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SCHIPLUIDEN

A NEOLITHIC SETTLEMENT ON THE DUTCH NORTH SEA COAST *c*. 3500 CAL BC

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Contents

20 Roots, tubers and processed plant food in the local diet

Lucy Kubiak-Martens

The remains of roots and tubers are a special aspect of the Schipluiden subsistence system: the gathering of starch-rich underground plant organs. Such remains are fairly frequently found in archaeological contexts but are often dismissed as unidentifiable plant material, and consequently underestimated, especially in relation to cereal remains. Recently developed methods for the identification of charred remains of vegetative tissues have changed this situation, and also our understanding of local subsistence at the Schipluiden settlement.

The remains of processed plant food found at Schipluiden are likewise unique. They allow significant advances in our understanding of the local diet, but they also provide detailed insight into European Neolithic subsistence in general.

20.1 Introduction

The role of root foods in past human diet has long been the subject of scholarly interest. For example, David Clarke (1976), who drew attention to the potential of plant resources for the subsistence economies of early Holocene hunter-gatherers, suggested that the edible biomass of temperate Europe was concentrated especially in resources such as roots and tubers. However, the lack of archaeobotanical evidence prevented a direct assessment of their significance not only in Clarke's model of Mesolithic Europe (Zvelebil 1994) but also in the European subsistence system as a whole. Techniques recently developed by Jon Hather (University College London) for the identification of charred remains of parenchymatous tissues deriving from soft vegetative organs such as roots, tubers, rhizomes and bulbs have changed this situation (Hather 1991, 1993, 2000). These new methods have been successfully applied at a number of archaeological, mainly pre-agrarian sites in temperate Europe. They have shown that root foods are among the resources that contributed substantially to pre-agrarian diet (see *e.g.* Perry 1999; Kubiak-Martens 1999, 2002; Mason/Hather 2000; Mason *et al.* 2002). Evidence of the use of wild roots and tubers by agrarian societies in temperate Europe has only just begun to be recovered (Hather 2000).

Other plant food remains that often confront us with identification problems are remains of processed plant material, such as processed cereal food (including porridge and bread remains) and mushes made from various fruits, nuts, seeds, roots and tubers or inner bark tissue. These remains occur fairly frequently in archaeobotanical contexts but are usually dismissed as unidentifiable plant material. This makes the remains of root foods and processed plant foods from Neolithic Schipluiden presented in this chapter of particular interest. These remains expand the range of consumed plant taxa and demonstrate that much evidence available in archaeological contexts may be missed if only standard recovery and identification methods are applied.

20.2 Methods

20.2.1 Preservation and recovery

Remains of vegetative plant tissue are generally very fragile, and therefore have a very small chance of being preserved in the archaeological record compared with remains of seeds or nutshells. This is due to the fact that soft tissues are often rich in water and oil, and are therefore susceptible to damage when exposed to fire (especially if they are not dried prior to charring) and readily fracture during the process of recovery from an archaeological site. The problem of identification therefore relates to fragments of tissue rather than whole organs (Hather 2000). Intact preservation of a whole organ is more common in the case of small vegetative organs. Tubers of lesser celandine (*Ranunculus ficaria*) for example often survive charring and subsequent taphonomic and recovery processes. That explains why they are relatively often encountered in archaeological contexts (Bakels 1988; Mason/Hather 2000; Bakels/Van Beurden 2001).

Remains of processed plant foods are very diverse. They may derive from either processed cereal food or mushes prepared from many other food plants and plant parts. In archaeological assemblages they may be preserved for example as clumps of coarsely ground cereal grains, isolated fragments of finely comminuted plant material or food residues (crusts) adhering to pottery fragments.

At Schipluiden, charred remains of parenchymatous tissues and remains of processed plant material were recovered during the analysis of the botanical samples. The hand-picked samples and 4-mm sieved samples (together over 500 samples) were also scanned for both categories of plant remains. In total, almost 100 pieces of parenchymatous tissue and fragments of processed plant foods were sorted to select potentially identifiable remains for a scanning electron microscope examination.

20.2.2 *Methods of identification*

The identification of charred remains of vegetative plant tissues and remains of processed plant material requires the use of a scanning electron microscope (SEM). The examinations concerned were carried out at the SEM laboratory in the National Herbarium in Leiden. Fragments of selected parenchymatous tissues and processed plant material were first fractured with a scalpel blade in order to obtain fresh surfaces and were mounted on SEM stubs using double-sided carbon tape strips. The fragments were then gold-coated and examined using a JOEL JSM-5300 scanning electron microscope. The specimens were described and photographed.

The anatomy of parenchymatous remains was examined with special attention being paid to the anatomical characters of the vascular tissue. Anatomical criteria outlined by Hather (1991, 1993, 2000) for the identification of charred remains of parenchymatous tissues and the BIAX *Consult* reference collection of vegetative plant parts were used in the identification.

The use of SEM is also essential for identifying processed plant material. The process of food preparation, which often involves grinding or pounding, destroys any morphologically recognisable plants remains. The traditional method for identifying seed remains (examination under a binocular microscope) is therefore insufficient. An alternative method such as examination under a scanning electron microscope provides an opportunity to explore the micro-morphological and anatomical features of very small fragments of plant remains (*e.g.* chaff remains, fragments of epidermis) that occasionally survive the process of food preparation.

20.2.3 *Chemical analyses*

Selected remains of processed plant material were subjected to chemical analyses in order to estimate their nutritional composition. The analyses were conducted by professor Jaap Boon at the FOM Institute for Atomic and Molecular Physics of the Foundation for Fundamental Research on Matter in Amsterdam (see chapter 20a for details).

The remains were analysed using Direct Temperature resolved Mass Spectrometry (DTMS). In principle, this method implies the mass spectrometric monitoring of a sample heated on a Pt/Rh filament. Compounds adsorbed or sequestered in the sample are evaporated before the non-volatile residue is thermally decomposed to smaller fragments. The result is a dataset that consists of mass spectra (mass range 20-1000 Dalton) collected as a function of time/temperature.

This method has been used to analyse complex organic materials, often in association with inorganic substances. Typical recent applications are carbonised grains and peas (Braadbaart 2004), carbonised food residues and residues encrusted on ancient pottery (Oudemans/Boon 1996). Although residues on pottery have often undergone severe thermal exposure either on the exterior of the pots or as burnt food residues on the interior, information can nevertheless be obtained on various elements, including fatty components (various acylglycerols, free fatty acids, various sterols), polycyclic aromatics deriving from soot, phenolic compounds from wood fires and various heteroaromatic compounds released from proteins and polysaccharides charred to varying extents. The degree of preservation to a great extent depends on the original burning and charring conditions (see chapter 20a).

