Paleobotanical
Publications
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Calamitean fragments in Permian cherts

from the Late Neogene to Early Pleistocene river systems of Saxony and Brandenburg

Fig. 1: *Calamites* fragment in chert from the Lauta gravel pit, Gehlert Collection, image width (hereafter abbreviated to W) 52 mm, D-116-28A

Abstract

This paper presents cherts from the Pleistocene river systems of the Elbe in Saxony and Brandenburg and the Mulde in Saxony, in which fragments of *Calamites* are frequently found alongside many other fossil plant remains. These specimens are supplemented by isolated finds from deposits in the Altenburger Land.

The primary aim of the work is to produce a photographic documentation of exemplary specimens and, through this, to facilitate the transfer of knowledge regarding the interpretation of the plant fragments depicted.

1 Introduction

Cherts and siliceous peat are among the most fascinating and enigmatic plant fossils, as their very nature makes them difficult to interpret (Barthel et al. 2001; Rößler et al. 2006; Mencl & Benčová 2010; Trümper et al. 2019, 2023a, 2023b; Lies & Rößler 2024). They contain heavily decomposed and therefore often poorly preserved plant material, and one must accept that the varied taphonomy of the plant remains reflects not only botany itself, but also the long process of fossilisation and the geological history following their burial. At the same time, it is precisely this enigmatic nature that can lead to the most exciting insights, provided one manages to unravel their secrets at least to some extent and reconstruct the botanical and geographical context despite the ‘limited’ evidence available.

Fig. 2: Fragmented cross-section of *Calamitea striata* (Cotta 1832) from the collection of the Museum of Natural History, Chemnitz (Inv. No. K3947). The wing-like preservation of individual segments is clearly visible; size approx. 8 × 9 cm

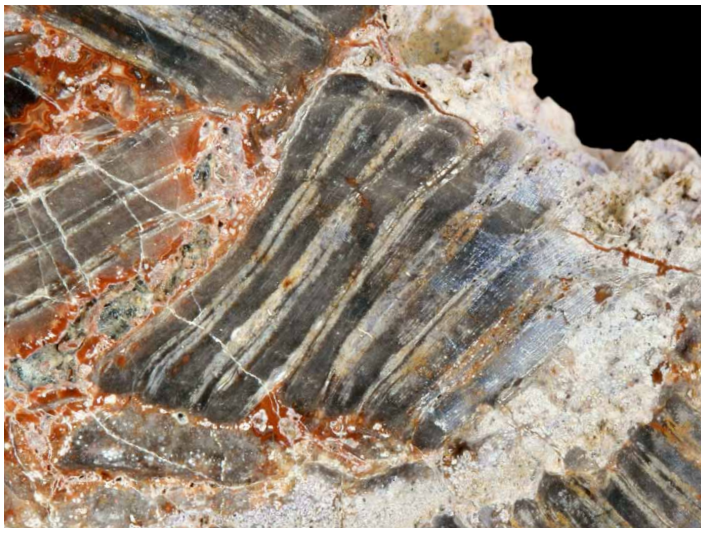


Fig. 3: Detail from Fig. 2, a single wing-like Calamites fragment with wood segments separated by interfascicular rays, W approx. 26 mm

Fig. 4: Detail from Fig. 3, individual wood segments in cellpreservation and interfascicular rays, W approx. 7 mm

Since the reliable identification of genera and families within a habitat can always lead to further insights into that very habitat, I consider it important at this point to collate knowledge on exemplary *Calamites* fragments and thereby facilitate the interpretation of certain plant fragments for future researchers.

