QUEST
QUATERNARY SCIENTIFIC

University of Reading

DOVERIDGE, DERBYSHIRE, UK

Phytolith analysis report

Date: 27th November 2019

Written by: Dr S. Elliott

QUEST, School of Archaeology, Geography and Environmental Science, Whiteknights, University of Reading, RG6 6AB

Tel: 0118 378 8945
Email: n.a.marini@reading.ac.uk
http://www.reading.ac.uk/quest

DOCUMENT HISTORY

REVISION	DATE	PREPARED BY	SIGNED	APPROVED BY	SIGNED	REASON FOR ISSUE
v1	27/11/19	S. Elliott		N. Marini		First edition

CONTENTS

1. NON-TECHNICAL SUMMARY

Three samples from the archaeological site of Doveridge, an early Bronze Age settlement where an inverted cremation urn was discovered, were prepared for phytolith analysis. The investigations were commissioned Wessex Archaeology. The aim was to ascertain whether phytoliths were well preserved, and whether they suggest anthropogenic influence, any evidence for food or fuel and whether the results can help to understand Bronze Age cremation rituals. The results of the analysis show large number of well-preserved grass phytoliths, many originating from C3 pooideae grasses and C4 panicoideae grasses. Wheat and barley have been positively identified and probably oat and rye. The grass phytolith assemblage originated from both the grass leaves/stems and the inflorescence bracts. This could indicate that (1) the material deposited in this context was grown during spring or early summer and (2) that the material deposited was not separated from the other plant parts before deposition, or that multiple stages of crop processing are represented. The environmental conditions suggested by the phytoliths are a moist and wet growing environment in an open area. The phytoliths probably do not represent fuel remains as very few are burnt or mantled.

2. INTRODUCTION

This report summarises the findings arising out of the phytolith analysis undertaken by Quaternary Scientific (QUEST), University of Reading, in connection with archaeological excavation carry out at Doveridge, Derbyshire (NGR 412290 334030) (Figure 1). Quaternary Scientific were commissioned by Wessex Archaeology to undertake the works. Three samples were removed from an inverted cremation urn (1001) from grave 1050 (Figure 2 and Table 1). The urn is a collared

type urn dating to the early Bronze Age. The aim in analysing these samples was (1) to understand the funery taphonomy of the site, (2) to establish whether phytolith remains are well preserved and (3) whether they suggest an environmental background signature, or (4) perhaps whether they are indicative of human activities. The later include establishing whether there is evidence for food plants, and how these relate to the cremation process; e.g. were the food plants eaten or part of a ritual, or do the plants suggest a fuel source? Can these results contribute to our understanding of cremation rituals and prehistoric plant and food production and processing?

3. METHODS

All three samples were processed using a standard phytolith extraction protocol as follows: (1) the sample was screened through a 0.5mm mesh to remove coarse sized particles; (2) approximately 2gm of dried raw sediment was weighed out; (3) calcium carbonates were dissolved using a dilution of 10% hydrochloric acid and then washed in distilled water three times; (4) clay was removed using a settling procedure and sodium hexametaphosphate (Calgon) as a dispersant. Distilled water was added and the samples left for seventy-five minutes before pouring off the suspense. This was repeated at hourly intervals until the samples were clear. Samples were then transferred into crucibles and left to dry at a temperature of less than 50°C; (5) after drying, samples were placed in a muffle furnace for two hours at 500°C to remove organic matter; (6) phytoliths were then separated from the remaining material using a heavy liquid calibrated to a specific gravity of 2.3. Phytoliths were transferred to centrifuge tubes and washed three times in distilled water. They were then placed in small Pyrex beakers and left to dry; (7) approximately two milligrams of phytoliths per sample were mounted onto microscope slides, using the mounting agent Entellan. Microscope slides were assessed using a Meiji MT4300L transmitted light microscope using x100 and x400 magnifications. The phytoliths were counted and categorised into types. Phytoliths were further classified as deriving either from woody (dicotyledon) or non-woody (monocotyledon) taxa. The results and quantification are based on a full count and scan with a minimum count of two hundred phytoliths per slide. An insufficient phytolith count can result in misrepresentation of plant assemblage. Therefore the most common value lies between 200 and 400 phytoliths counted per slide (e.g. Alexandre et al., 1997; Carter, 2000; Blinnikov et al., 2002). The results are displayed in Tables 1-4 and Figures 1-42.

4. RESULTS & INTERPRETATION OF THE PHYTOLITH ANALYSIS

A total of 318, 301 and 335 phytoliths were identified from respectively samples <124>, <128> and <131>, when observed at x400 magnification. The results of the phytolith counts are presented in Table 2 and the weight percentage of phytolith in Figure 3. The quantified results expressed as a percentage for each phytolith type (of the total number of phytoliths identified) are presented in Figure 4. In addition to the single celled phytoliths, the remainder of the slides were scanned to identify all multi-celled phytolith forms; these are presented in Figure 5.

In these sediment samples collected from the archaeological site at Doveridge the preservation of the phytoliths is good, only between eight and 13 degraded phytoliths were identified from the samples (see Table 3), and only two phytoliths were unidentifiable form one of the samples (see Table 3). Two single phytoliths were observed with occluded carbon within the single celled phytolith count (Figures 8, 21 and 31) indicating direct exposure to fire, and two melted silica phytoliths were observed (Figures 25 and 39), silica melts above a temperature of 600-900 degrees Celsius (different forms melt at different temperatures) (Table 3). The presence of low numbers of occluded carbon phytoliths and melted silica suggests that minimal plant material from the cremation urn was directly exposed to fire, and that the cremated remains were probably placed into the urn either with non-decomposed plant material, or with sediments where plant material had previously decomposed and phytoliths released into the sediments. Phytoliths represent the remains of *in situ* decomposition of plant material, but whether the plant material was deposited in its organic form within the urn, or whether the sediments were added to the urn with previously decomposed plant material, we cannot tell from the phytolith analysis. There was some micro-charocal identified in the slides (see Figure 26).

Examination of the weight percent of phytoliths extracted from the original sediment weight can provide an estimation of the number of phytoliths in each sample, and therefore an estimation of the amount of plant material deposited in each context. It only provides and estimation because at 2.3 specific gravity all components of silica are extracted (including sponge spicules and diatoms), therefore the weight percent represents all microscopic silica particles. Dry plant material can produce a range of concentration of phytoliths, depending on species, plant part and particularly whether the species is a monocot or dicot. As an example, Millet plant material from China was examined by Zuo and Lu (2011) and the results show a range of percentage of phytoliths extracted from dry plant matter. In their study from the original dry plant matter for *Setaria italica* the phytoliths represented between 4.04-6.00 % of the dry matter, and in *Panicum miliaceum* the phytoliths represented 4.24-5.41 % of the dry matter (Zuo and Lu, 2011). The weight percent of phytoliths from archaeological sediments is dependent on the archaeological site, and ideally a background off-site control sample will be analysed in addition to the archaeological samples to examine how much the weight percent has increased in the anthropogenically altered sediments. Examples of weight percent of phytoliths from a range of sites include: contexts from Neolithic samples from Catal Hoyuk, Turkey studied by Rosen (1995) contain between 0.5-7.2% phytoliths (Rosen, 1995); contexts from the modern ethnographic Bedouin campsite WF916 in Jordan examined by Vos (2018) contain between 0.001-0.020% phytoliths (Vos *et al.*, 2018); and Iron Age and Roman contexts from Silchester, UK, examined by Elliott contain between 0.0005-0.0035% phytoliths (Elliott, 2018). From Doveridge, the archaeological samples contain between 0.45 and 0.71 weight percent of phytoliths extracted from the original sediment samples (see Figure 3). The highest weight percent of phytoliths is in sample <128> and the lowest in sample <131>, indicating that more plant material is present in sample <128>. The weight percent is high compared with two of the examples provided above (Silchester and WF916). This can be further attested when counting the phytoliths, lots were observed in each field of view (Figure 13) only one to two thirds

of a single row on the microscope slide needed observation to reach the minimum phytolith count, although the entire slide was scanned to identify multi-celled phytolith forms.

The samples contained phytoliths from monocotyledonous plants (grasses) and dicotyledonous plants (shrubs and trees). It is not possible to directly compare the number of phytoliths produced by monocots and dicots because plants have different abilities to produce phytoliths, and in particular Poaceae produce more than other monocotyledons (Zuo and Lu, 2011). Comparing monocots and dicots, the monocots can produce up to twenty times more phytoliths than the dicots (Albert and Weiner 2001). However, between 97.1 and 98.7%% of the phytoliths identified originated from grasses (monocots) suggesting a dominance of grasses in these sediments.

The stems and leaves of all monocots produce smooth/sinuate elongate phytoliths (Figures 16, 21 and 23); the dendritic elongate phytoliths (Figure 11) come from the inflorescence (husks) of grasses. In sample <131>, 42.4% of the phytolith assemblage comes from grass leaf/stems and 14.9% from grass inflorescence. In sample <128>, 37.5% of the identified phytoliths come from grass leaf/stems and 14.3% from grass inflorescence. And in sample <124>, 39.6% of the phytoliths are from grass leaf/stems and 16.4% from grass inflorescence. There is very little variation between the three samples; but sample <124> contains slightly more husks than the other two samples. The presence of leaves and stems and husks could indicate that the whole plant was deposited, or the material from multiple stages of crop processing was deposited; the initial removal of waste (leaves and stems) and subsequent removal of husks during winnowing (Harvey and Fuller, 2005). It also suggests that the plants were grown during the spring or early summer where the seeds and inflorescence of the grasses would be present.

Multi-celled phytoliths originating from the grass inflorescence which are preserved in the samples can facilitate identification of grasses to genus. For example cereals are identified in their multi-celled phytolith form; different identifiable attributes can assign a multi-celled phytolith form to a specific genus. Two of the attributes (minimum) should be positively identified to assign a multi-celled phytolith, if only one is identified then it gets assigned to a compares favourably category (*cf.*). The attributes are the form of the waves and the number of pits on the papillae (for barley, wheat, oat and rye grass) and in addition, the shape of the cork cells for wheat and barley (Rosen 1992). Barley (*Hordeum*) multi-celled phytoliths have dendritics of even amplitude which are squared at the base, papillae with 7-9 pits and rounded cork cells (Rosen, 1992; see Figure 6). Wheat (*Triticum*) multi-celled phytoliths have dendritics of uneven amplitude which are rounded at the base, papillae with 10-12 pits and pointed cork cells (Rosen, 1992; see Figure 6). Rye grass (*Lolium*) has dendritic waves that are regular and rounded and papillae with 18-20 pits (Rosen, 1992; see Figure 6). Oat grass (*Avena*) has dendritics which are rod like and straight with highly ornamented hair like projections and papillae with 18-20 pits (Rosen, 1992; see Figure 6). From the three samples analysed from Doveridge, multi-cells were positively identified from barley (*Hordeum*) in sample <124> and wheat (*Triticum*) in sample <128> (see Figures 9 and 19). Multi-cells assigned to cf. barley were identified in all three samples, c.f. wheat in sample <128> and cf. oat grass (*Avena*) in sample <131> (Figure 32). Without the multi-cellular forms, singular elongate

dendrtitic phytoliths are not often assigned to as cf. genus category. However, some of the single elongate dendritics have features which are similar to wheat, barley, oat grass and rye grass (not identified in multi-celled phytoliths). Sample <124> has dendritics with waves similar to wheat and barley (Figures 18 and 7), sample <128> dendritics are similar to wheat and rye grass (Figures 29 and 22), and sample <131> dendritics are similar to wheat, barley and oat grass (Figures 42, 30, 32, 36 and 40).

The grass can be further classified from short celled phytoliths which can be attributed to either C3 or C4 grasses. All three samples were dominated by short cells originating from the grass C3 subfamily pooideae (rondel phytoliths; Figures 15, 20, 23 and 28), representing between 11.3 and 14.5%. All samples also had short cells from grass C4 subfamily panicoideae (bilobes; Figures 20 and 41), representing between 3.7 and 5.8%. The presence of short celled phytoliths from grass C4 subfamily chloridoideae was minimal, between 0 and 0.7%. C3 pooideae grasses prefer moist and wet environments and include barley, rye, oat and wheat (Twiss, 1992) which have all been identified in the samples from the elongate dendtritcs and multi-celled inflorescence phytoliths. C4 panicoideae grasses prefer humid environments and include taller grasses such as sorghum and maize. Overall the short celled phytoliths suggest a moist, wet and humid environment.

The only other identifiable plants form the phytolith assemblages is sedges (*Cyperaceae*), these are identified from cone phytoliths and polyhedral granulate phytoliths. Cone phytoliths (Figure 33) were identified in all three samples, representing between 0.6 and 1.6%, while polyhedral granulate phytoliths were only identified in sample <128> (0.3%; Figure 27). The presence of sedges also suggest a wet growing environment.

A large proportion of crenate phytoliths (Figure 35) were identified in each sample, representing between 12.2 and 17.6%. Crenate phytoliths are produced in the epidermis of the Pooideae grass subfamily (Twiss *et al.*, 1969; Mulholland, 1989; Twiss, 1992). Some research has suggested that crenates are produced in grass species which prefer to grow in open areas in comparison to closed areas (Bremond *et al.*, 2004), therefore suggesting an open environment rather than a more closed shrubland environment.

The remainder of the phytolith assemblage present do not tell us anything specific about the plant remains present. Some keystone phytoliths (Figures 24 and 31) can be attributed to certain plants, for example *Oryza* (rice) and *Bambusoideae* (bamboo), but none of the kesystones, identified in samples <128 > and <131>, belong to these types. The keystones that were identified are common, but not exclusive to reeds (*Phragmites*). They may have originated from reeds, due to the other indicators of a wet environment, such as short celled phytoliths and sedges. The remaining phytoliths from the monocotyledonous plants occur widely throughout all grasses, as well as the entirety of the plant (bulliforms, Figures 23 and 34; hair/trichomes, Figures 8 and 23). Dicotyledonous phytoliths (globulars, Figure 37; plateys, blocks, silica aggregate, tracheids, Figure 17; etc.) cannot be further classified into plant part and none of the phytoliths present can be classified to genus or species.

The other aspect which should be highlighted is the presence of minimal diatoms (Figures 12 and 40) and sponge spicules (Table 3). All siliceous materials are separated by the heavy liquid during the final stages of the phytolith extraction procedure. Diatoms have a cell wall made from silica and many types of sponge spicule can be siliceous. Therefore diatoms and sponge spicules are residual in the phytolith samples and are intrusive to the quantified assemblage. Both diatoms and sponge spicules are indicative of moist and wet conditions in the environment, as they live in water. This may be indicative of a wet environment, further emphasising the phytolith results.

5. CONCLUSIONS

The overall number of phytoliths and the morphotypes identified in the assemblages suggests an anthropogenic origin to the plant material, rather than natural deposition. The assemblage of phytoliths is very well preserved with multi-celled phytolith forms identified in all three samples. An absence of these multi-celled forms would suggest poor preservation and increased taphonomic post-depositional breakdown. The weight percent of phytoliths extracted from the sediments is relatively high and the assemblages are dominated by grass phytoliths, with wheat and barley being positively identified, and probably rye and oat as well. Therefore, the phytolith analysis ascertained the presence of a range of cereals which were probably being consumed at the site. Without samples from non-funerary contexts it is difficult to ascertain whether these foods were only used/eaten as part of the funerary ritual, or whether they were widespread across the site in all contexts. In the future non-funerary contexts and off-site control contexts should also be analysed for comparative purposes. There is a dominance of C3 pooideae grasses (identified from rondel short cells, crenates and multi-celled cereal forms), but also C4 panicoideae grasses identified. The presence of C3 pooideae grasses, C4 panicoideae grasses, sedges, sponge spicules and diatoms suggest a wet and moist environment surrounding the site, and possibly an open environment suggested by the high percentage of crenates and low presence of dicotyledonous phytoliths (from shrubs and trees). The phytoliths exhibit only minimal exposure to fire (occluded carbon) and melting, suggesting that the grasses identified from these contexts were not a fuel source.

Cereals (wheat, barley and probably rye and oat) were being grown and consumed at the site in addition to probable processing at the site due to the presence of multiple phases of crop processing (removal of waste leaf/stems and removal of husks). There is evidence for spring and summer growing of these crops due to the presence of inflorescence bracts, but whether these were stored and consumed all year round is impossible to ascertain without analysing possible storage features.

The plant material represented in the phytolith assemblage could correspond to plant material directly deposited in the cremation urn; this material is mostly not burnt, so does not represent any organic remnants associated with the body prior to cremation. The other possibility is that it

represents plant material utilised at the site and decomposed into the sediments, and subsequently the sediments have been incorporated with the cremation ashes in the inverted urn.

In future, it is advised that to submit both a control sample, in order to examine what is anthropogenic and whether increased plant material is deposited on site in comparison to off site, as well as samples from non-funerary contexts for comparison, to see what plant material is ritually utilised.

6. REFERENCES

Alexandre, A., Meunier, J.-D., Lezine, A.-M., Vincens, A., Schwartz, D. (1997) Phytoliths: indicators of grassland dynamics during the late Holocene in intertropical Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* **136**, 213–229.

Albert, R.M. and Weiner, S. (2001) Study of phytoliths in prehistoric ash layers from Kebara and Tabun caves using a quantitative approach. *In:* Meunier, J.D. and Colin, F., eds. *Phytoliths: Applications in Earth Sciences and Human History.* Lisse: A.A. Balkema Publishers, 251–266.