20.3 Root foods

The remains of parenchymatous plant foods are represented in the Schipluiden assemblage as charred root fragments of the sea beet (*Beta vulgaris* subsp. *maritima*), bulbs of the wild onion/leek (*Allium* sp.) and tubers of the sea club-rush (*Bolboschoenus maritimus*). In addition, there were fragments of isolated parenchyma with no vascular tissue preserved, so no further identification was possible.

20.3.1 *Sea beet (Beta vulgaris subsp. maritima) roots*

Charred remains of sea beet roots were recovered from the analysed well sample 31 (phase 2) and from the manually collected sample no. 3351 (Unit 20). The plant remains were identified on the basis of anatomical characters observed in parenchymatous and vascular tissue (fig. 20.1-2).

The storage root of *Beta* can be identified on the basis of a particular type of anomalous secondary growth. Each bundle of vascular tissue has a cambium associated with it, which divides to produce vascular and storage parenchyma. This process is repeated many times, observable in transverse section in the form of concentric rings of vascular tissue between which are the bands of storage parenchyma (Hather 1993, 2000). In the charred remains preserved in sample no. 3351, these concentric rings of vascular tissue had survived in part; the areas of parenchymatous tissue can be observed between them (fig. 20.1).

Sea beet (fig. 20.3) occurs naturally on shingle beaches, tidal drift deposits and the drier areas of salt marshes in temperate Europe (Langer/Hill 1991). The plant is a biennial dicotyledon with succulent leaves and fleshy roots growing to lengths of up to 30 cm and thicknesses of 3-4 cm. The roots are rich in starch and sugar, which are concentrated in the parenchymatous tissue. From such direct evidence as charred root fragments recovered from the occupation deposits at Schipluiden we can infer that sea beet roots were

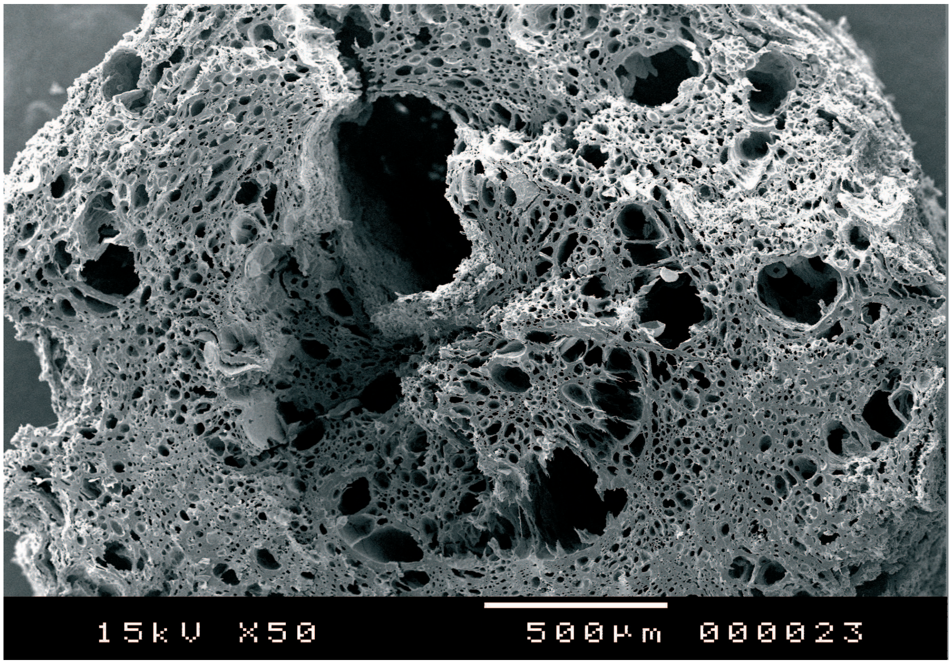

Figure 20.1 SEM micrograph of charred root fragment of sea beet (*Beta vulgaris* subsp. *maritima*) from sample no. 3351. Visible are concentric rings of vascular tissue (partly deteriorated) and storage parenchyma (transverse surface, magnification 50×).

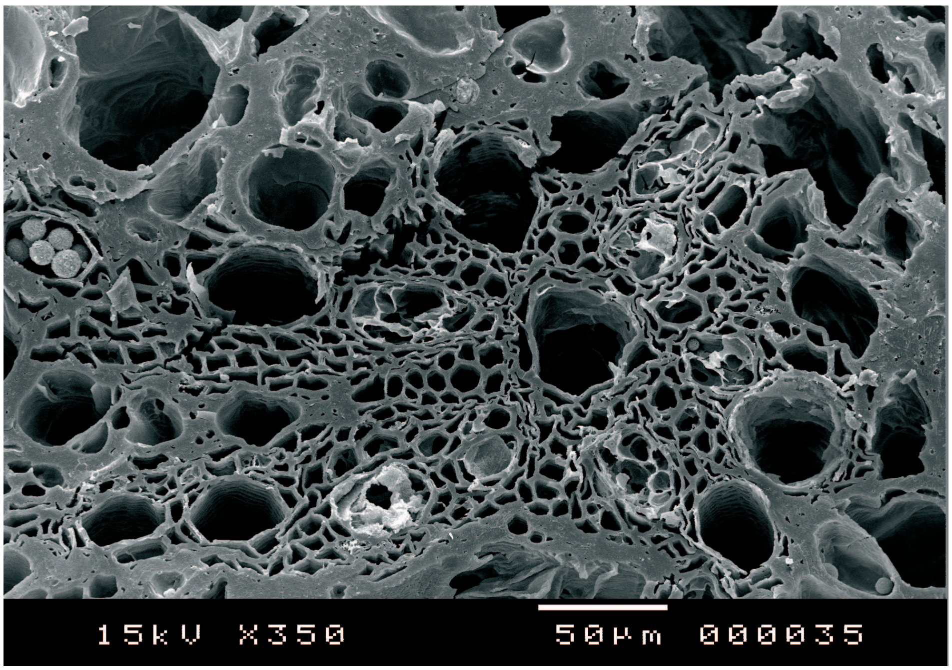

Figure 20.2 SEM micrograph of charred fragment of parenchymatous tissue, deriving from sea beet (*Beta vulgaris* subsp. *maritima*) root found in sample 31. Ground tissue with remnants of vascular tissue (transverse surface, magnification 350×).

gathered as food. They will have been readily available in many places with favourable conditions for this plant near the settlement. We can further suggest that the roots were exposed to domestic fire as part of their cooking process. According to many ethnographic accounts of the North American indigenous people, one of the most common methods used to make roots digestible and palatable involved cooking in an underground pit, though some roots were simply roasted over a fire or baked in hot ashes (Turner *et al*. 1990; Kuhnlein/Turner 1991).

