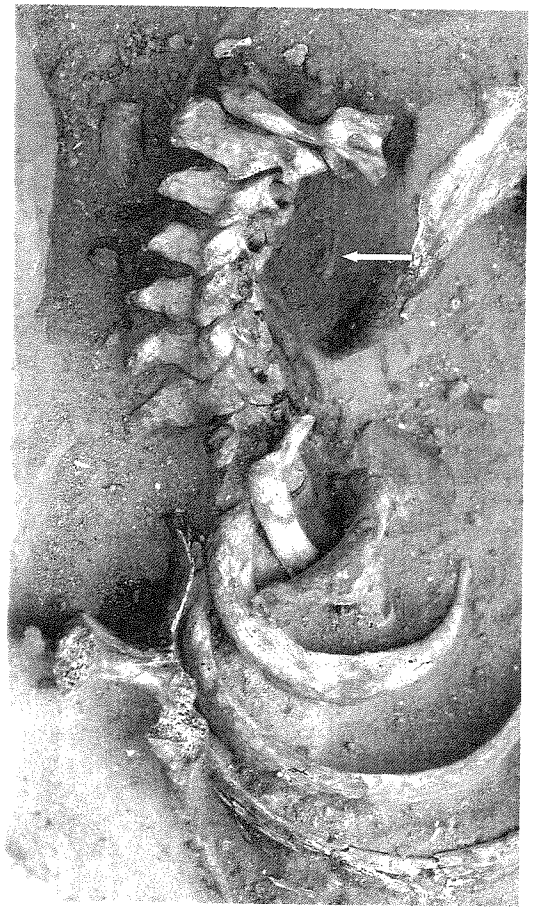

Figure 40. Asa Koma (Republic of Djibouti, eastern Africa), early Neolithic. Excavation by X. Gutherz, R. Joussaume, J.-P. Cros and H. Duday.

during decomposition of the muscles that surround it, the hyoid bone generally falls and separates. However, in this case it has been found in its original position: the white arrow shows the large right horn of the hyoid bone. This proves that this very fine sediment has progressively filled the empty space left by the muscles' decay. This has been called the 'hour-glass' effect (Duday 2005).

In the Neanderthal burial at Kebara in Israel the hyoid bone was also found in its original position in a primary deposit (Figure 41). The body of the hyoid bone and the large horns are linked and were found *in situ*. Since the sediment is also fine and powdery, we again conclude that the filling of the space was progressive.

An early Neolithic burial (of 'Cardial' type and with impressed Ligurian pottery) found in Abri Pendimoun at Castellar, near Nice provides another example (Binder *et al.* 1993). The corpse was buried in a pit on its left side and in a contracted position, with one hand under the mandible (Figure 42). Again the sediment here is very fine. Some traces of later disturbances caused by a burrowing animal have been found, including the displacement of the fifth lumbar vertebra. The left hand is still in anatomical connection and is in potential disequilibrium, because of which it should have fallen under the action of gravity. This has not happened because the sediment has filled the volume left with the disappearance of the soft tissue. The hyoid bone appears transversally inside the mandible. The left foot seems smaller than the right, but this is only an optical effect, since it was in a vertical position against the side of the pit. A distance of 15.5 cm. can be found between the distal extremity of the hallux and the posterior aspect of the calcaneus. Under the head of the first metatarsal the sesamoid bones were found (their name derives from their sesame seed-like shape). The sesamoid bones of the first

metatarsal are about 6.5 mm. long and have remained in their original position. Usually during decomposition the feet fall into the space left by the decay of the muscles under the plantar surface. This is evidence that decomposition occurred in a filled space in which the volume occupied by the corpse was progressively filled with sediment after the decay of soft tissue.

In all burials of this type, the sediment turns out to be extremely fluid (sandy, ashy or very fine). This phenomenon is only possible when burials are in a filled space and cannot be true if there is originally a void around the corpse.

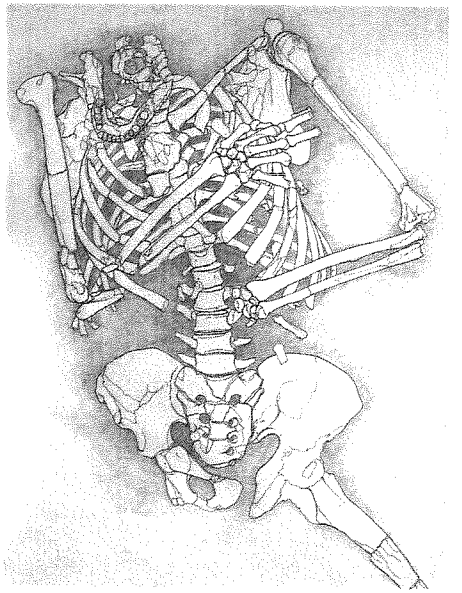

Figure 41. Cave at Kebara (Israel), middle Palaeolithic, plan by D. Ladiray.

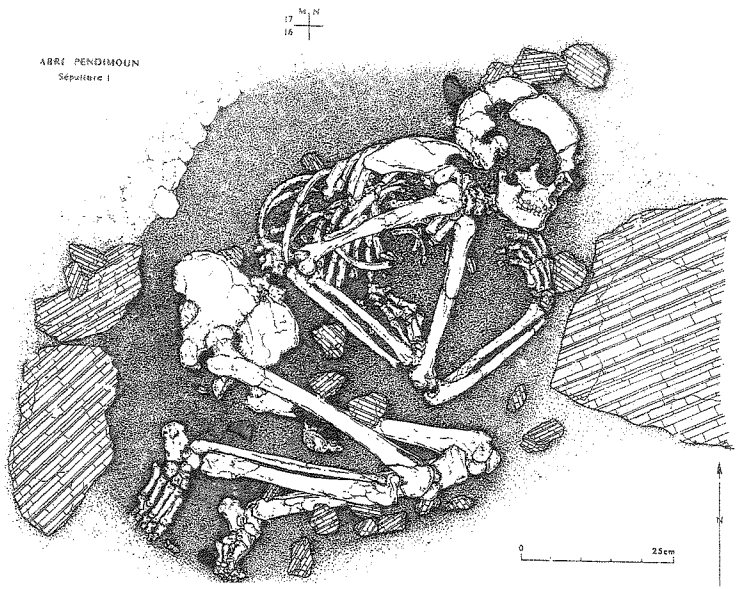

Figure 42. Abri Pendimoun at Le Castellar (Alpes Maritimes, France), early Neolithic. Excavation by D. Binder and H. Duday, plan by H. Duday.