Blinnikov, M.S., Busacca, A., Whitlock, C. (2002) Reconstruction of the Late Pleistocene grassland of the Columbia basin, Washington, USA, based on phytolith records in loess. *Palaeogeography, Palaeoclimatology, Palaeoecology* **177 (1–2)**, 77–101.

Bremond, L., Alexandre, A., Véla, E. and Guiot, J. (2004) Advantages and disadvantages of phytolith analysis for the reconstruction of Mediterranean vegetation: an assessment based on modern phytolith, pollen and botanical data (Luberon, France). *Review of Palaeobotany and Palynology*, **129 (4)**, 213-228.

Elliott, S. (2018) The Phytoliths. *In:* Fulford, M., Clarke, A., Durham, E. and Pankhurst, N. (eds.) *Late Iron Age Calleva. The pre-conquest occupation at Silchester insula IX.* Britannia Monograph

Harvey, E.L., Fuller, D.Q (2005) Investigating crop processing using phytolith analysis: the example of rice and millets. *Journal of Archaeological Science* **32**, 739-752.

Mulholland, S.C. (1989) Phytolith shape frequencies in North Dakota grasses: a comparison to general patterns. *Journal of Archaeological Science*, **16 (5)**, 489-511.

Rosen, A.M. (1992) Preliminary Identification of Silica Skeletons from Near Eastern Archaeological Sites: An Anatomical Approach. *In:* Rapp (Jr), G. and Mulholland, S.C. (eds.) *Phytolith Systematics. Emerging Issues.* New York: Plenum Press, 129-147.

Rosen, A.M. (1995) Phytolith indicators of plant and land use at Çatalhöyük. *In:* Hodder, I. (ed.) *Inhabiting Çatalhöyük: reports from the 1995-1999 seasons*, McDonald Institute for Archaeological Research, Cambridge, 203-212.

Twiss, P.C., Suess, E. and Smith, R.M. (1969) Morphological classification of grass Phytoliths 1. *Soil Science Society of America Journal*, **33 (1)**, 109-115.

Twiss, P.G. (1992) Predicted World Distribution of C3 and C4 Grass Phytoliths. *In:* Rapp (Jr), G. and Mulholland, S. C., (eds.) *Phytolith Systematics. Emerging Issues.* New York: Plenum Press, 113-128

Vos, D., Jenkins, E. and Palmer, C. (2018) A dual geochemical-phytolith methodology for studying activity areas in ephemeral sites: Insights from an ethnographic case study from Jordan. *Geoarchaeology*, **33 (6)**, 680-694.

Zuo, X. and Lü, H. (2011) Carbon sequestration within millet phytoliths from dry-farming of crops in China. *Chinese Science Bulletin*, **56 (32)**, 3451-3456.

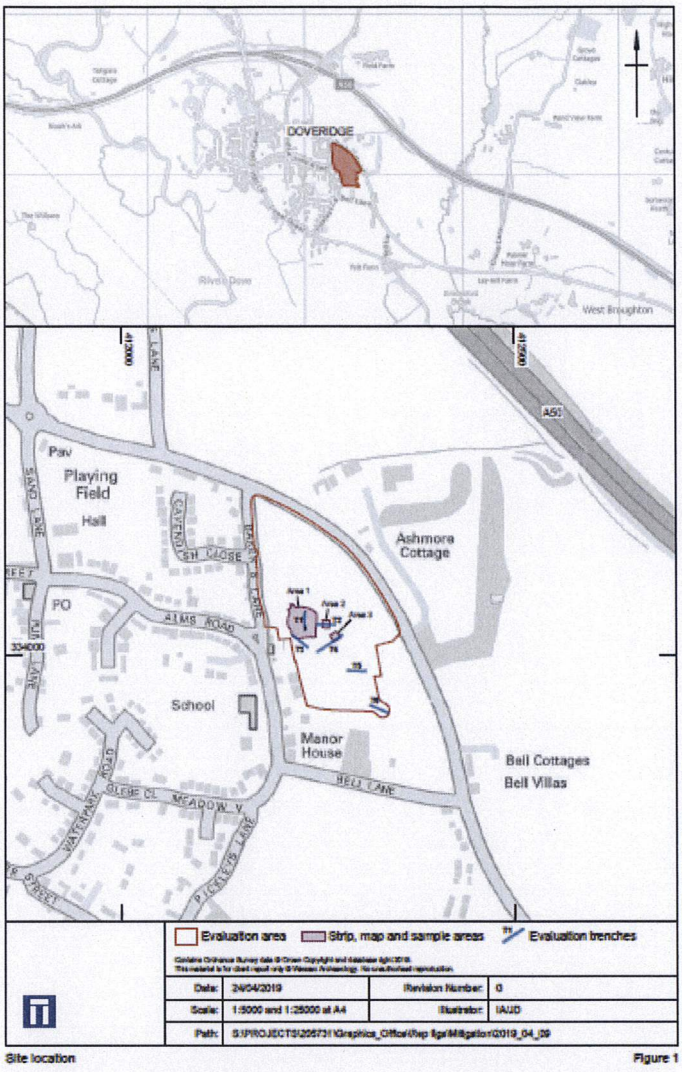

Figure 1: Location of Doveridge excavation, off of Derby Road, Derbyshire, DE6 5LA (NGR 412290 334030).

Figure 2: Inverted cremation urn 1001 in grave 1050 where samples <124>, <128> and <131> were taken, Doveridge, Derbyshire.

Table 1: List of phytolith samples, Doveridge, Derbyshire.

Inverted Cremation Urn	Grave	Urn Type	Date	Samples
1001	1050	Collared Urn	Early Bronze Age	<124>, <128>, <131>

Table 2: Single cell phytolith results of the phytolith analysis, Doveridge, Derbyshire.

	Counts			Percentage		
	<131>	<128>	<124>	<131>	<128>	<124>
Bilobe	20	11	13	5.97	3.65	4.09
Bulliform	2	2	1	0.60	0.66	0.31
Cone	2	2	5	0.60	0.66	1.57
Crenate	41	53	50	12.24	17.61	15.72
Cross	0	0	1	0.00	0.00	0.31
Elongate dendritic	46	39	47	13.73	12.96	14.78
Elongate sinuate	23	11	25	6.87	3.65	7.86
Elongate smooth	118	98	100	35.22	32.56	31.45
Elongate trapeziform	0	6	9	0.00	1.99	2.83
Hair/trichome	16	14	9	4.78	4.65	2.83
Keystone	2	1	0	0.60	0.33	0.00
Papillae	1	0	1	0.30	0.00	0.31
Polylobe	3	7	11	0.90	2.33	3.46
Rondel	48	41	36	14.33	13.62	11.32
Saddle	1	2	0	0.30	0.66	0.00
Barley husk	1	0	1	0.30	0.00	0.31
Leaf-stem	1	4	1	0.30	1.33	0.31
Mesophyll	0	1	0	0.00	0.33	0.00
Unidentifiable husk	1	1	2	0.30	0.33	0.63
Wheat husk	0	1	0	0.00	0.33	0.00
cf. Barley	1	1	2	0.30	0.33	0.63
cf. Wheat	0	1	0	0.00	0.33	0.00
cf. Lolium	1	0	0	0.30	0.00	0.00
Blocks	1	1	0	0.30	0.33	0.00
Globular granulate	4	1	0	1.19	0.33	0.00
Platey	0	0	1	0.00	0.00	0.31
Polyhedrol granulate	0	1	0	0.00	0.33	0.00
Sheet	0	1	1	0.00	0.33	0.31
Tracheid	1	1	1	0.30	0.33	0.31
Silica aggregte	1	0	1	0.30	0.00	0.31
Total Monocotyledons %	-	-	-	97.91	98.34	98.74
Total Mdicotyledons %	-	-	-	2.09	1.66	1.26
Total Singles identified	335	301	318	-	-	-

Table 3. Other microscopic remains and features observed during counting and identification of silica phytoliths (numbers counted), Doveridge, Derbyshire.

	<131>	<128>	<124>
Burnt	1	0	1
Degraded	13	5	8
Sponge spicule	1	1	1
diatom	8	9	7
Melted silica	1	1	0
Unidentified single	0	0	2

Table 4: Multi- celled phytolith results of the phytolith analysis, Doveridge, Derbyshire.

	<131>	<128>	<124>
Barley husk (no of multi-cells)			**2**
Long cell			8
Cork cell			5
Papillae			1
Bulliforms (no of multi-cells)	**1**		
Bulliform	10		
Grass leaf-stem (no of multi-cells)	**4**	**10**	**27**
Long cell smooth	24	29	134
Long cell sinuate	10	10	14
short cell	4		3
Unidentifiable grass husk (no of multi-cells)	**3**	**5**	**9**
Long cell	15	18	32
Cork cell	3		2
Papillae		3	2
Wheat husk (no of multi-cells)		**1**	
Long cell		3	
Cork cell			
Papillae		2	
cf Barley (no of multi-cells)	**1**	**1**	**2**
Long cell	2	3	4
cf Weat (no of multi-cells)		**1**	
Long cell		3	
Cork cell			
Papillae			
cf. Rye grass	**1**		
Long cell	7		
Total Multi-cells Identified	**10**	**18**	**40**
Number of Single cells identified in Multi-cells	**75**	**71**	**205**

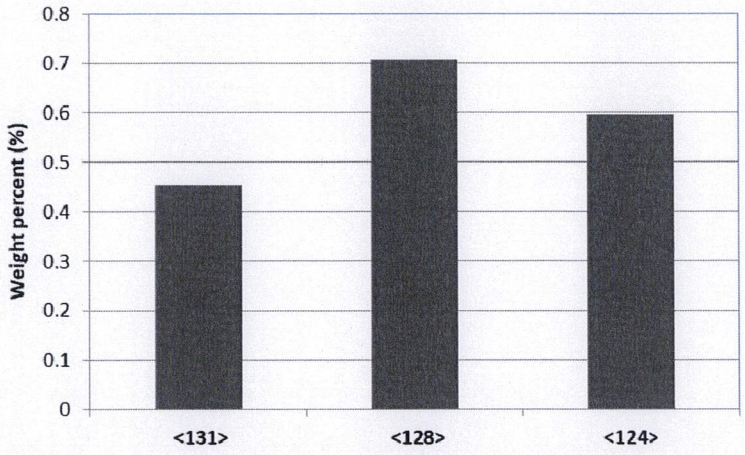

Figure 3: Weight percent of phytoliths extracted form original sediment samples, Doveridge, Derbyshire.

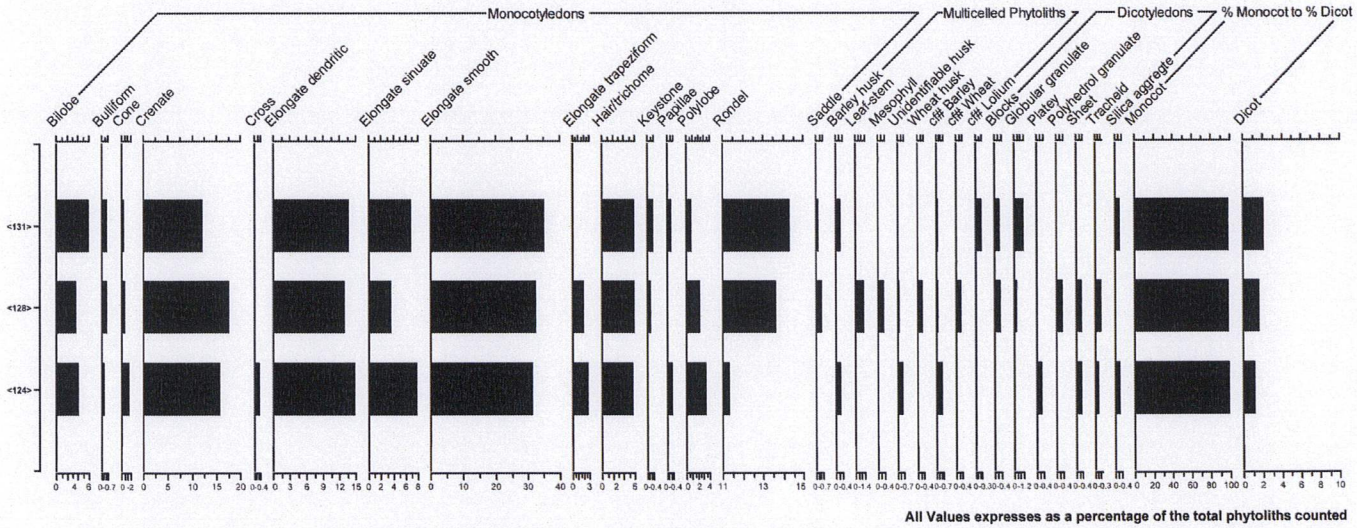

Figure 4: Phytolith percentage diagram, Doveridge, Derbyshire.

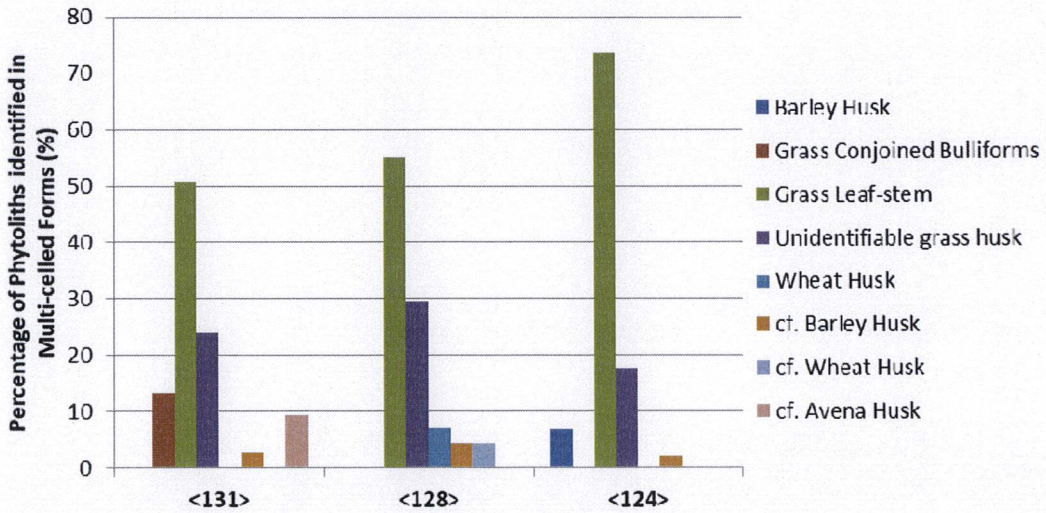

Figure 5: Multi-celled phytoliths identified, expressed as a percentage of total number of multi-celled phytoliths identified, Doveridge, Derbyshire.

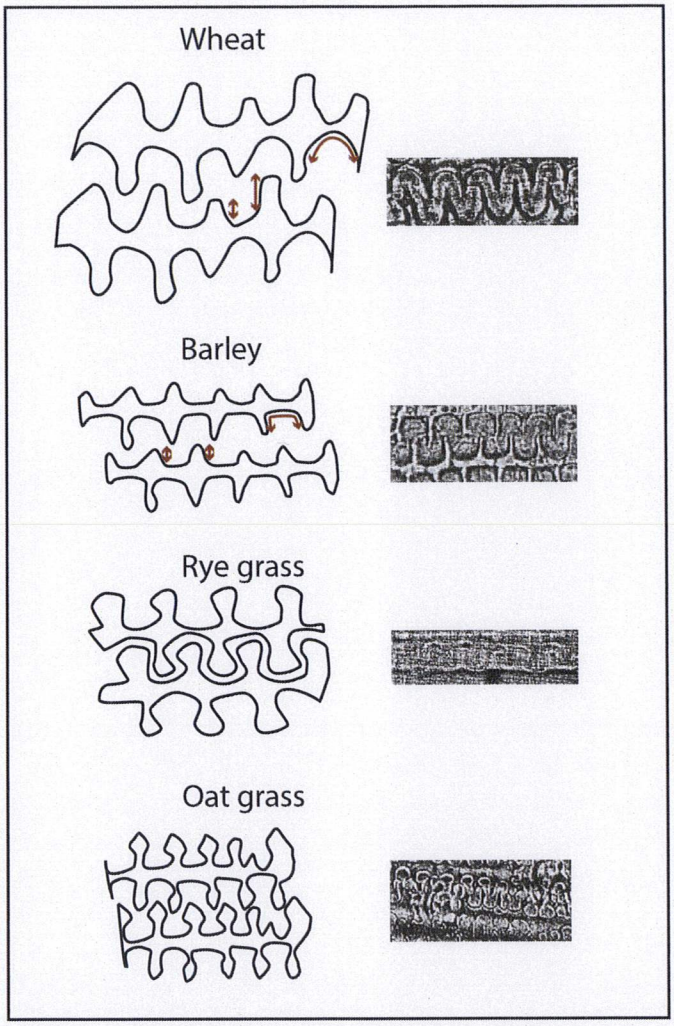

Figure 6: Diagramatic and pictoral representation of differences between elongate dendritic phytoliths from wheat, barley, rye grass and oat grass. Wheat have waves of irregular length and rounded bases (annotated in red); barley has waves of even amplitude and squared bases (annotated in red); rye grass has waves that are regular and rounded; oat grass has straight rod like highly ornamented waves (modified from Rosen, 1992).