Evidence of the gathering of sea beet roots as plant food has also been found in other archaeological contexts,

Figure 20.3 Specimen of *Beta vulgaris* subsp. *martima*, showing the edible root. After Körber-Grohne 1994.

Figure 20.4 Charred bulb of wild onion/leek (*Allium* sp.) from sample no. 2388 (magnification 5×).

including two late Mesolithic sites in the *Veenkoloniën* (peat district) in the Dutch province of Groningen (Perry 1999), the late Mesolithic Ertebølle settlement at Tybrind Vig in Denmark (Kubiak-Martens 1999) and the late Bronze Age site at Mile Oak in Britain (Hather 2000). The presence of charred perianths identified in Late Neolithic shell middens near Aartswoud in the Netherlands also indicates exploitation of sea beet as a food plant (Pals 1984).

20.3.2 Wild onion/leek (Allium sp.) bulbs

One almost complete elongated bulb and a few bulb fragments of wild onion/leek (*Allium* sp.) were encountered in 4-mm sieved samples nos. 2388 and 4633 (both from Unit 20). The identification was based on both the morphology of the bulb remains and the anatomy of the parenchymatous and vascular tissue.

The preserved charred bulb was 12 mm long and measured 6 mm across (fig. 20.4). A distinct scar was observed at the distal end of the bulb. Internally the bulb fragments comprised fairly closely packed bands of storage parenchyma (fig. 20.6). They were separated by a system of cavities, formed by the expansion of water vapour during the process of charring. Vascular tissue was preserved in the form of vascular bundles, randomly arranged within the parenchymatous tissue. They were amphicribal concentric in arrangement, with xylem elements embedded in a phloem tissue (fig. 20.7). Combined morphological and anatomical criteria allowed identification only to genus level. Reliable identification of the species concerned here requires more

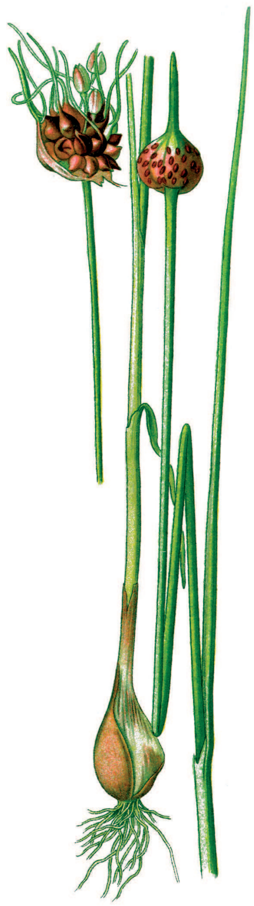

Figure 20.5 Sand leek (*Allium scorodoprasum),* showing small onions.

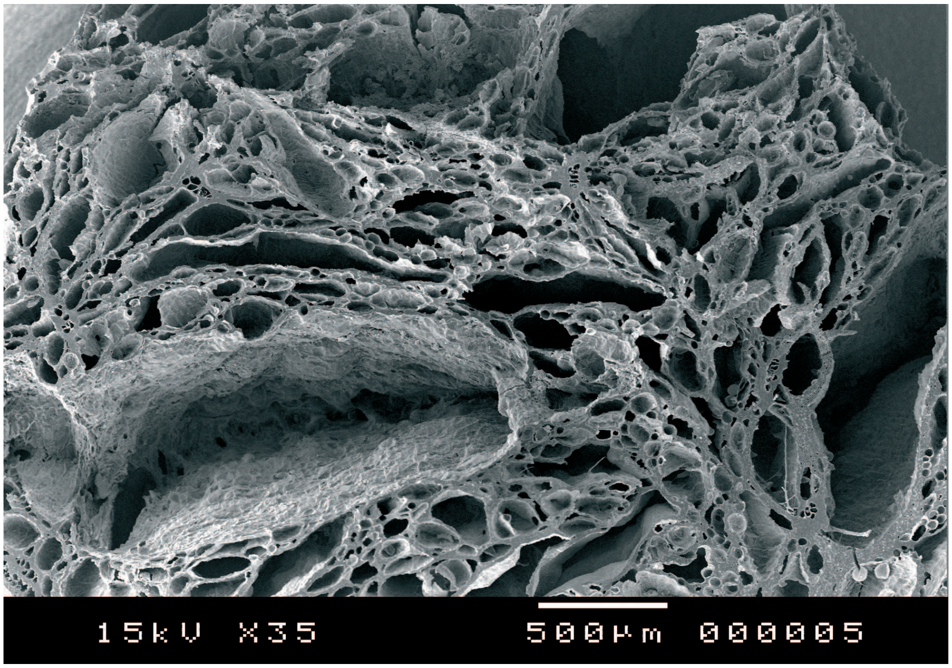

Figure 20.6 SEM micrograph of transverse section through *Allium* sp bulb, showing storage parenchyma and vesicular cavities (transverse surface, magnification 35×).

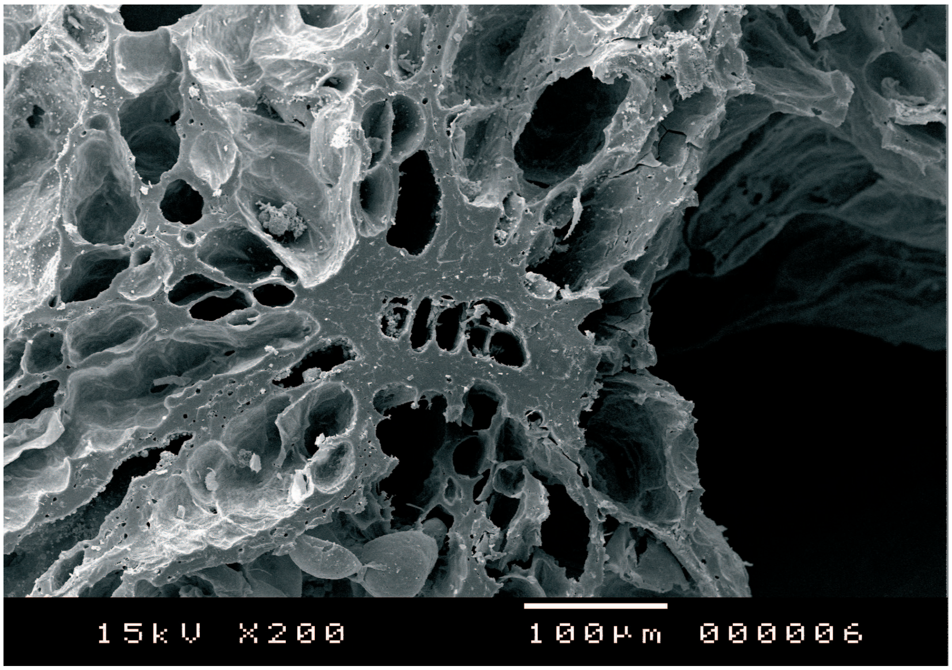

Figure 20.7 SEM micrograph of an individual vascular bundle in *Allium* sp. parenchymatous tissue. Xylem elements are embedded in phloem tissue. Charring caused the phloem to deteriorate to a solid ring of carbon; the xylem vessels have survived almost intact (transverse surface, magnification 200×). Detail of fig. 20.6.

detailed anatomical study of the diversity of the parenchymatous and vascular tissues within the genus *Allium*.

There are four native *Allium* species in the Netherlands (which may still be found here today) that produce more or less elongated bulbs: *Allium schoenoprasum*, *A. scorodoprasum*, *A. ursinum* and *A. carinatum*. On the basis of their environmental requirements, we may assume that at least two of these species will have grown in the vicinity of the site: sand leek (*Allium scorodoprasum*, fig. 20.5), which finds its optimum conditions in sandy dune shrubs and grassy habitats, and chive (*Allium schoenoprasum*).

The charred bulb remains found in the Schipluiden assemblage suggest that the plants were brought to the settlement and became charred when exposed to cooking fire. Many (if not all) members of the lily family store their main carbohydrates as inulin rather than starch. Cooking is therefore required to improve their digestibility and palatability. At Schipluiden, the bulbs (and also the green leaves) may have been used as food and/or added to other foods as flavourings. Although all roots have the highest concentrations of stored substances between autumn and early spring, they can be gathered and used throughout the greater part of the year. The bulbs of the lily family may however have been difficult to locate after the green tops had died in late summer. For the inhabitants of the Schipluiden settlement they may have been the first green vegetables to appear in spring. The small size of the *Allium* sp. bulb recovered suggests that the bulb and probably the leaves were gathered in spring. For comparison, the author collected bulbs of ramsons (*Allium ursinum*) in late March (before flowering time) and latter in mid June. The spring bulbs were approximately 1 cm in length and 4 mm across, while the summer bulbs measured approximately 4 cm in length and 1 cm across. The bulbs collected in spring very closely resembled the archaeological find.

Evidence obtained at other archaeological sites adds much credibility to this interpretation. Charred bulb and fragmentary bulb remains of wild garlic or ramson (*Allium* cf. *ursinum*) were encountered at the Late Mesolithic Ertebølle site at Halsskov in Denmark. They were interpreted as remnants of food lost in cooking fires (Kubiak-Martens 2002). Revealing evidence also comes from the Neolithic lakeshore settlements in Switzerland, where large amounts of *Allium* pollen were recovered from many organic layers (Heitz-Weniger 1978). In addition, pollen of *Allium* (possibly *ursinum*) was retrieved from the contents of a pot (Hadorn 1994). This points directly to the use of *Allium* either as a green and/or root vegetable or for flavouring other food.

Many ethnographic records provide evidence of regular use of various species of wild onions, leek, garlic and chives of the genus *Allium* in the traditional diet of indigenous peoples in North America (Turner *et al*. 1990, Kuhnlein/Turner 1991). Often, both the green leaves and the bulbs were consumed. Some species, for example nodding onion (*Allium cernuum*) and chives (*Allium schoenoprasum*), were gathered in spring (before flowering) for their green leaves and bulbs, and again in autumn for their bulbs. The Thomson Indians of British Columbia, for example, harvested the bulbs of nodding onion in spring and cooked them in underground pits. They sometimes used the bulbs to flavour other foods, too. The strong-tasting bulbs of wild leek (*Allium tricoccum*) were reportedly eaten by various groups in eastern Canada. They were eaten raw, and also cooked in soups and stews.

20.3.3 Sea club-rush (Bolboschoenus maritimus) tubers

Charred remains of sea club-rush (*Bolboschoenus maritimus*) were encountered in the 4-mm sieved sample no. 2362 (phase 3). The identification was based on the anatomy of parenchymatous and vascular tissues. All the remains had well-preserved parenchymatous and vascular tissue, which indicates that the tubers were charred in a dry, rather than a fresh state.

The charred remains preserved at Schipluiden were picked out under a light microscope as parenchyma fragments with clearly curved outer surfaces. When the fragments were refitted they were found to derive from ovoid organs, approximately 2 cm long and 1 cm in diameter (fig. 20.8). Internally, the tuber fragments were composed of isodiametric polygonal parenchyma cells measuring 30 to 50 μm across (fig. 20.10). Vascular bundles were randomly arranged within the parenchymatous tissue (fig. 20.11) and characteristic thick fibre sheaths were observed that were much wider at the xylem pole than at the phloem (fig. 20.12).

Figure 20.8 Charred tuber of sea club-rush (*Bolboschoenus maritimus*) from no. 2362 (magnification 5×).

Figure 20.9 Sea club-rush (*Bolboschoenus maritimus)* with tubers in the present-day salt marsh environment of the Land van Saeftinge, province of Zeeland.

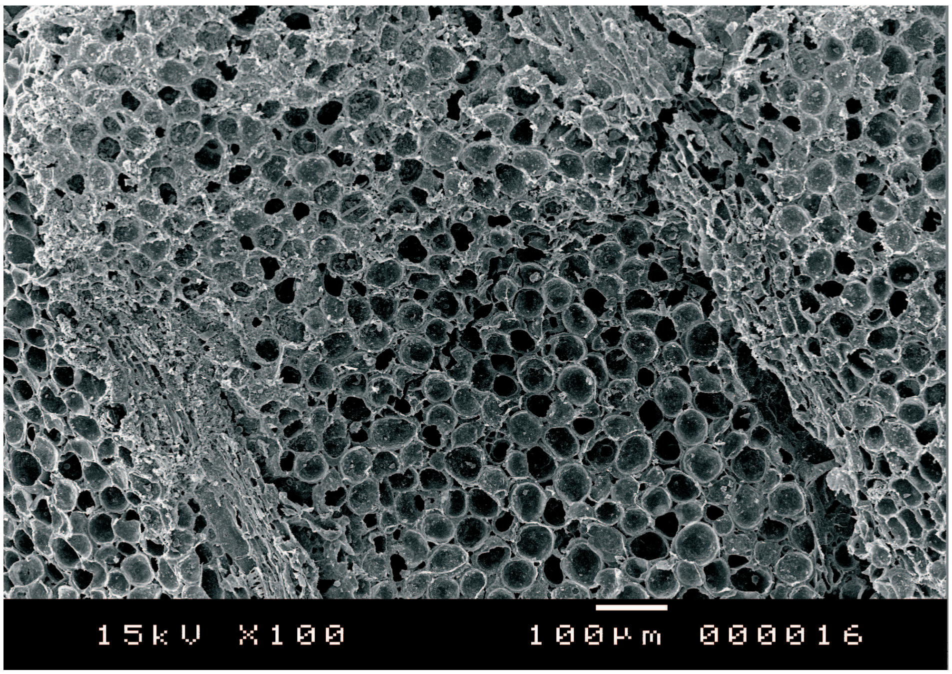

Figure 20.10 SEM micrograph of parenchymatous tissue of *Bolboschoenus maritimus* in longitudinal surface. Tracks of the vascular system are visible (magnification 100×).