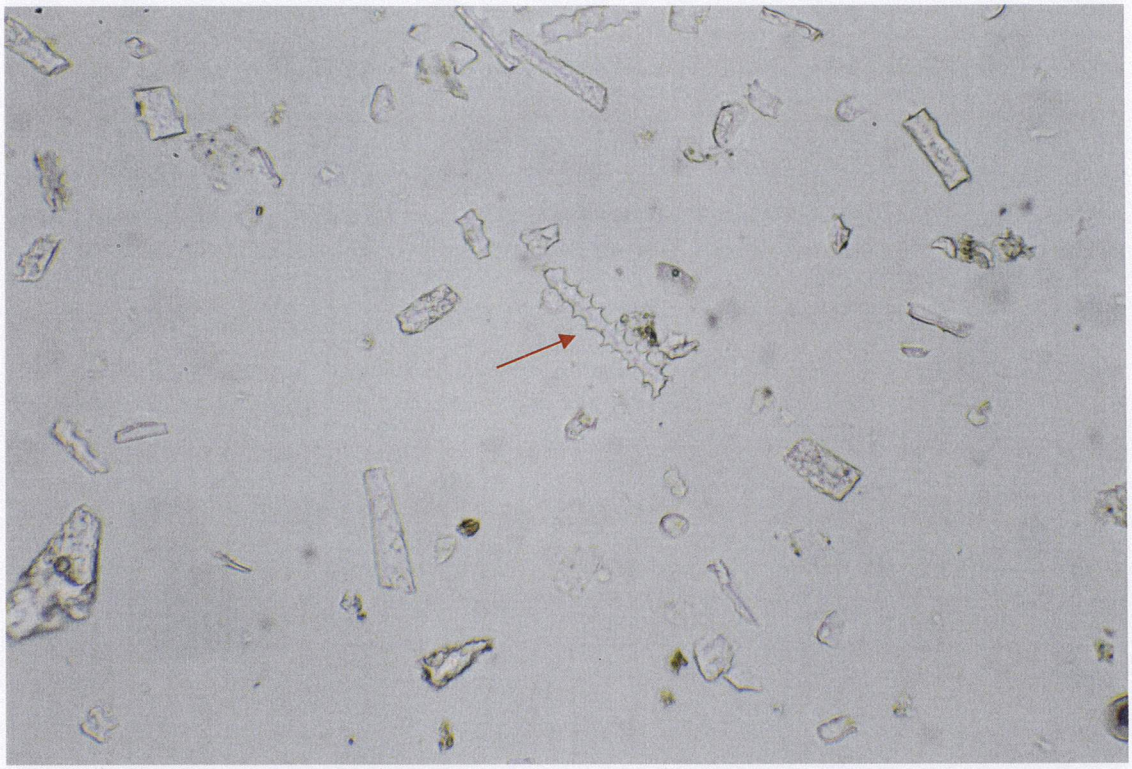

Figure 7: Elongate dendritic grass phytolith with waves similar to barley, sample <124>, to compare with Figure 6, Doveridge, Derbyshire.

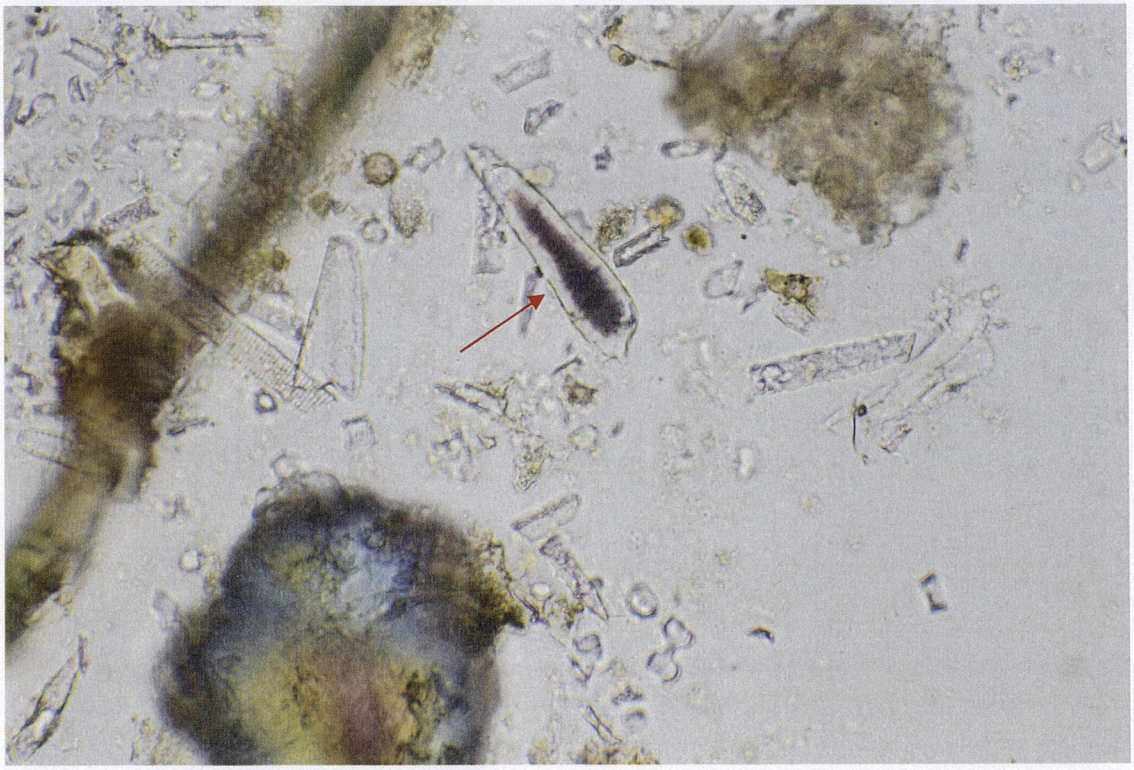

Figure 8: Hair/trichome grass phytolith, showing occluded carbon from exposre to fire, sample <124>, Doveridge, Derbyshire.

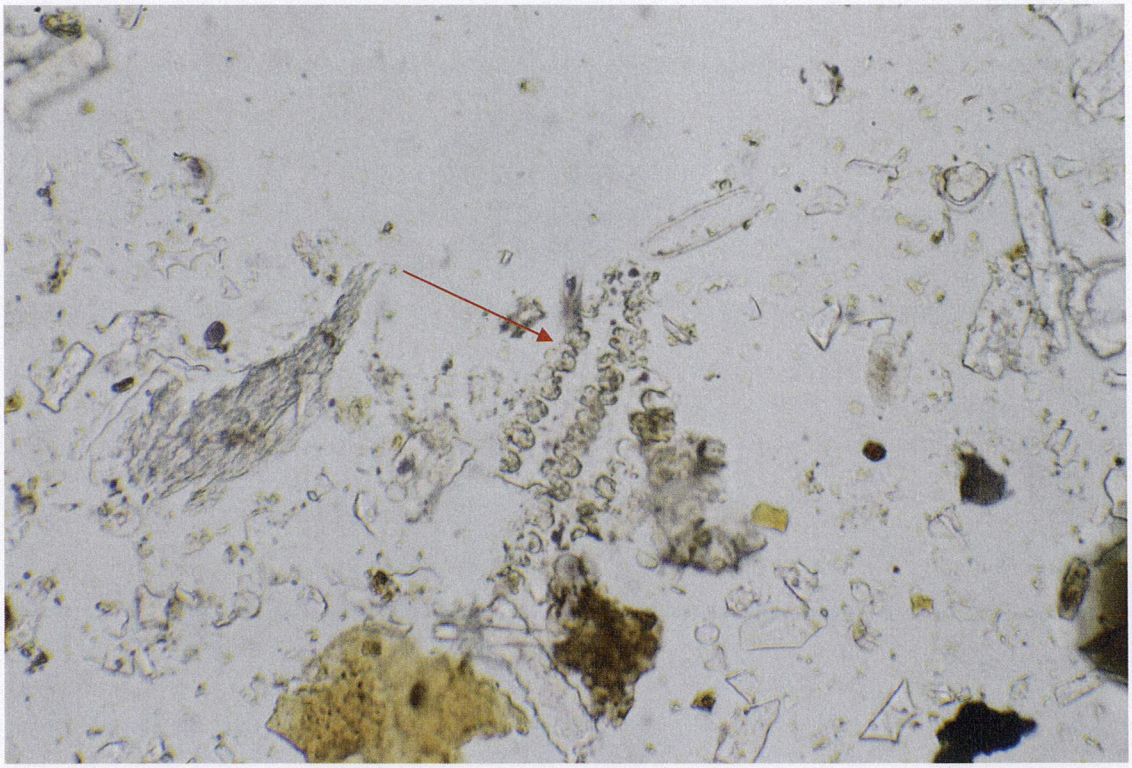

Figure 9: Multi-celled grass elongate dendritic, cf. barley, sample <124>, Doveridge, Derbyshire.

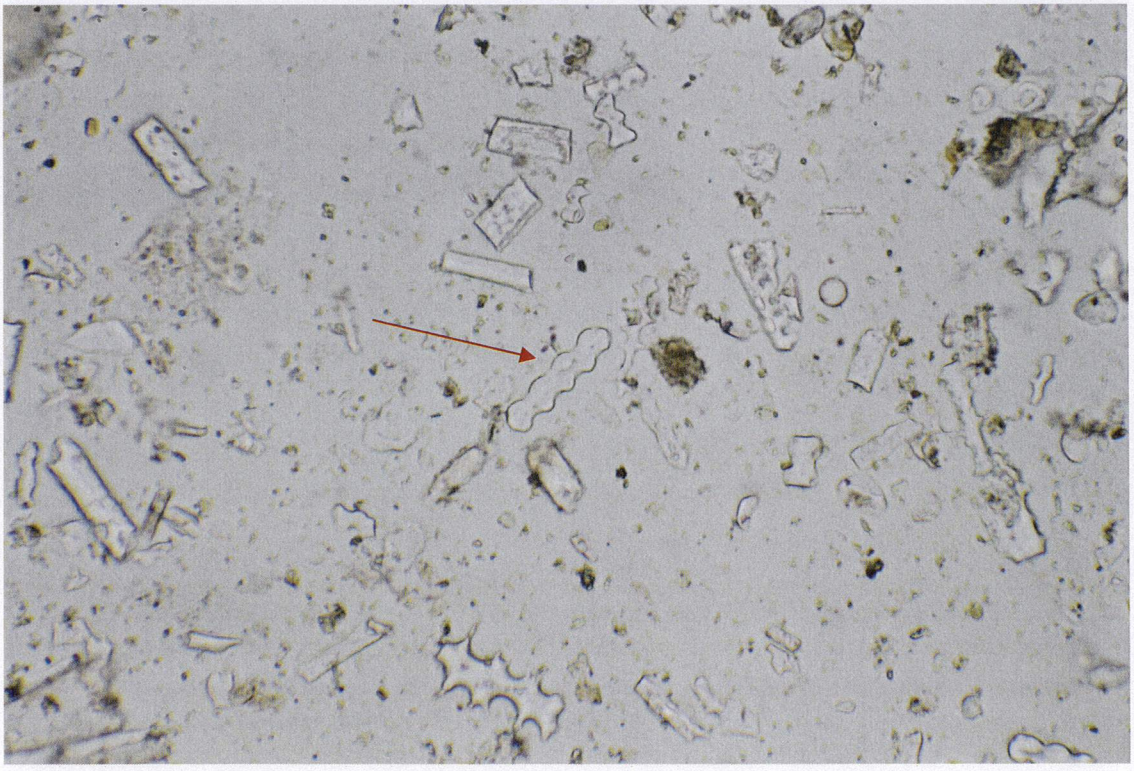

Figure 10 Creante grass phytolith, sample <124>, Doveridge, Derbyshire.

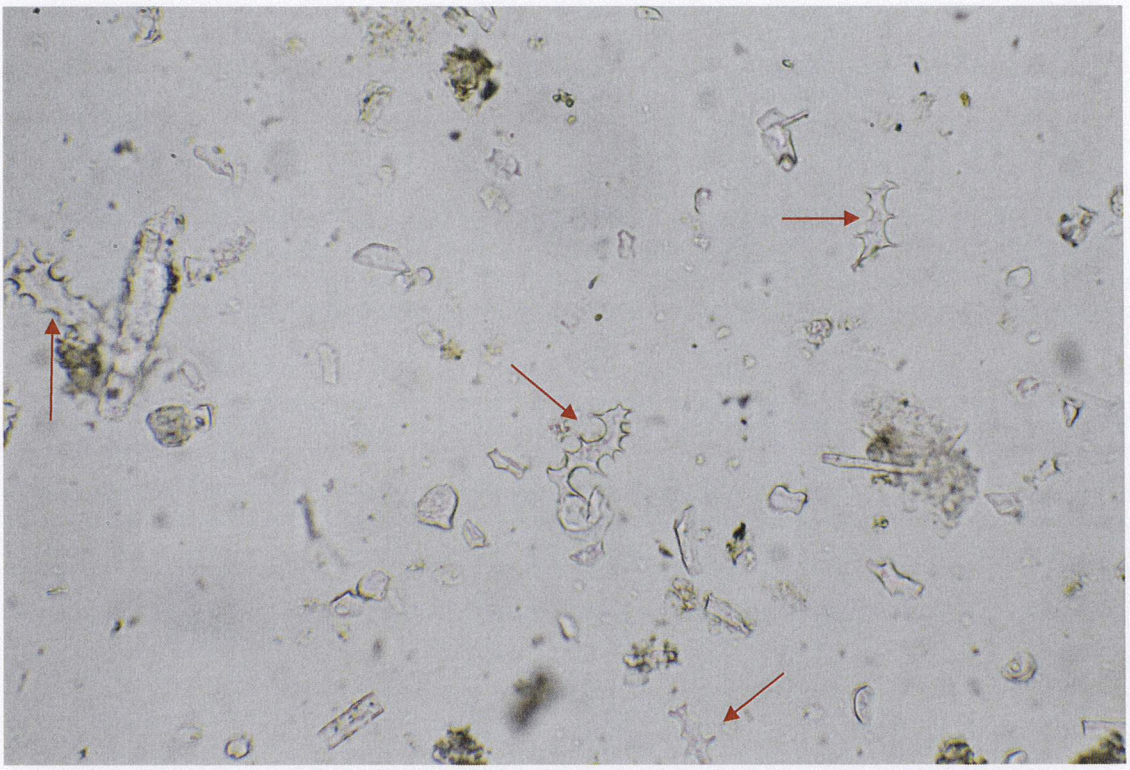

Figure 11: Elongate dendritic grass phygtoliths, sample <124>, Doveridge, Derbyshire.

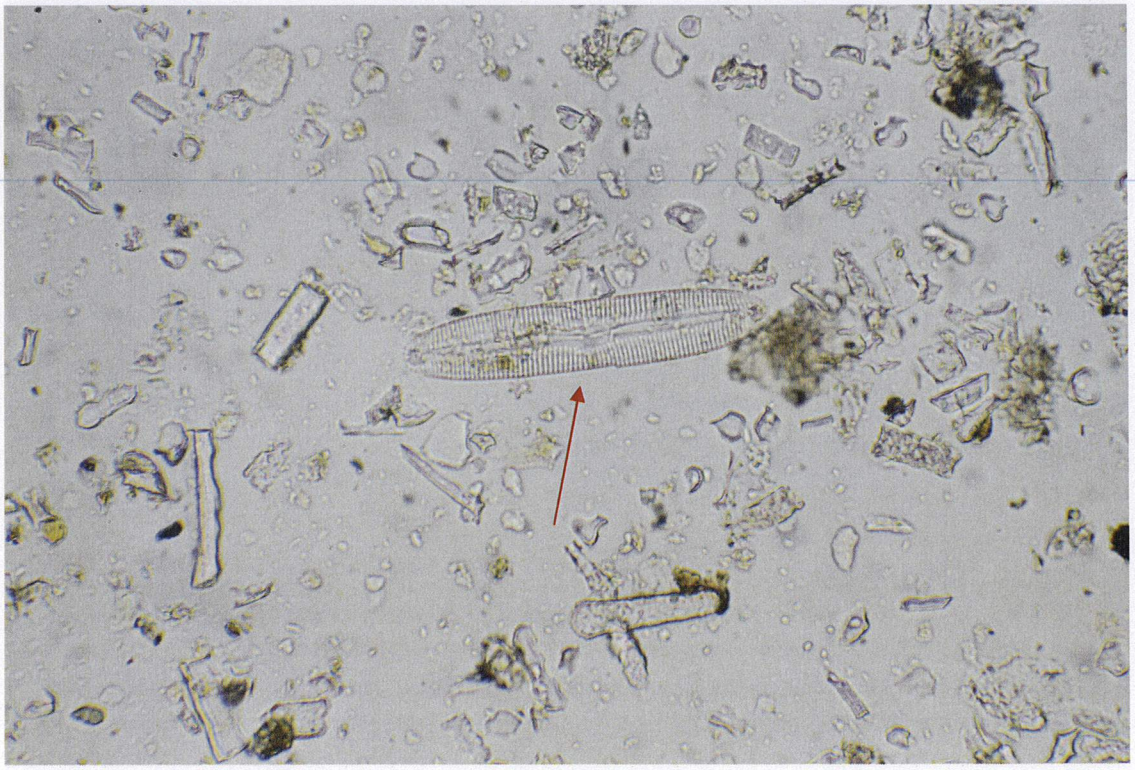

Figure 12: Diatom, sample <124 >, Doveridge, Derbyshire.

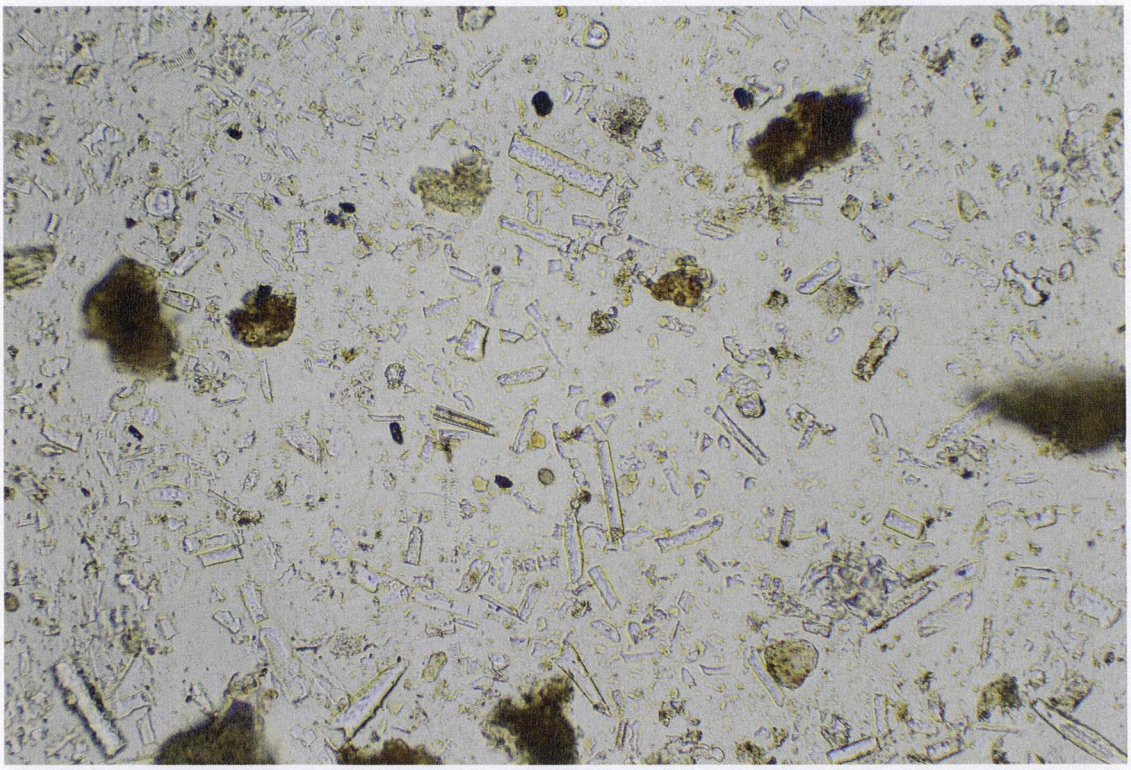

Figure 13: Photograph taken at x200 to show the number of phytoliths in each field of view, sample <124>, Doveridge, Derbyshire.

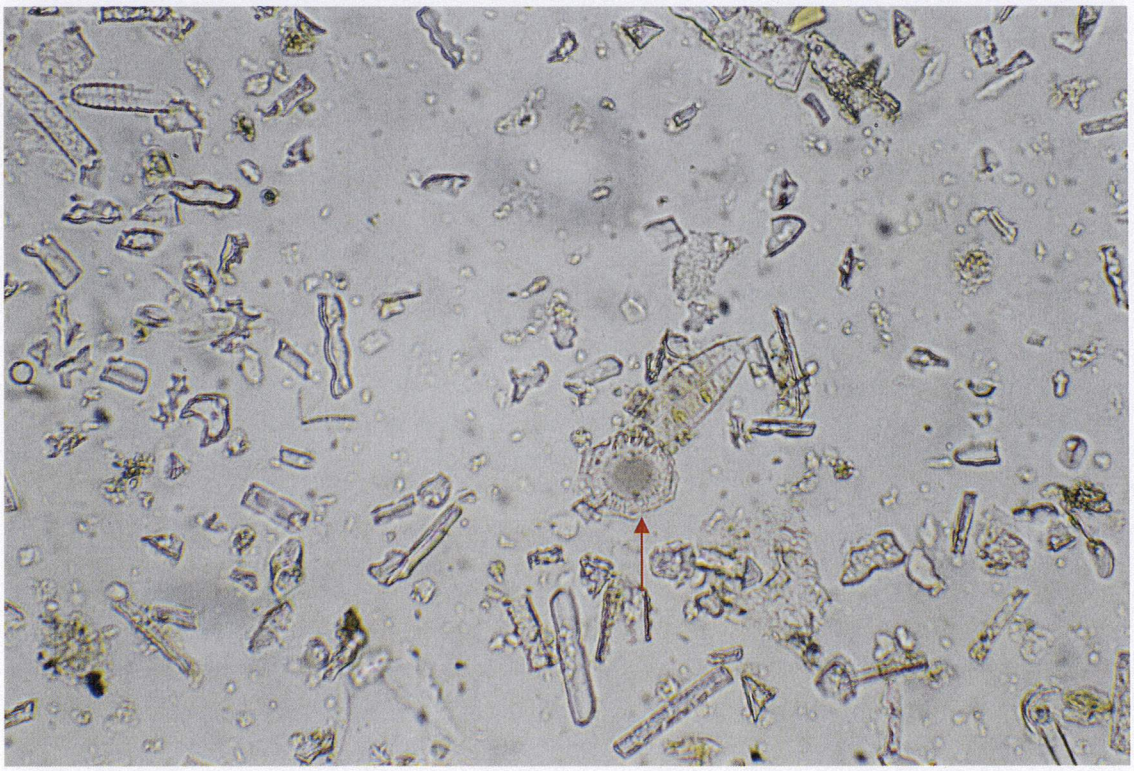

Figure 14: Detached papillae, with c.15 pits, sample <124>, Doveridge, Derbyshire.

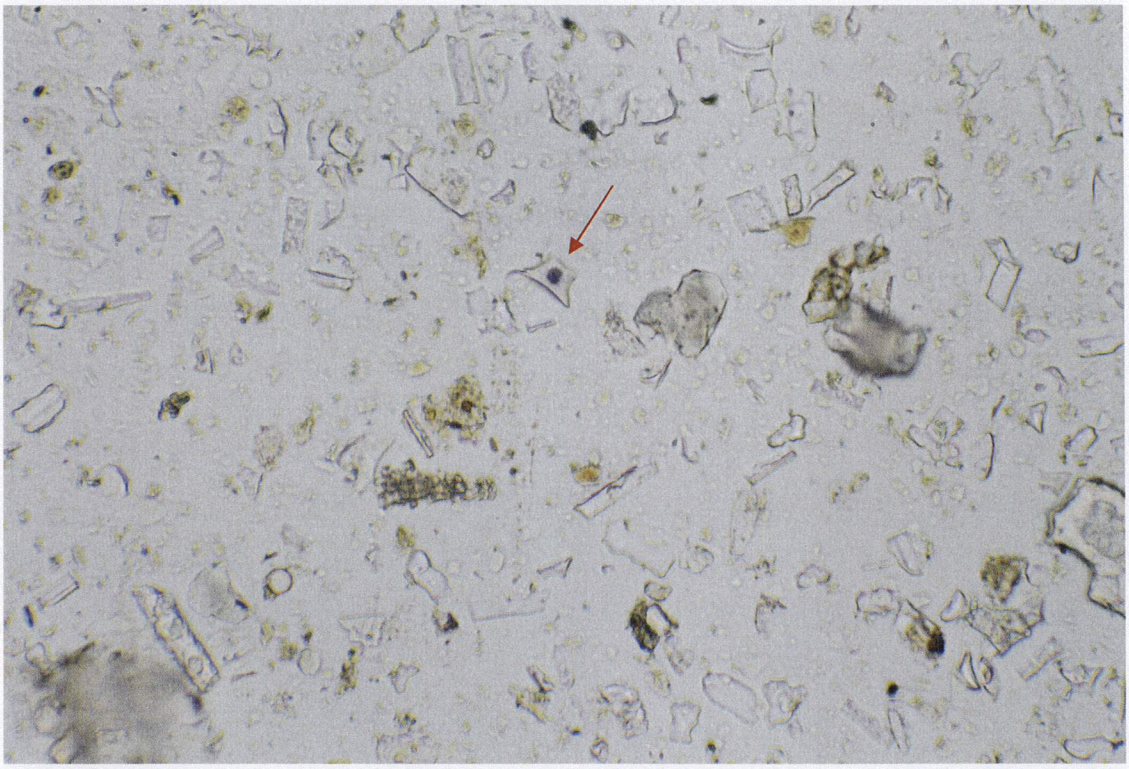

Figure 15: Short cell rondel phytolith from C3 pooideae grass, sample <124 >, Doveridge, Derbyshire.

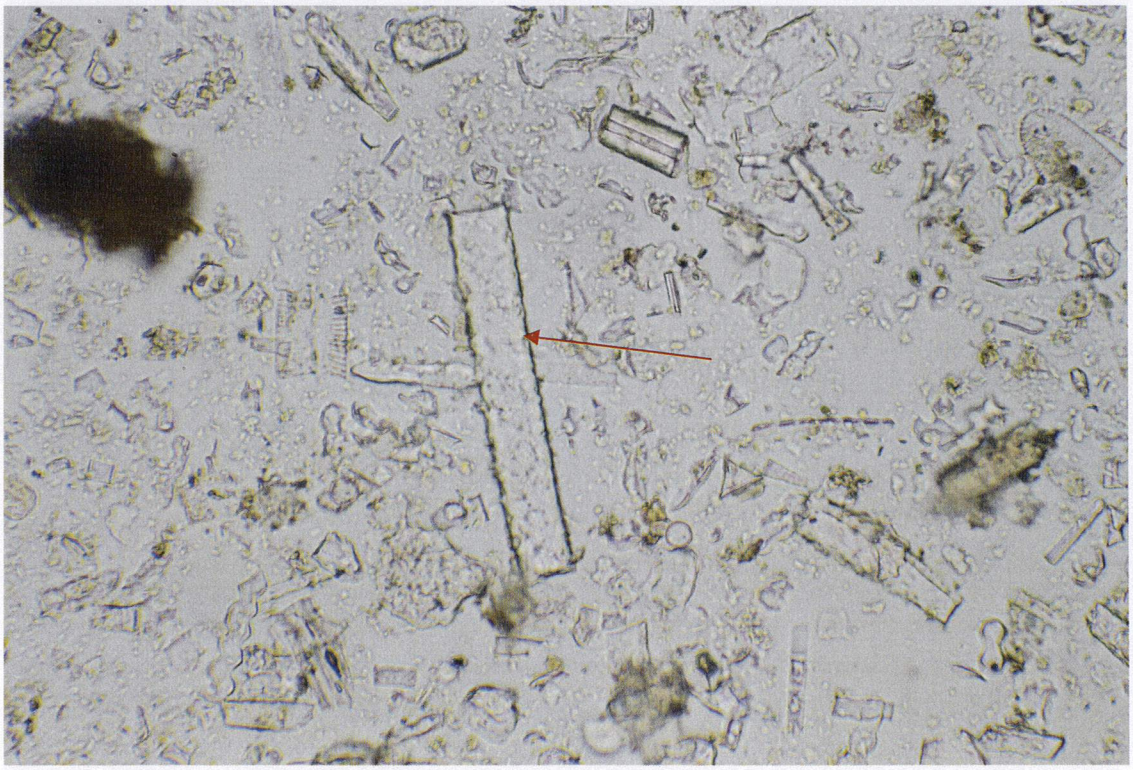

Figure 16: Grass leaf/tem elongate smooth, sample <124 >, Doveridge, Derbyshire.

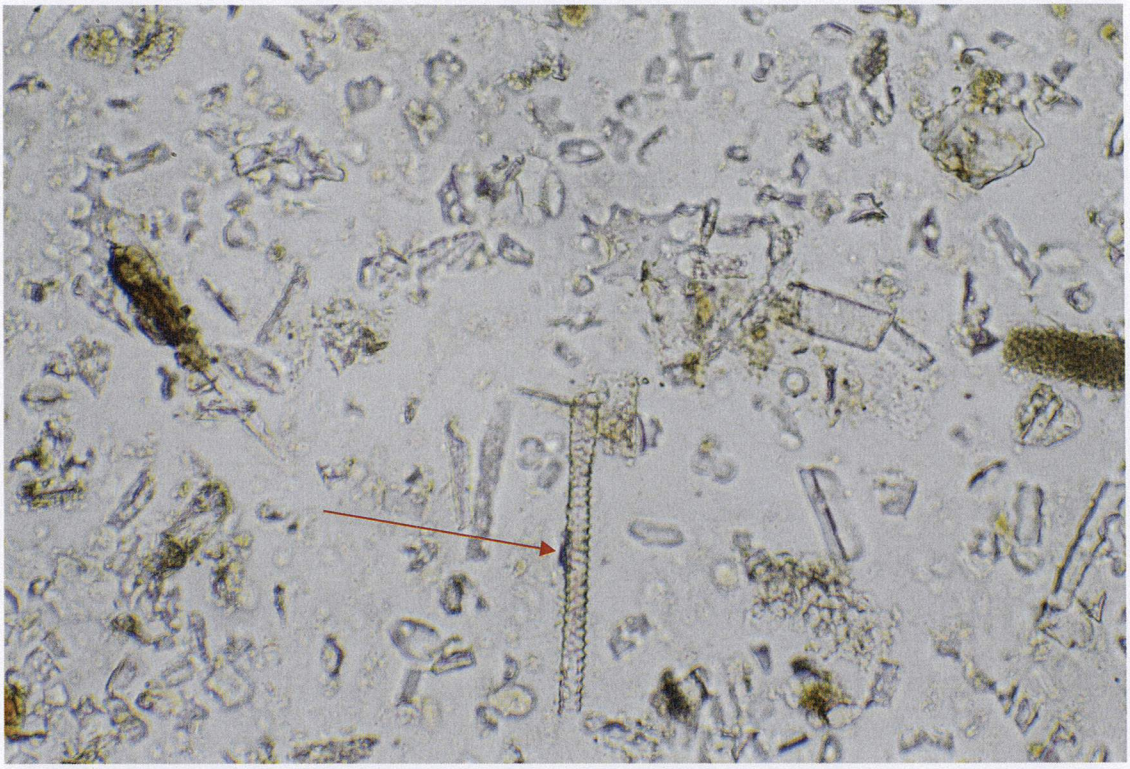

Figure 17 : Dicotyledon tracheid, sample <124>, Doveridge, Derbyshire.

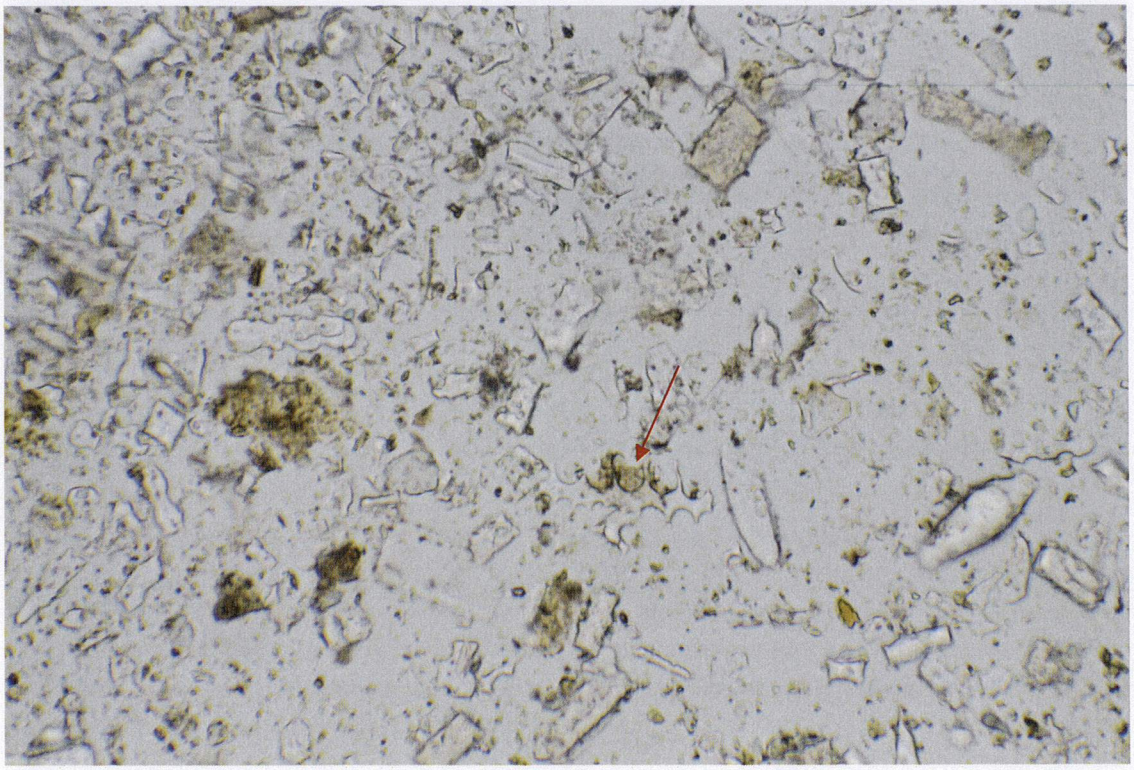

Figure 18: Elongate dendritic grass phytolith with waves similar to wheat, sample <124>, to compare with Figure 6, Doveridge, Derbyshire.