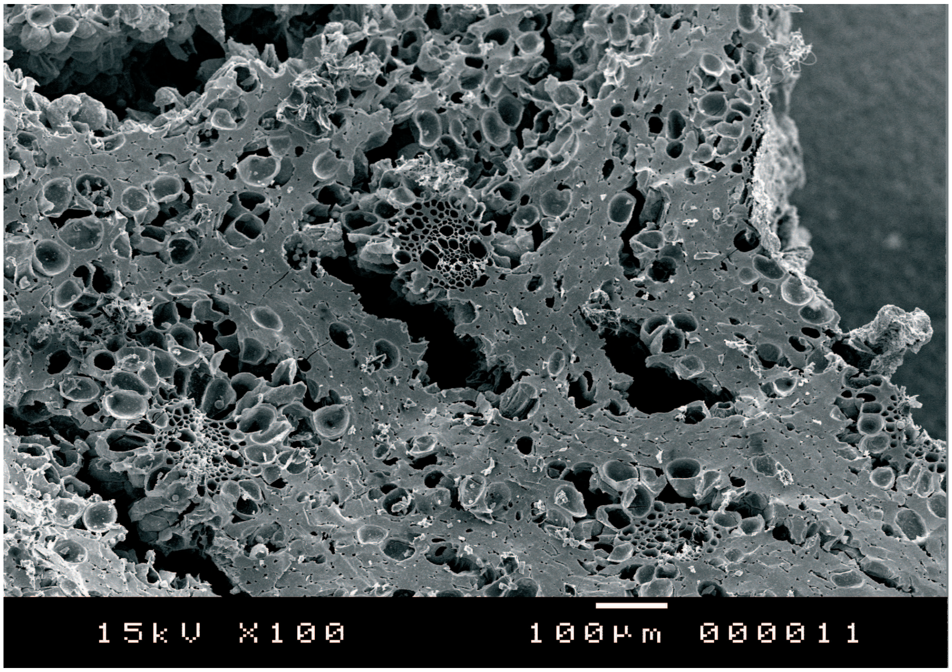

Figure 20.11 SEM micrograph of vascular bundles randomly arranged within the parenchymatous tissue of a *Bolboschoenus maritimus* tuber (transverse surface, magnification 100×).

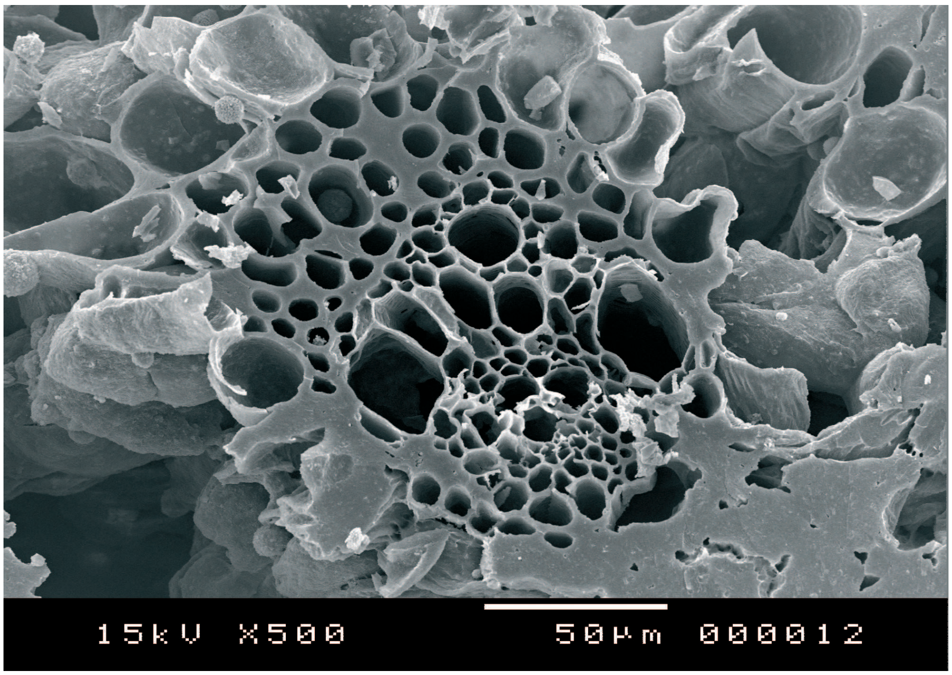

Figure 20.12 SEM micrograph of an individual vascular bundle in the parenchymatous tissue of a *Bolboschoenus maritimus* tuber. Note the thick fibre sheath, that is much wider at the xylem pole than at the phloem (transverse surface, magnification 500×). Detail of fig. 20.11.

Sea club-rush finds its optimum conditions in brackish marsh vegetations but can also grow in freshwater marshes. The tubers are formed as terminal swellings of the rhizomes. They are ovoid, up to 4 cm long and 2 cm in diameter (fig. 20.9).

The probability of tubers of sea club-rush having been introduced into the settlement as gathered food is supported by archaeobotanical finds recovered at other sites. For example, charred remains of rhizomes of the closely related club-rush (*Scirpus* sp.) were found together a