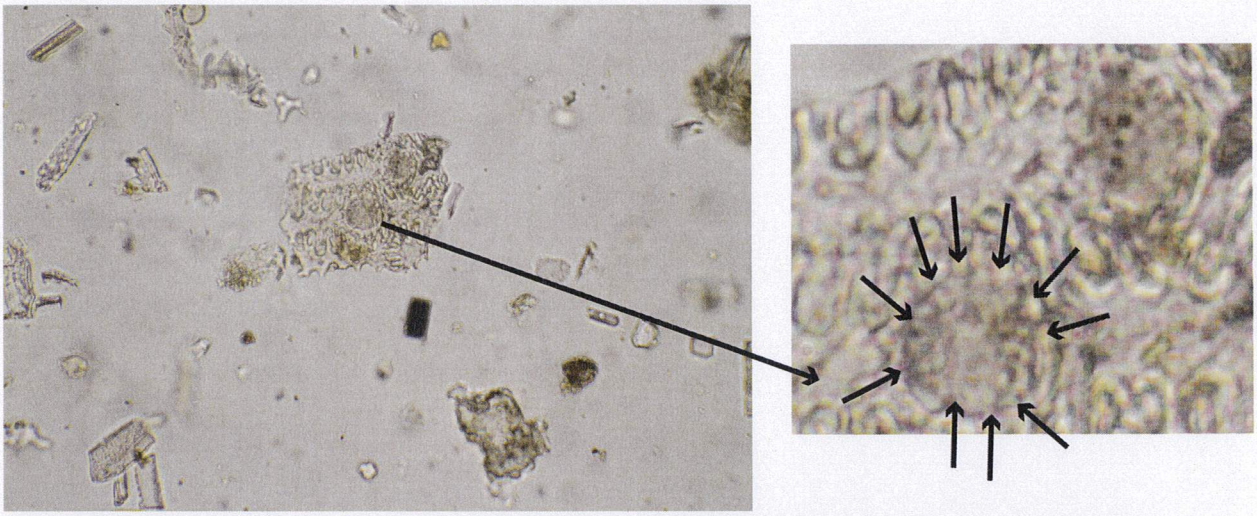

Figure 19: Multi-celled grass elongate dendritc with papillae with 10 pits (indicated on the right with arrows) from wheat (compare with Figure 6), sample <128>, Doveridge, Derbyshire.

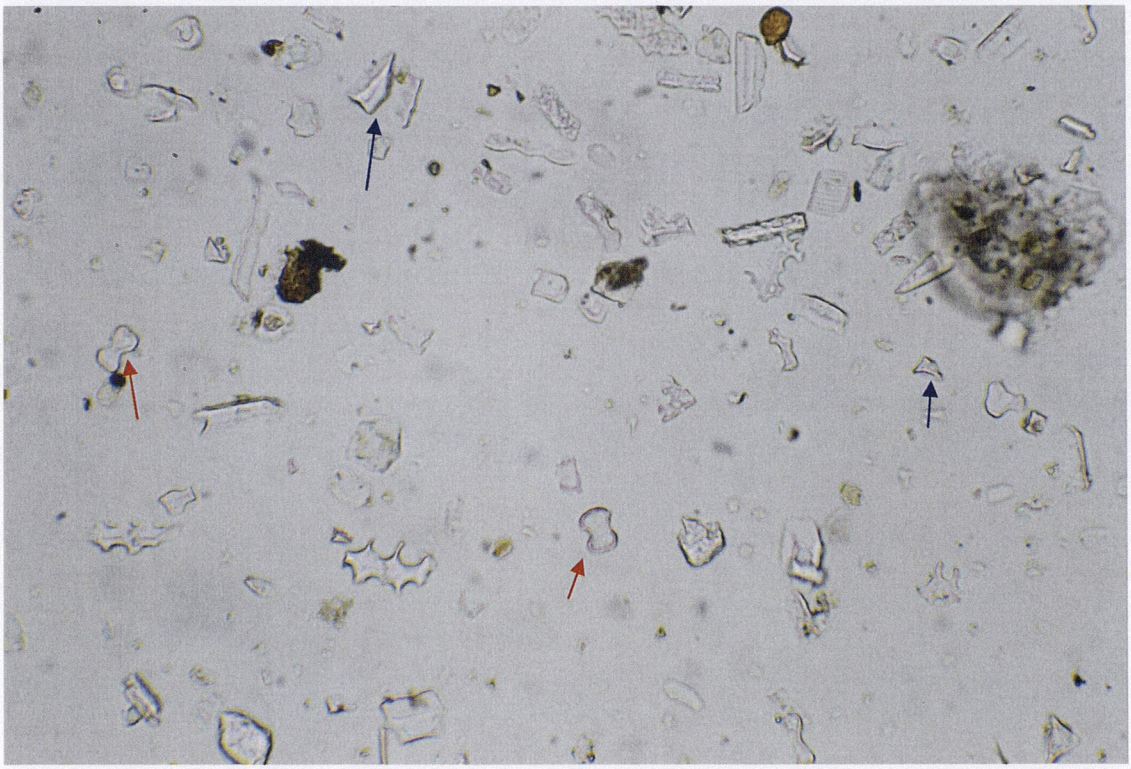

Figure 20: Short celled phytoliths, rondels from C3 pooideae grasses in red and bilobes from C4 panicoideae grasses in blue, sample <128>, Doveridge, Derbyshire.

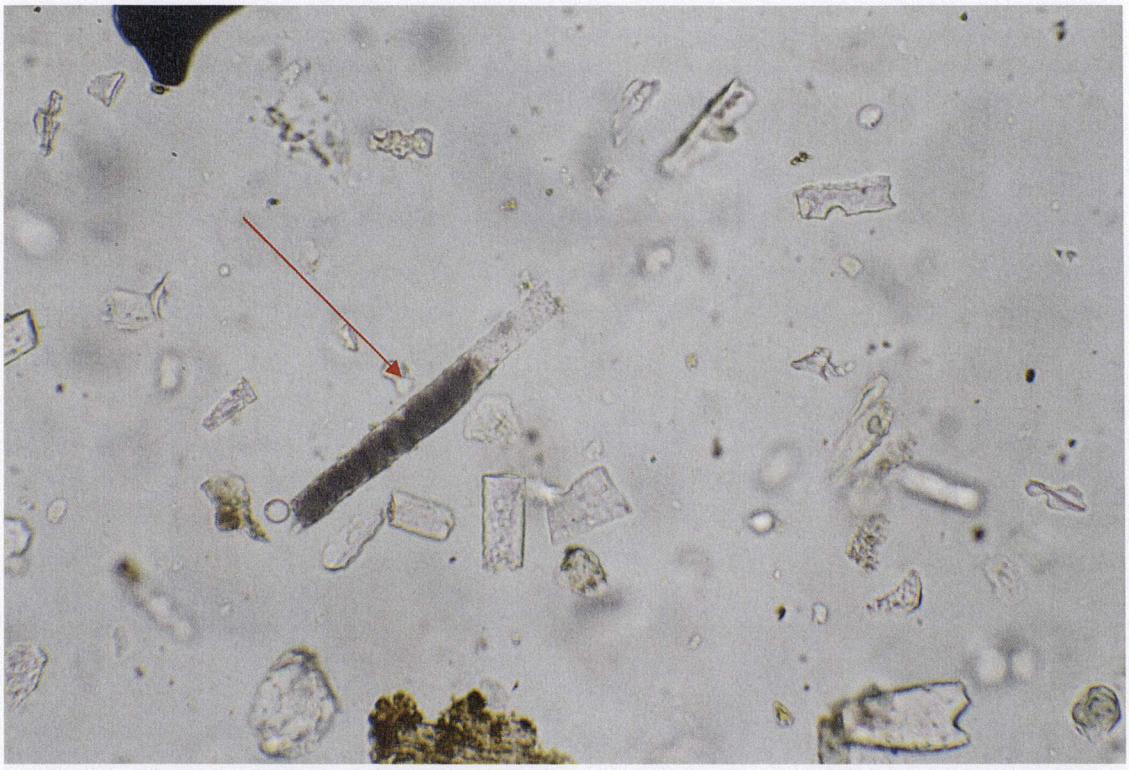

Figure 21: Grass elongate smooth phytolith with occuluded carbon from exposure to fire, sample <128>, Doveridge, Derbyshire.

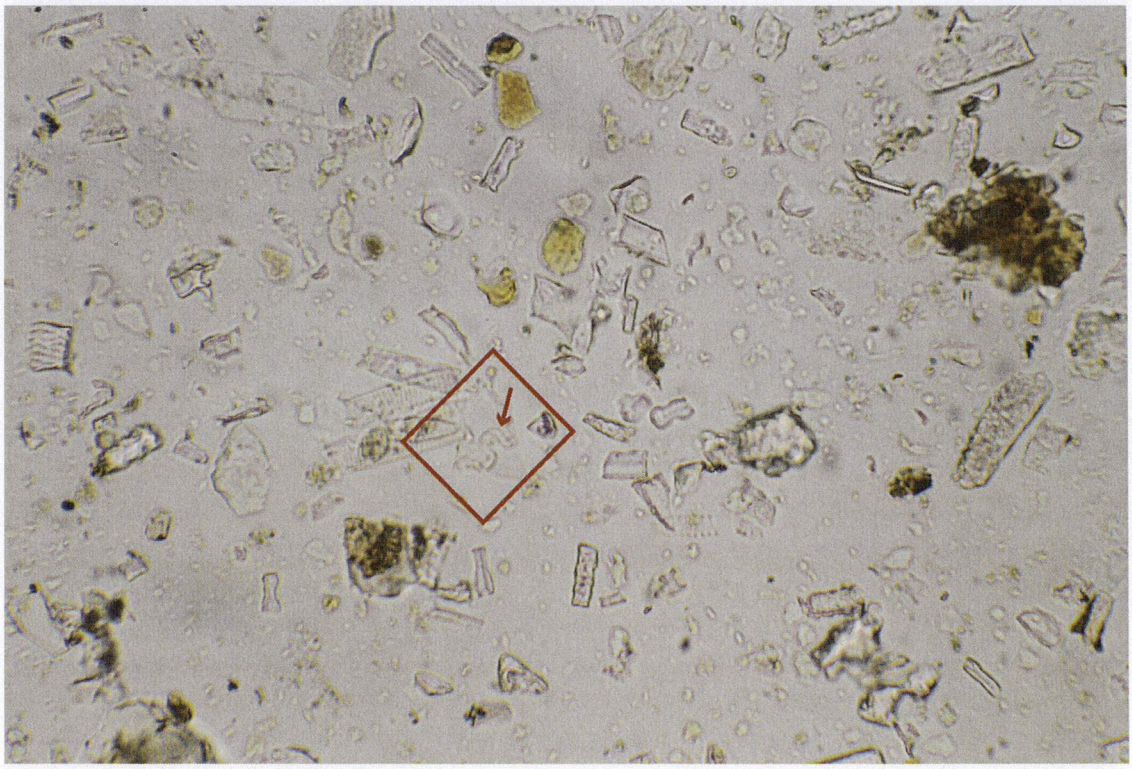

Figure 22: Elongate dendritic grass phytolith with waves similar to rye, sample <128>, compare with Figure 6, Doveridge, Derbyshire.

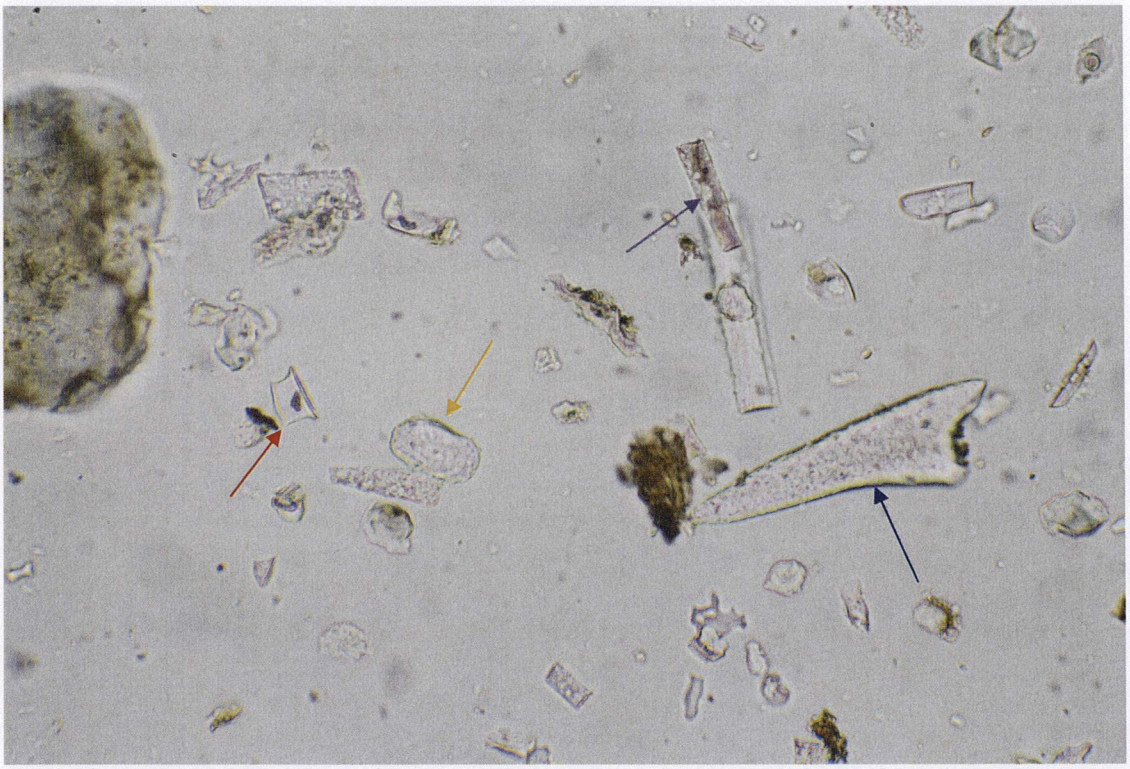

Figure 23: Grass phytoltihs : rondel (red), hair/trichome (blue), elongate smooth (purple), bulliform (yellow), Doveridge, Derbyshire.

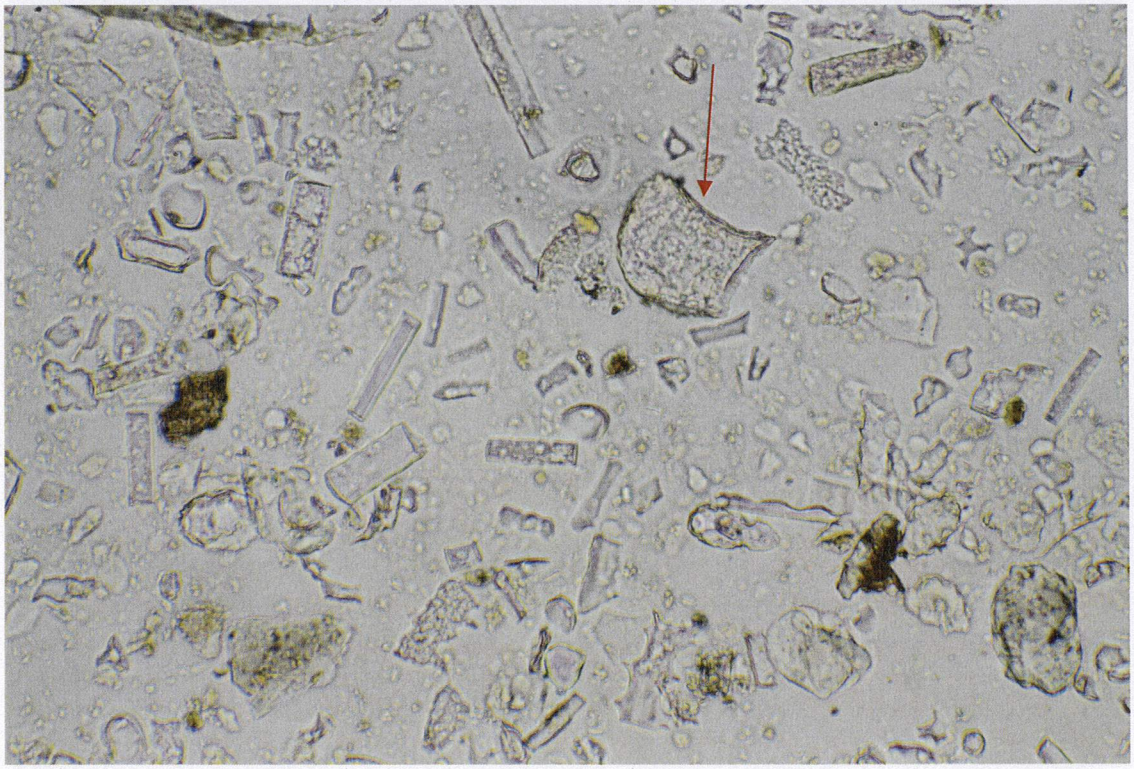

Figure 24: Grass keystone phytolith showing slight degradation on surface, sample <128>, Doveridge, Derbyshire.