b

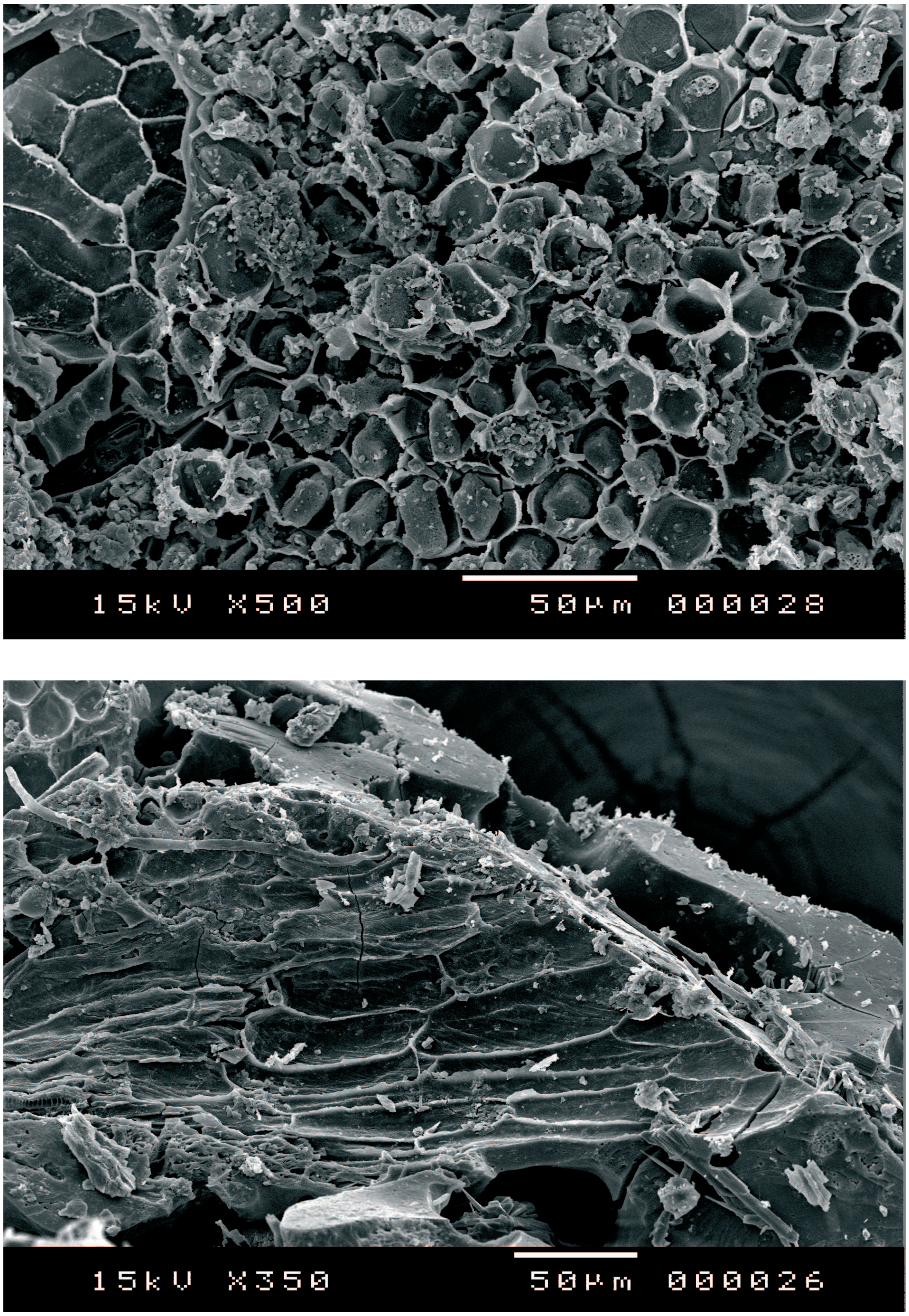

Figure 20.13 Plant food mush made from roots or tubers with the addition of leaf/stem food, sample 2876, (magnification 500×).
a isolated parenchymatous tissue characteristic of root or tuber
b stem/leaf fragment embedded within parenchymatous matrix

with charred vegetative tissues of other edible plants at two Late Mesolithic sites in the aforementioned *Veenkoloniën* in the Dutch province of Groningen (Perry 1999).

20.3.4 Processed root food

Isolated fragments of charred finely comminuted plant material dating from all the occupation phases were frequently found in both the analysed and the 4-mm sieved

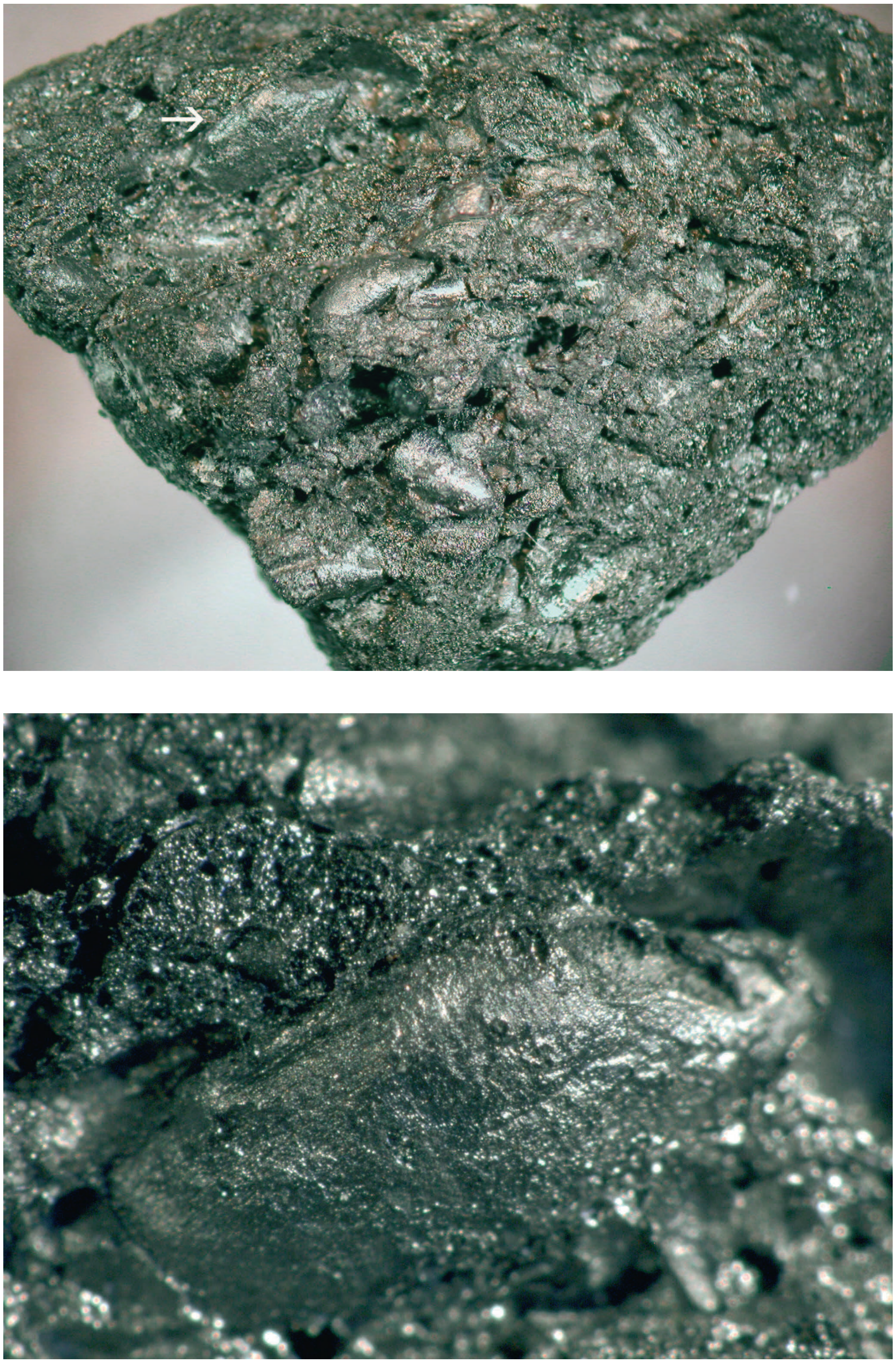

Figure 20.14 Charred remains of processed emmer (*Triticum dicoccon*) in a porridge-like food, made of coarsely crushed emmer grains, no. 7074, phase 2a.
a overall view (5×)
b detail (20×)

samples. On closer examination under the scanning electron microscope, some fragments of no. 2876 from Unit 20 were found to consist of processed parenchymatous tissue deriving from either root or tuber organs (fig. 20.13a). Fragments of stem/leaf epidermis were seen to be embedded in the parenchymatous matrix (fig. 20.13b). The combination of two

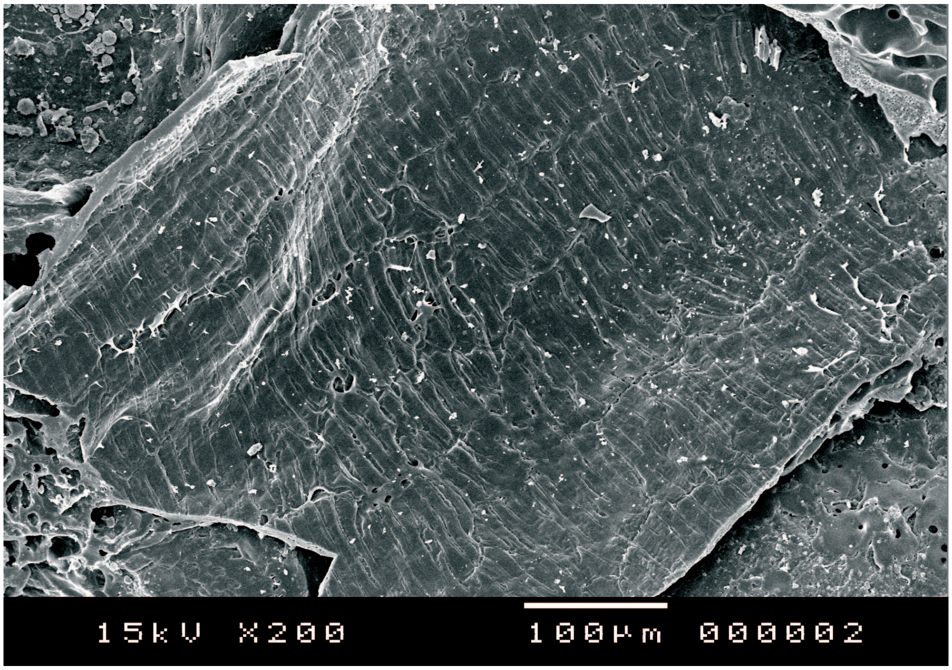

Figure 20.15 SEM micrograph showing transverse cell layers of emmer (*Triticum dicoccon*) grain epidermis recovered from encrusted material, no. 4084, phase 2b (magnification 200×).

different categories of plant material cannot possibly be interpreted in any other way than as representing a plant-food mush made from roots or tubers with the addition of green leaves and/or stems. The type of root/tuber food used to make this mush could not be identified because no vascular system had survived within the parenchymatous tissue.

20.4 Processed plant food

20.4.1 Cereal food remains

An interesting feature of the Schipluiden plant assemblage, especially with respect to the occupants' subsistence is the presence of charred remains of processed cereal food. Two, relatively large, fragments of cereal products were found in the 4-mm sieved samples nos. 7292 and 7074, both dated to phase 2a. Both fragments consist almost exclusively of emmer (*Triticum dicoccon*) grains, mixed with a small quantity of chaff remains (fig. 20.14a). No weed seeds were noted. The whole and fragmented grains (coarsely crushed and not ground) were embedded in a featureless, rather glassy matrix (fig. 20.14b). The nature of the matrix suggests that the cereals were cooked with the addition of some liquid (possibly water) and were eaten as porridge. Chemical analysis revealed no evidence of preserved milk or meat fats. Neither did it yield any evidence of starch. A question that needs to be addressed is whether high temperatures of the fires may have affected the preservation of organic molecules in archaeological remains. An experiment using present-day emmer grains showed that the molecular composition of residues that were exposed to a temperature of 250 ºC still consisted of starch and protein. The amount of polysaccharides however decreased when the residues were heated to a temperature higher than 310 ºC (Braadbaart *et al*. 2004).

These remains of processed emmer food are of special interest for at least two reasons. They represent the remnants of food (final products) that formed part of the diet of the people who lived at Schipluiden, and they are the earliest direct evidence of the processing of cereal food so far found in the Netherlands. Remains of processed cereal food were previously known only from the Neolithic lakeshore settlements in Switzerland (Lake Neuchâtel) and Germany (Lake Constance, Maier 1999).

20.4.2. Food residues on pottery

Selected specimens of charred food residues that were encrusted on the exterior surfaces of pots when the food contained in the pots boiled over during cooking, and burnt food residues from the interiors of pots were subjected to scanning electron microscope examination and chemical analyses.

A thick layer of crust was scraped from the exterior rim of pot fragments no. 4084, from phase 2b. Under the scanning microscope this crust was found to comprise a featureless matrix with inclusions of epidermal fragments of emmer (*Triticum dicoccon*) grain (fig. 20.15), suggesting that (at least some of the) food was made from emmer grain. Chemical analysis showed that proteins contributed to the