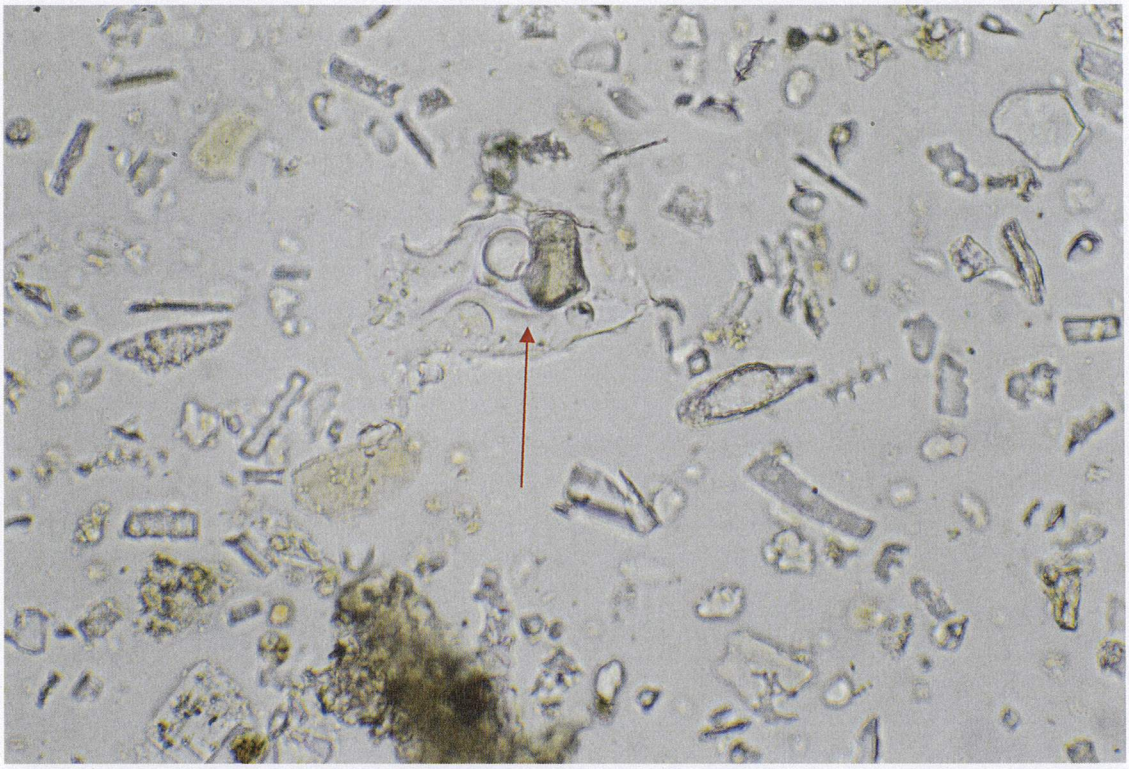

Figure 25: Melted silica, sample <128 >, Doveridge, Derbyshire.

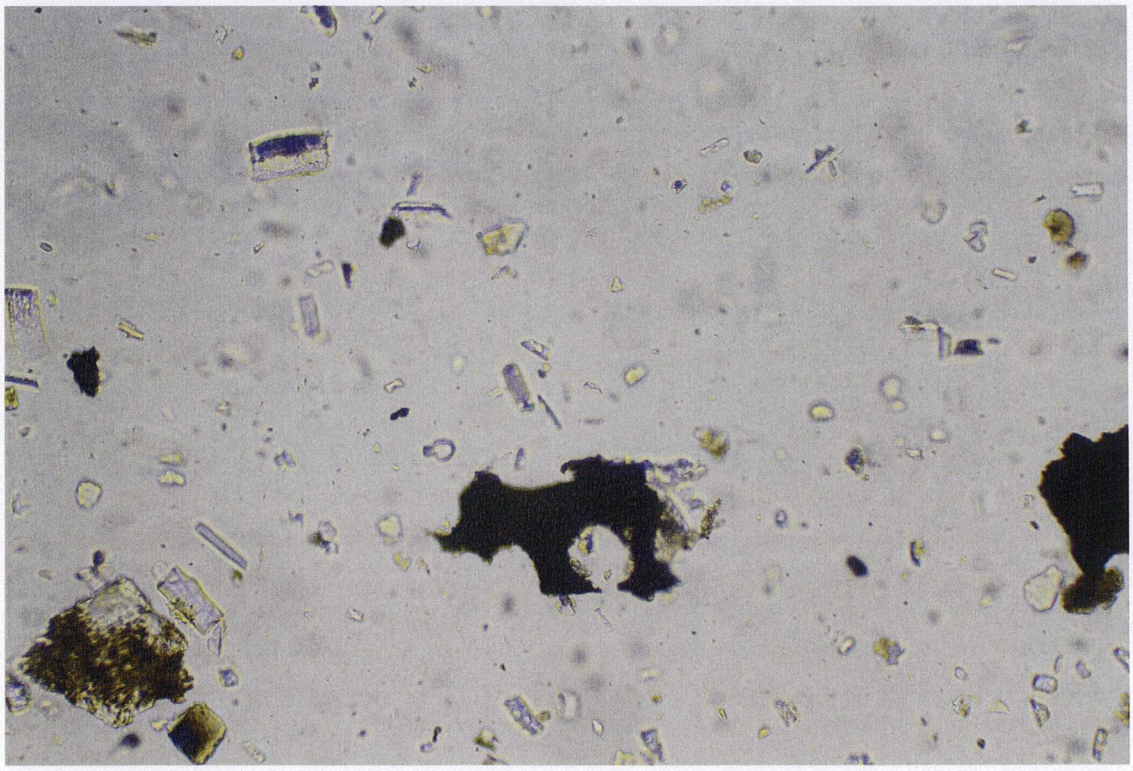

Figure 26: Microcharcoal observed in sample <128>, Doveridge, Derbyshire.

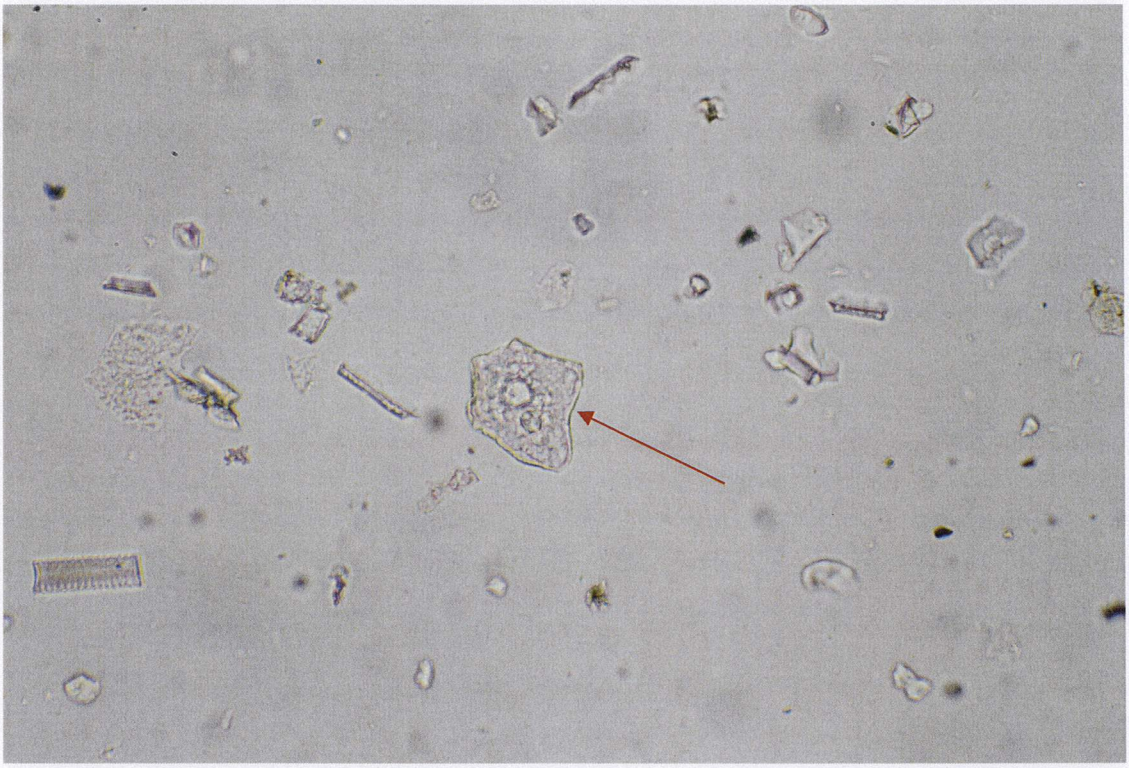

Figure 27: Polyhedral granulate from sedge (*Cyperaceae*), sample <128>, Doveridge, Derbyshire.

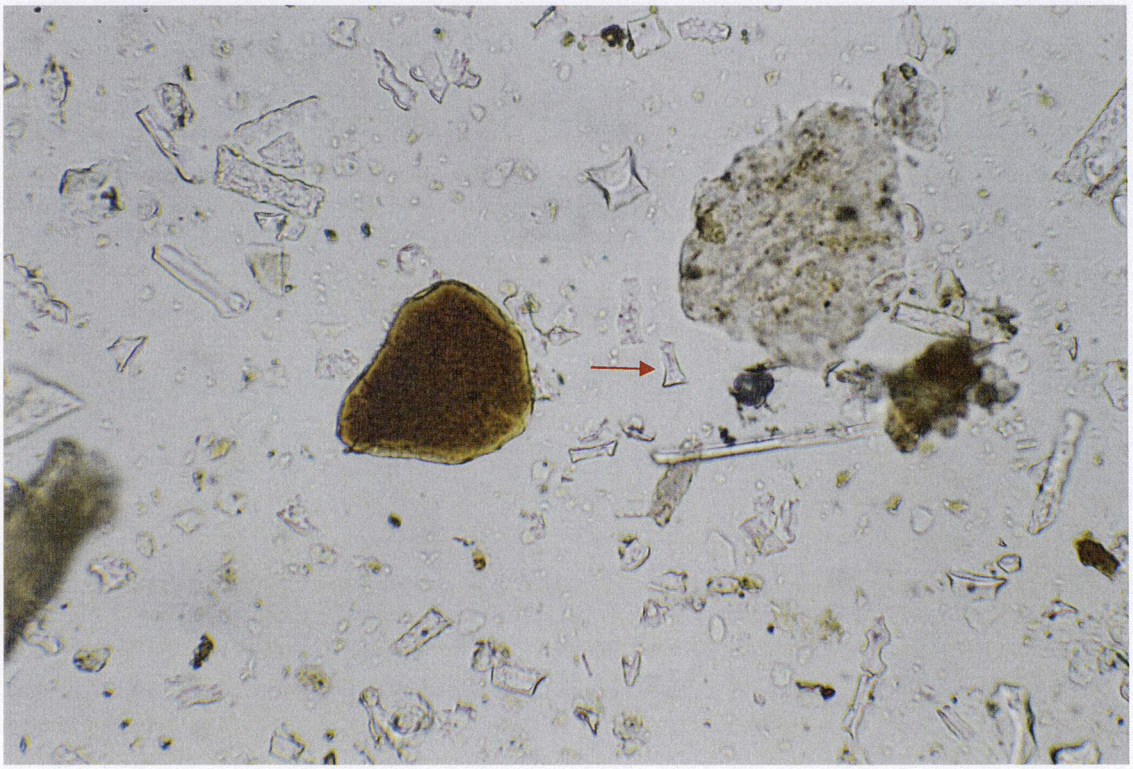

Figure 28: Grass tall rondel phytolith, sample <128>, Doveridge, Derbyshire.

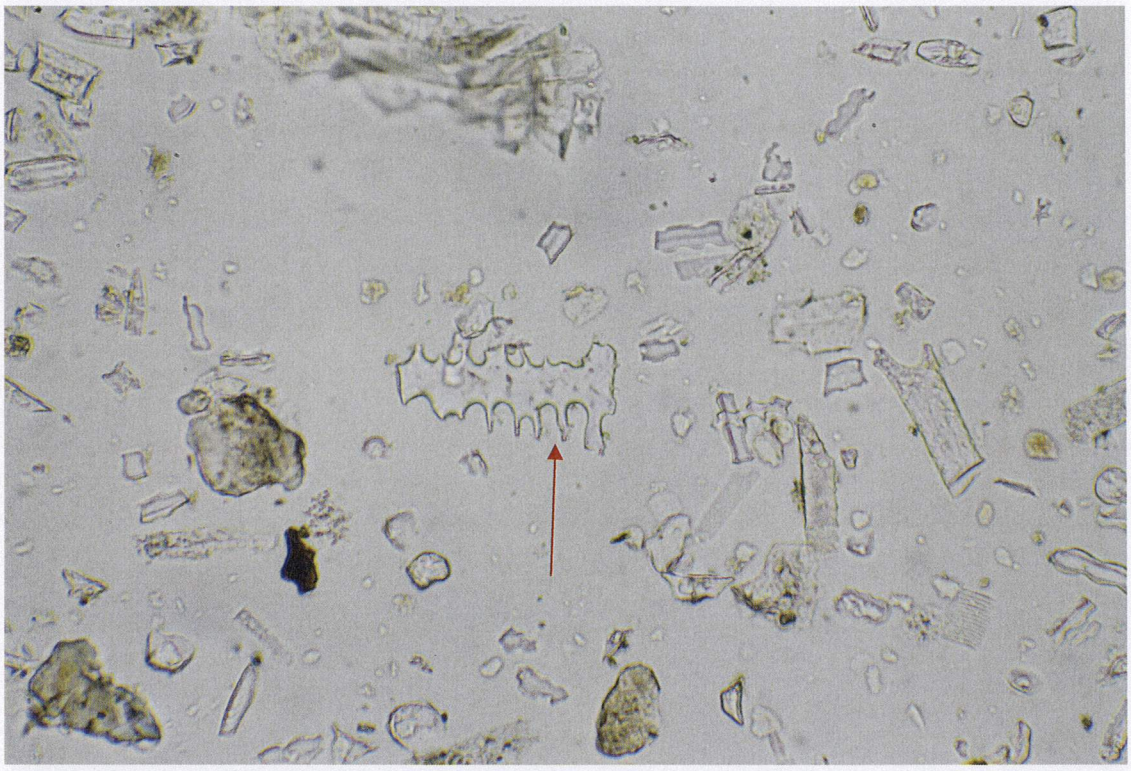

Figure 29: Elongate dendritic grass phytolith with waves similar to Wheat, sample <128>, to compare with Figure 6, Doveridge, Derbyshire.

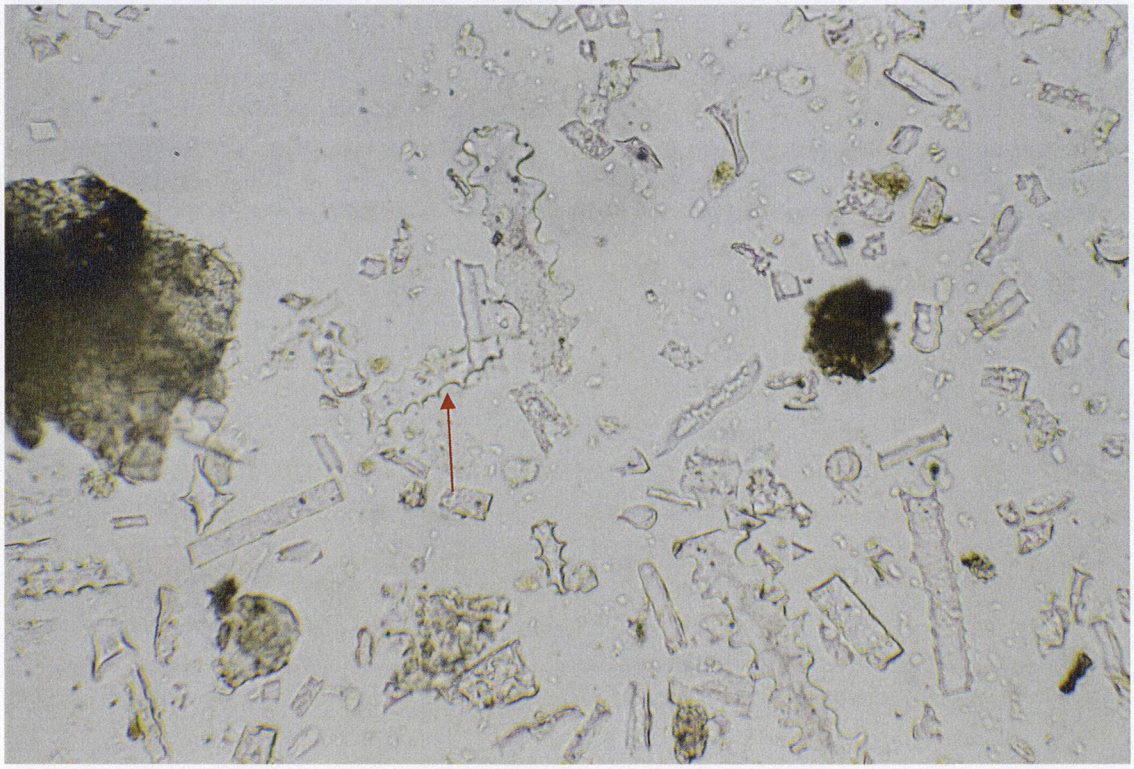

Figure 30: Elongate dendritic grass phytolith with waves similar to barley, sample <131>, to compare with Figure 6, Doveridge, Derbyshire.

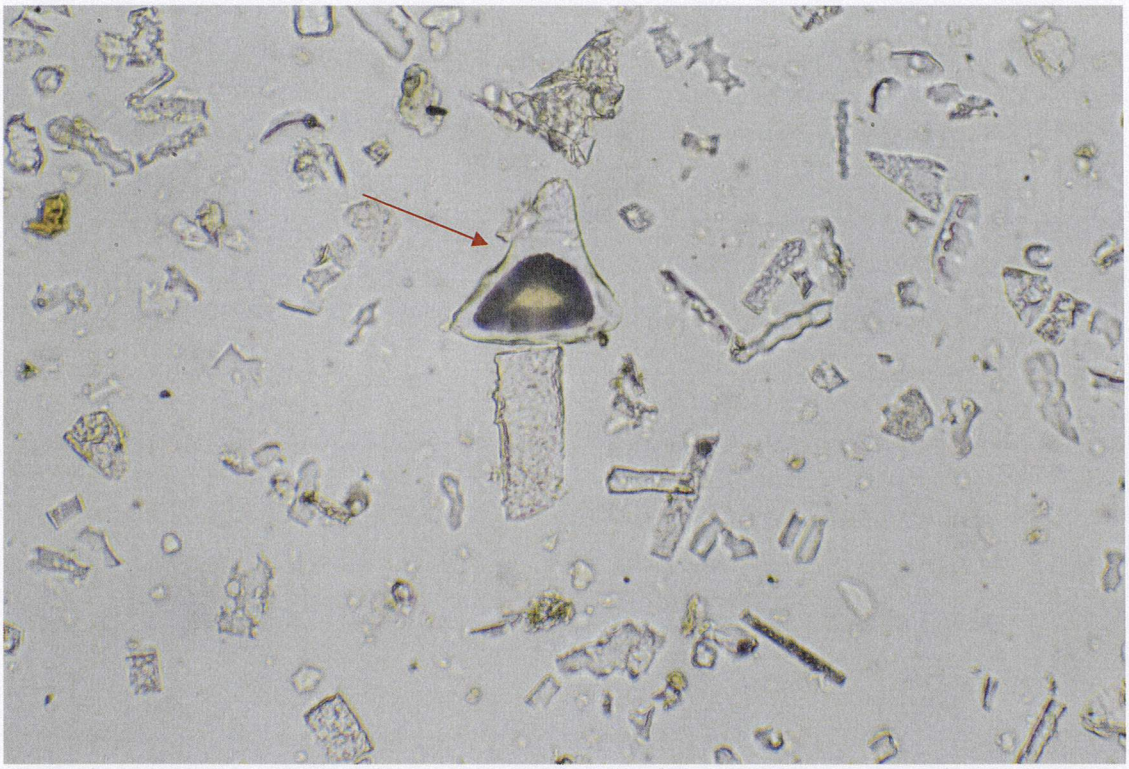

Figure 31: Keystone phytolith with occluded carbon from exposure to fire, sample <131>, Doveridge, Derbyshire.

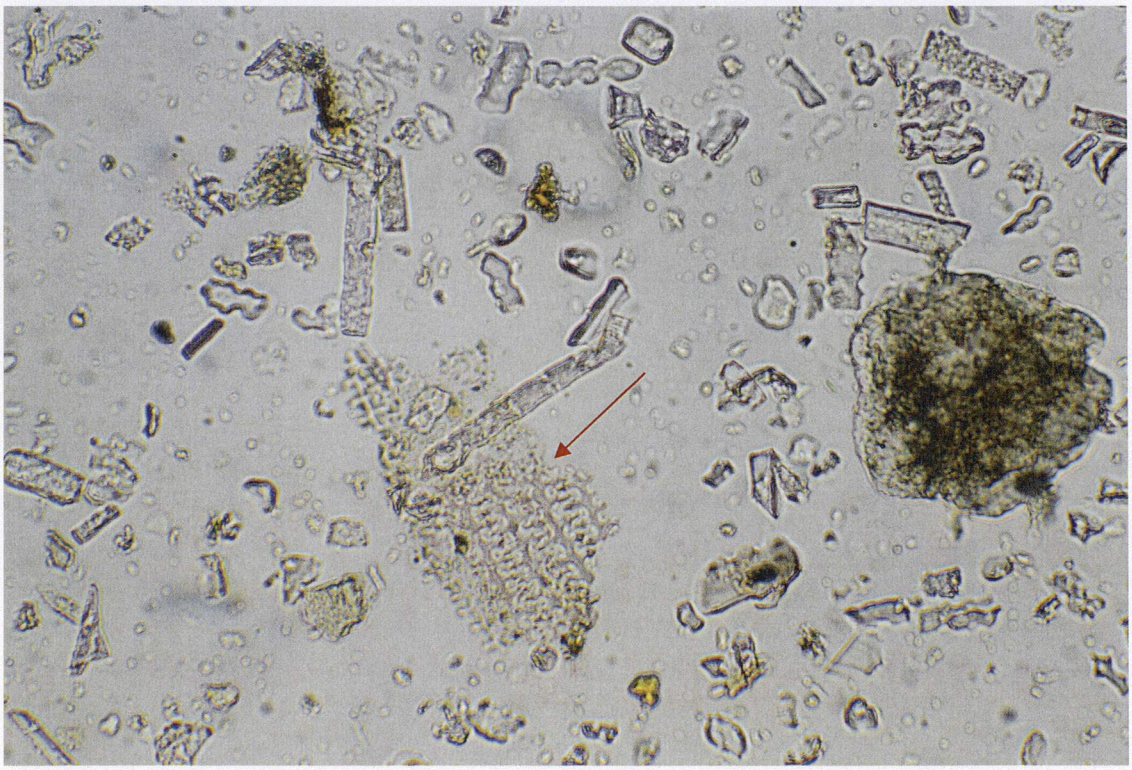

Figure 32: Multi-celled grass inflorescenvce phytoliths cf. Oat Grass, sample <131>, to compare with Figure 6, Doveridge, Derbyshire.

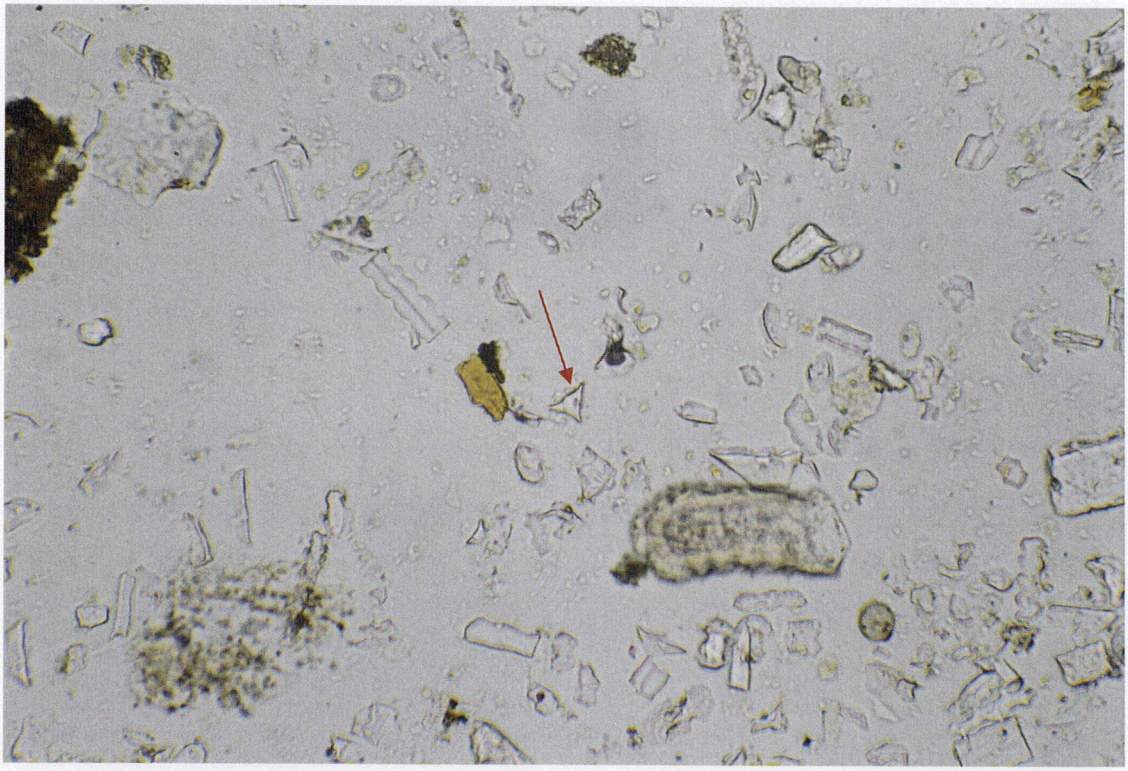

Figure 33: Cone phytolith from sedges (*Cyperaceae*), sample <131>, Doveridge, Derbyshire.

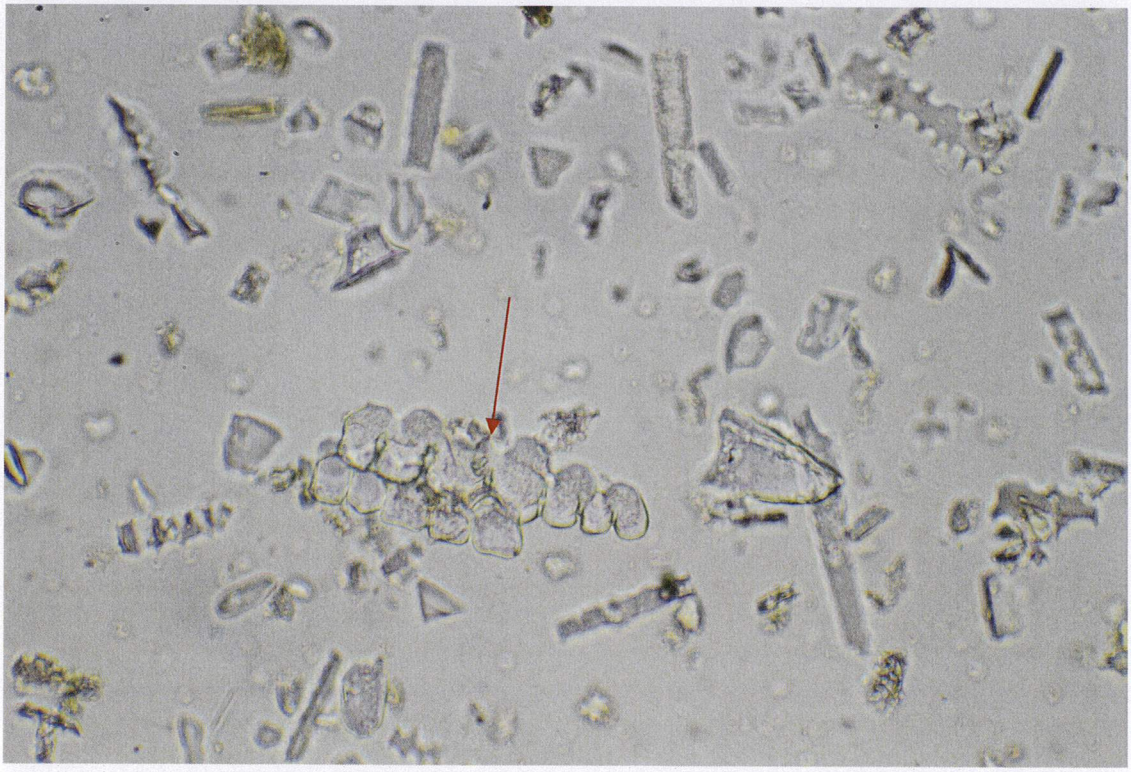

Figure 34: Conjoined grass bulliforms, sample <131>, Doveridge, Derbyshire.

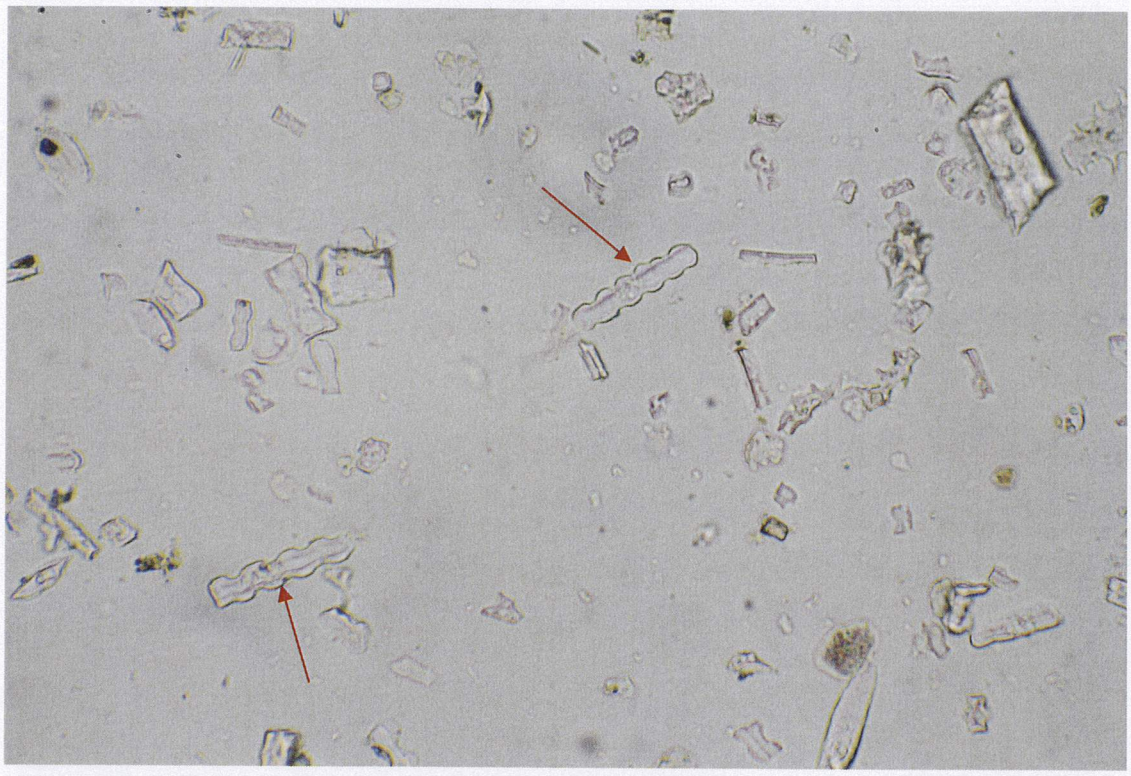

Figure 35: Grass crenate phytoliths from C3 pooideae grasses, sample <131>, Doveridge, Derbyshire.

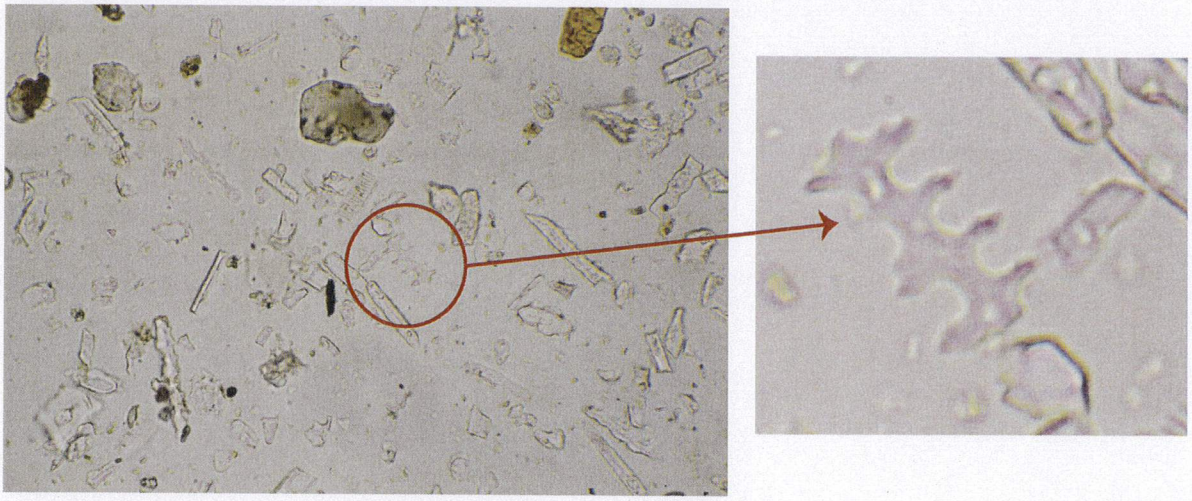

Figure 36: Elongate dendritic grass phytolith with waves similar to oat grass, sample <131>, to compare with Figure 6, Doveridge, Derbyshire.