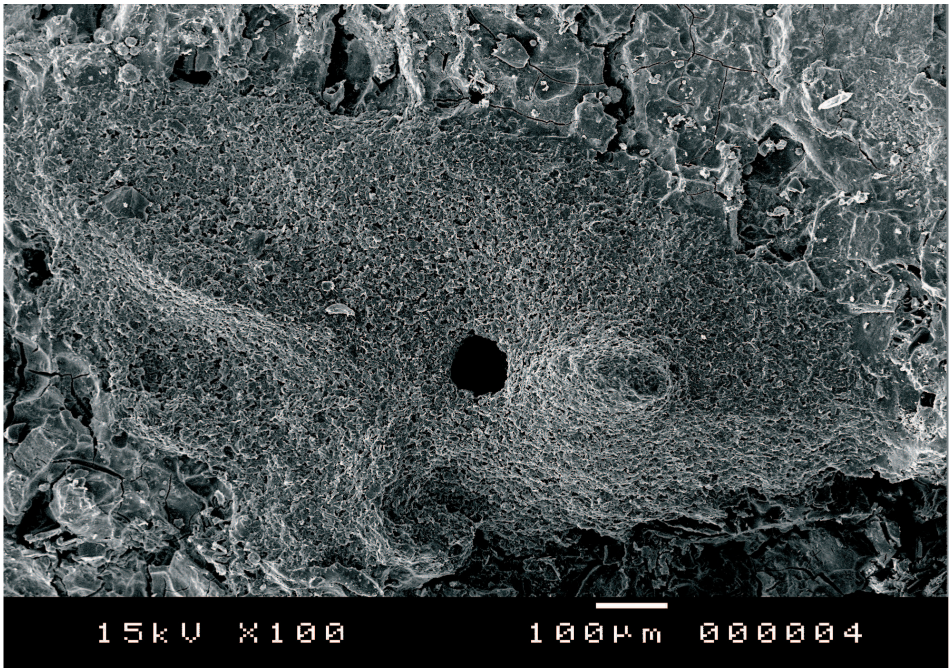

Figure 20.16 SEM micrograph of encrusted material showing remains of orache/seablite (*Atriplex*/*Suaeda*) embedded within the matrix, no. 3206, phase 2a (magnification 100×).

nutritional spectrum, though it could not be ascertained whether they were of plant or animal origin. There was however no evidence of starch and/or fats (chapter 20a). The absence of starches in the chemical matrix could be explained by the relatively high degree of charring, which may have destroyed the organic compound.

Under SEM examination, another fragment of encrusted remains (no. 3206, phase 2a) was found to have a rather fine texture, comprising remains of the seeds of possibly orache/seablite (*Atriplex*/*Suaeda*) embedded in the matrix (fig. 20.16). The seed remains indicate that we are dealing with either plant food made from cereals (in this case the

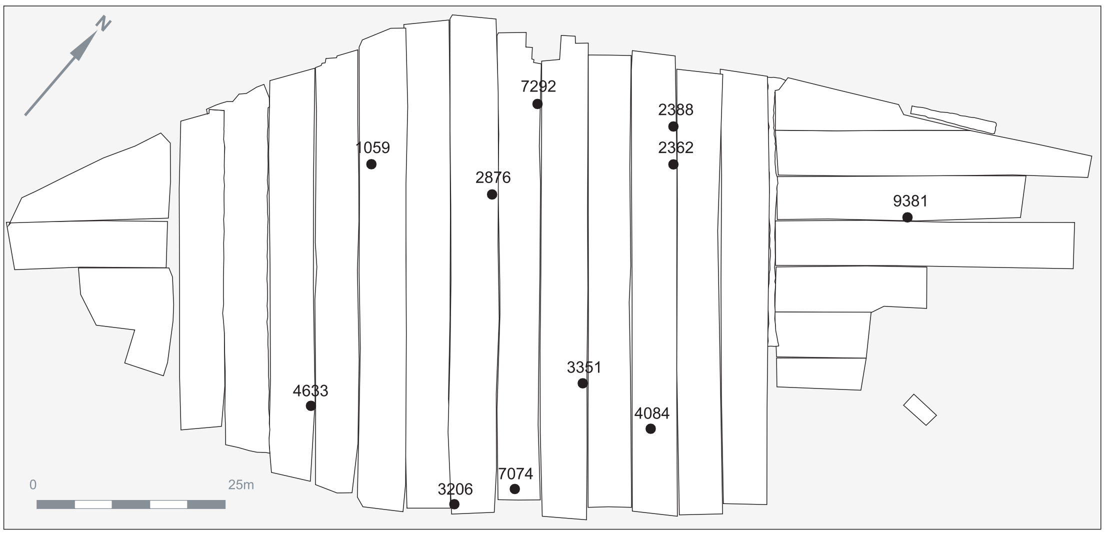

Figure 20.17 Points at which the samples discussed in this chapter were taken.

Atriplex/*Suadea* seeds will have made their way into the assemblage as weeds) or a plant food mush made from chenopod seeds. Many members of the Chenopodiaceae family are well known for their edible seeds that are rich in protein and carbohydrate. Some of the members of this family, for example various species of *Chenopodium* and *Atriplex,* are indeed assumed to have been a source of food in past human diets (Kuhnlein/Turner 1991; Moore *et al*. 2000).

Two other fragments of food residues had a very fine matrix in which no morphological or anatomical features could be made out under the SEM. Chemical markers obtained for very fine residues preserved on the interior of a small pot (no. 1059, Unit 20) point to a relatively uniform dissociation of the organic matter. The spectrum indicates unsaturated fatty acids, proteins and cholesterol. The observed composition points to a plant oil source. The combination of proteins and compounds deriving from plant oil suggests that plant seeds were the source of the organic matter. There are no preserved diglycerides that could support a milk source for the lipids (see chapter 20a). The Schipluiden archaeobotanical record presents us with at least two plant species that can be seen as potential sources of seed oil, namely turnip (*Brassica rapa*) and dogwood (*Cornus sanguinea*). *Brassica rapa* is well-known for its oleaginous seeds (rape seeds) and edible vegetative parts. The status of turnip as a cultivated crop is somewhat obscure. Although remains of the seeds of turnip have been found in archaeobotanical contexts at Neolithic sites and are commonly known from sites from the Bronze Age onwards, it is not certain whether the plant was actually cultivated or occurred only as a weed in arable fields (Bakels 1997). Turnip oil is liquid as it contains unsaturated fatty acids, and it can therefore be used for cooking and also for burning in oil lamps (Bieleman 1992). *Cornus sanguinea* grows naturally at the edge of woods and its stones are very rich in oil, which can be used for both consumption and burning.

Evidence of charred proteins in combination with saturated fatty acids and a mono-unsaturated fatty acid was also provided by residues encrusted on the interior of a pot fragment (no. 9381, phase 3). Several sterols suggest a plant oil source. The composition resembles that of no. 1059 (see chapter 20a).

20.5 Conclusions

The study of charred remains of parenchymatous root foods and processed plant foods provided evidence of the diversity of the diet of the Schipluiden occupants. The study also demonstrated the great potential of appropriate recovery and identification techniques for reconstructing past human diets.

The root food remains indicate a different direction in the Schipluiden subsistence system, towards the gathering of starch-rich underground plant organs, and point to the exploitation of various ecological zones: the coastal area for sea beet roots and more local ecological zones for bulbs of wild onion/leek in phase 2, and for tubers of fresh/brackish wetland plants such as sea club-rush in phase 3. Although root foods can be consumed throughout the greater part of the year, they have their highest concentration of stored substances between autumn and early spring. At Schipluiden, the root foods may have been especially appreciated during the winter months, when other plant foods were in scarce supply.

The remains of emmer and other processed plant foods recovered at Schipluiden are equally unique. They allow significant advances in our understanding of local subsistence and diet, and they certainly provide detailed insight into the daily life of the Neolithic occupants of Schipluiden.

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