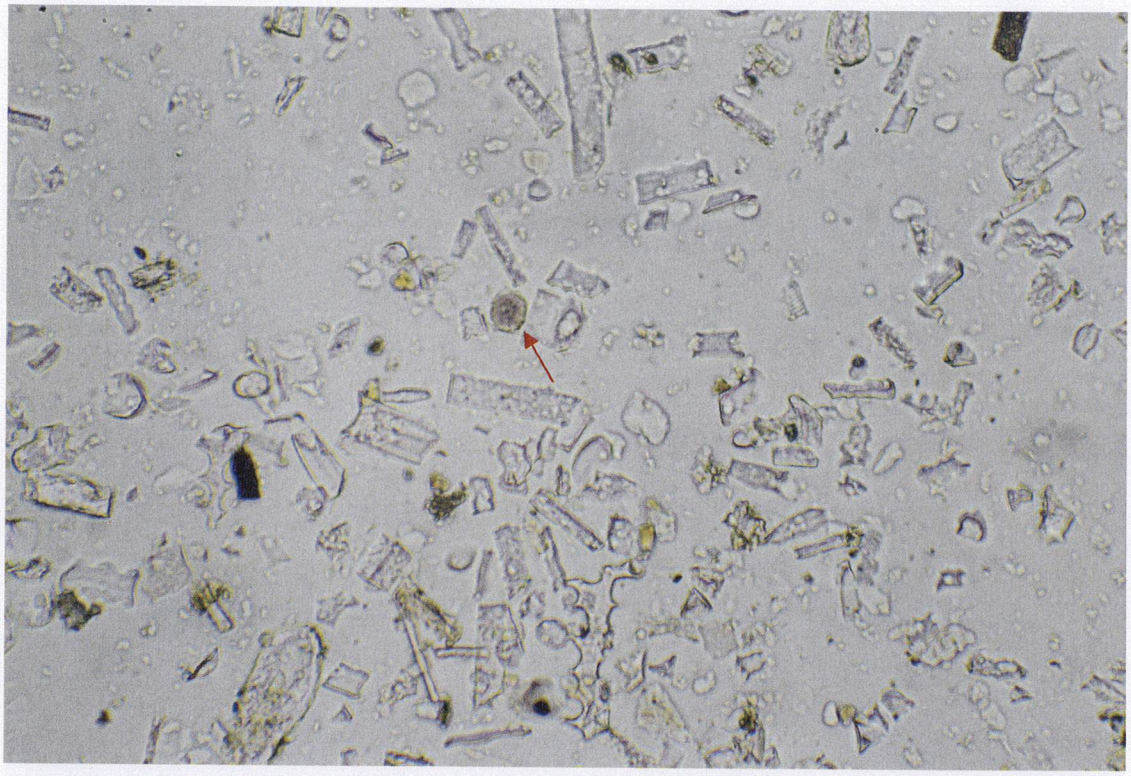

Figure 37: Dicotyledonous globular granulate phytolith, sample <131>, Doveridge, Derbyshire.

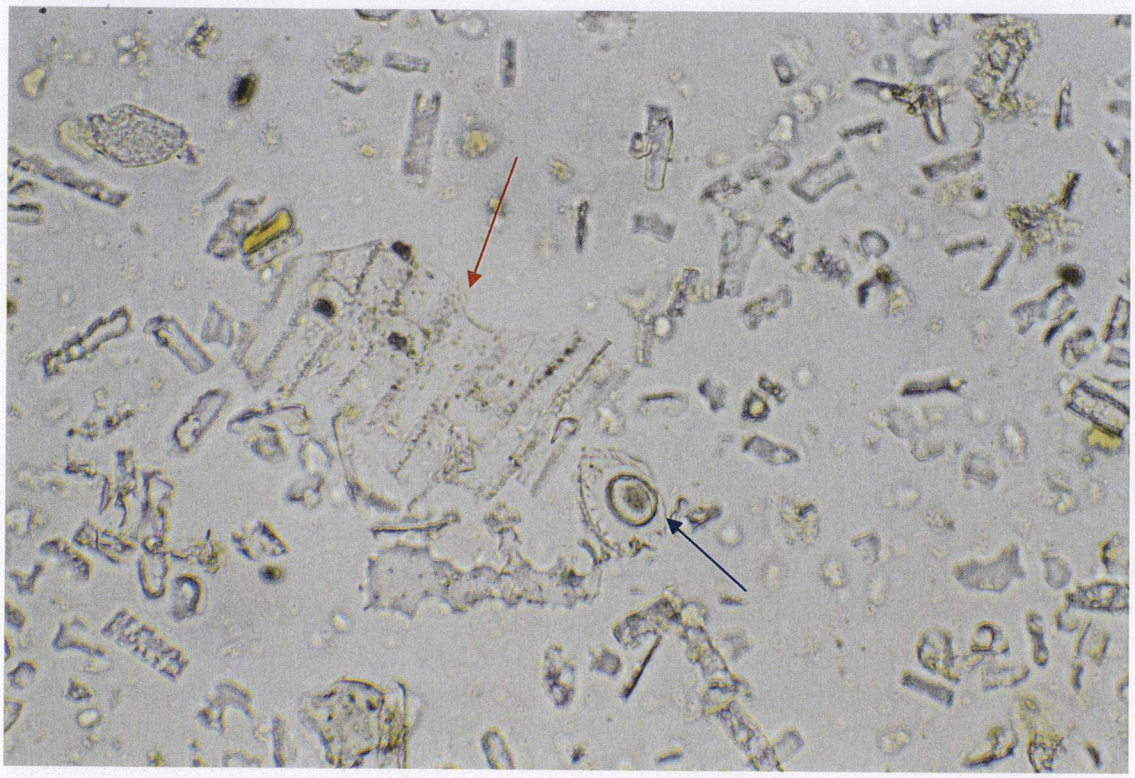

Figure 38: Grass leaf/stem multi-cell (red) and detached papillae with c.10 pits (blue), sample <131>, Doveridge, Derbyshire.

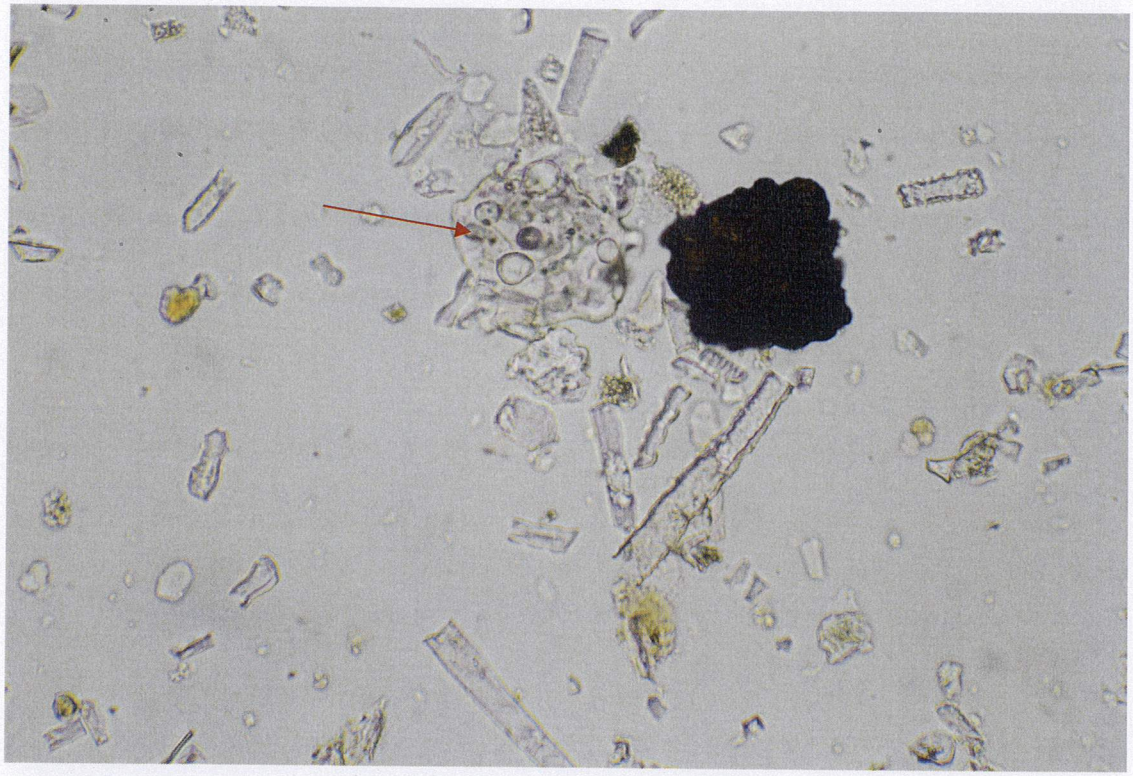

Figure 39: Melted silica, sample <131>, Doveridge, Derbyshire.

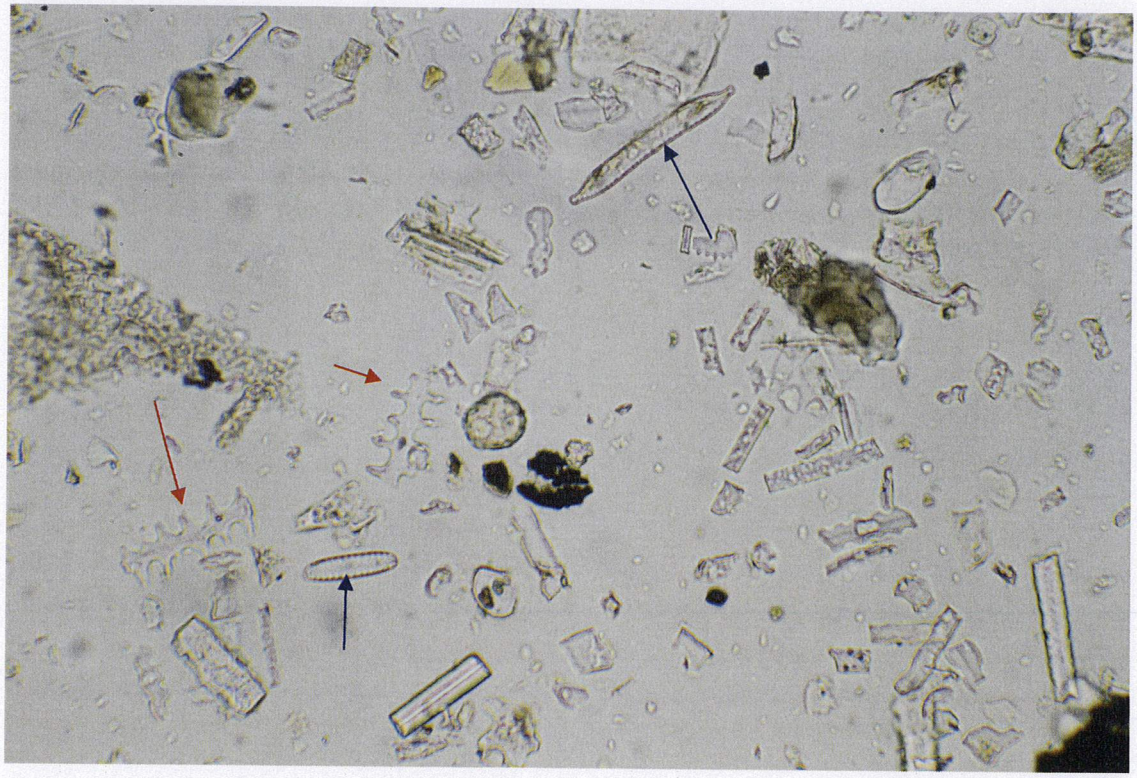

Figure 40: Two elongate dendritic grass phytoliths with waves similar to oat grass (red), to compare with Figure 6, and diatoms (blue), sample <131>, Doveridge, Derbyshire.

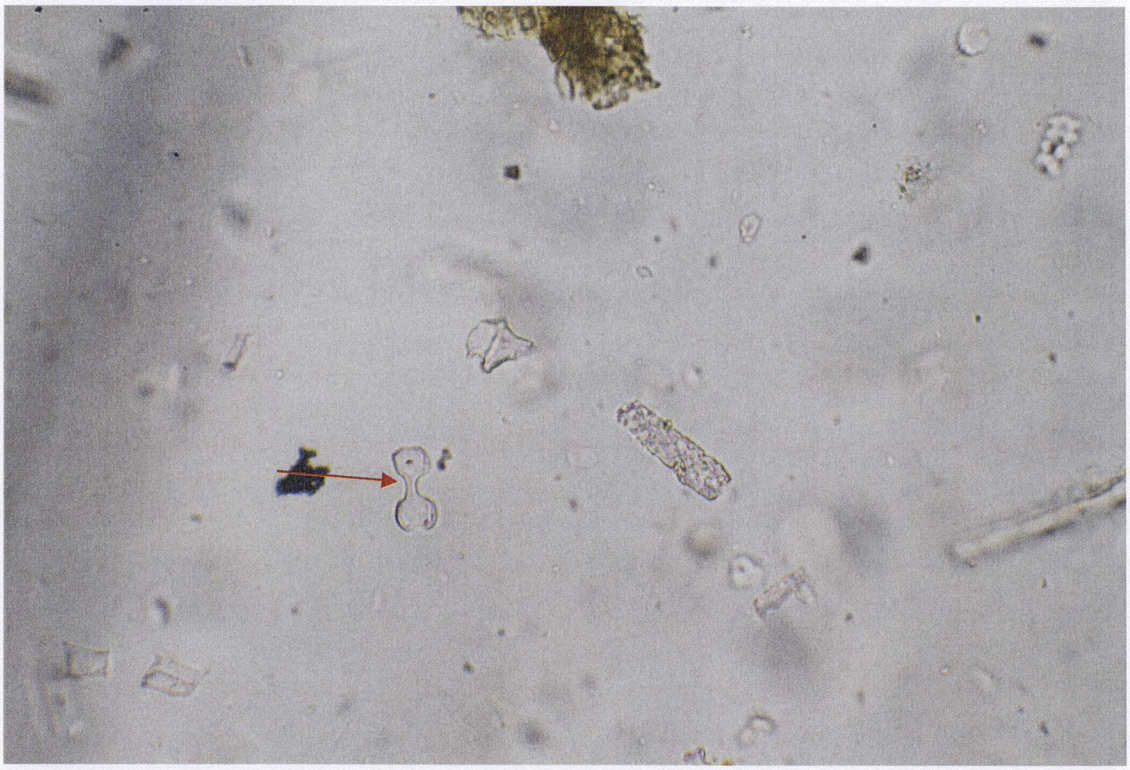

Figure 41: C4 panicoideae short celled bilobe grass phytolith, sample <131>, Doveridge, Derbyshire.

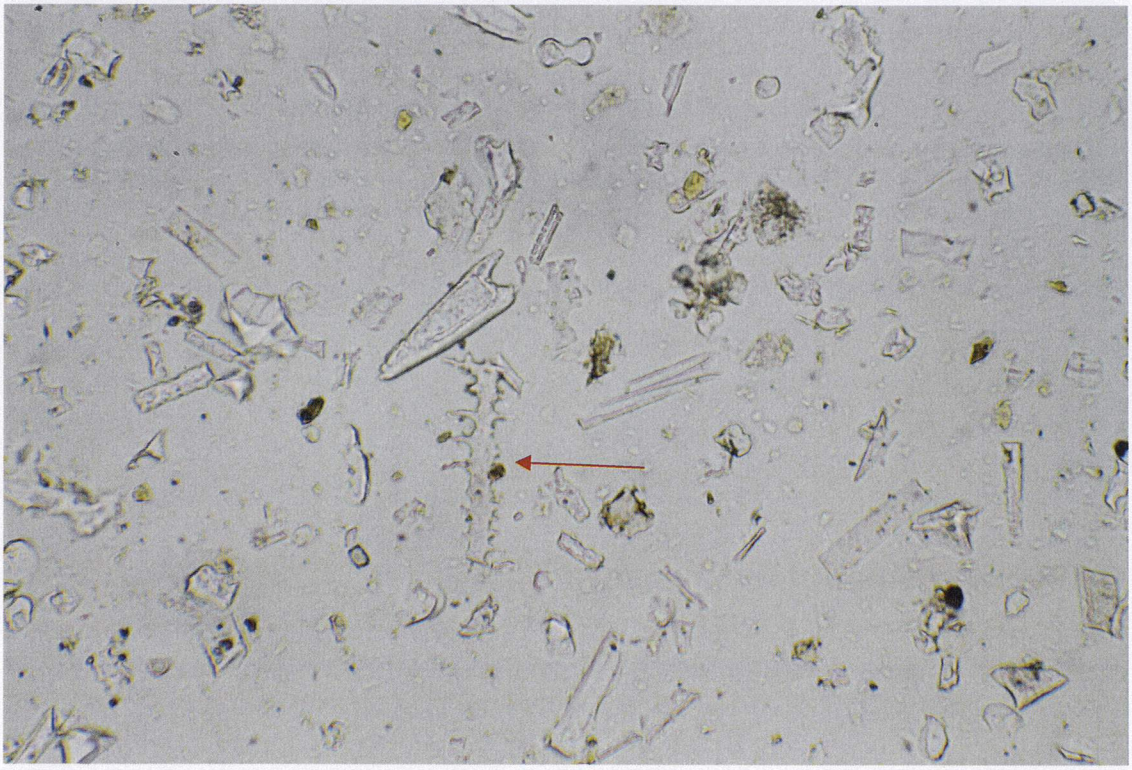

Figure 42: Elongate dendritic grass phytolith with waves similar to wheat, to compare with Figure 6, sample <131>, Doveridge, Derbyshire.