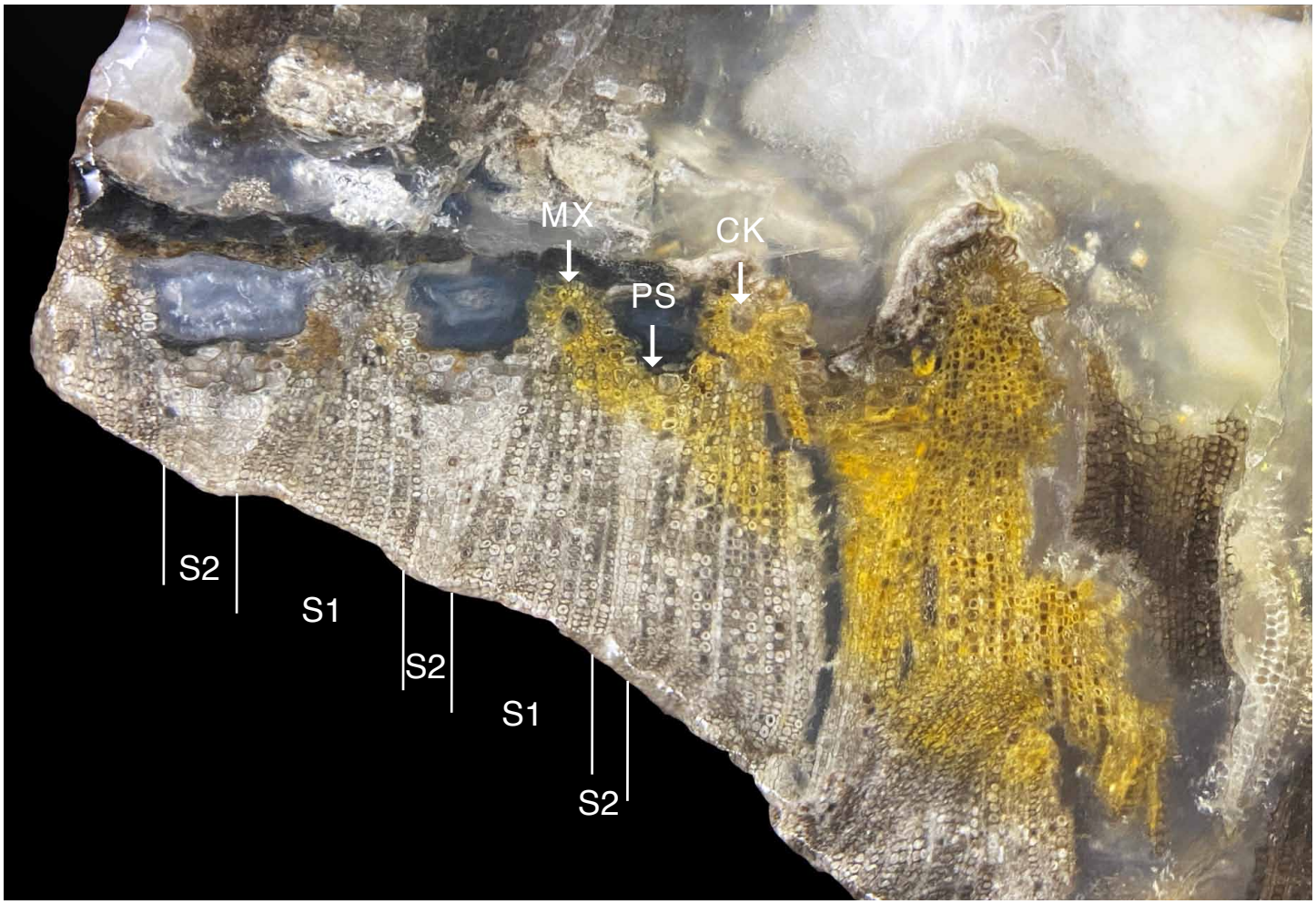


Fig. 5: *Calamites* fragment (Arthropitys sp.) with carinal canals, found in the field near Abenberg (Roth district), MX = metaxylem, PS = primary parenchyma ray, CK = carinal canal, S1 = large, thick-walled tracheids, S2 = parenchyma cells of the interfascicular vessel, Wiesenmüller Collection, W approx. 8 mm

In the vast majority of cases, however, it is unlikely to be possible to identify the preserved fragments to species level. The state of preservation is often so incomplete that diagnostically relevant characteristics, in particular the structure of the radial tracheid walls (Rößler et al. 2007), are not sufficiently preserved. Often, it is not only the state of preservation but also the minute size of the fragments that stands in the way of an exact identification: in the case of *Calamites* species, branching is also relevant for species identification. However, this is never assessable in small pieces such as those found in river gravel. An unambiguous taxonomic classification of *Calamites* remains is therefore often impossible, and at present one can only rely on circumstantial evidence or indirect inference.

2 General remarks on calamites and their signs of decay

Calamites are among the most widespread and frequently occurring plant fossils in the continental deposits of the Upper Carboniferous and Lower Permian (Barthel 2001, 2004; Hilton et al. 2001; Freytet et al. 2002; Martín-Closas & Galtier 2005; Kerp et al. 2007). Compared to the abundance of imprints and

Fig. 6: *Calamitea* fragment from Chemnitz-Hilbersdorf, size approx. 6 × 2.5 cm

Fig. 7: Cylindrically structured features in a chert from Priefel, W approx. 5.5 cm, #0328

medullary casts, which dominate the record of calamites, larger stems preserved anatomically are rather rare (Rößler & Noll 2006). However, only the latter enable advances in palaeobiological understanding (Rößler & Noll 2010).

As it is virtually impossible to determine which fossil *Calamites* stem belongs to which *Calamites* medullary core, the anatomically preserved remains are traditionally classified into three fossil genera. This classification is based both on differences in the parenchyma cells within the primary parenchyma rays (in the case of *Arthropitys* and *Arthroxylon*) and on the presence of different types of tracheids in the wood (*Calamitea*). The parenchyma cells within the interfascicular medullary rays are indistinguishable in *Calamitea* and *Arthropitys*. Typical of both are orthogonal cells arranged in a roof-tile-like pattern in the radial section (Rößler & Noll 2007). For further anatomical distinctions and characteristics regarding *Arthropitys* and *Calamitea*, see in particular Rößler & Noll 2007 and 2010.

Because the wood is segmented by interfascicular rays (cf. Figs. 2–4), remains of *Calamites* are often still recognisable and identifiable even when poorly preserved (cf. Figs. 8–10). This fact is an advantage for the study of cherts. Furthermore, the reliable identification of wood or calamite remains in cherts can demonstrate the progressive decomposition (see Figs. 13–16) of a particular wood type depending on the respective taphonomic conditions.

The segmentation of calamites, medulloses and stigmaries (Figs. 3, 11 & 19), caused by progressive decomposition, is linked to their strongly radially structured tissue organisation and to a higher overall proportion of parenchyma. Owing to this segmentation, such tissues are prone to displacement – and consequently detachment – when pressure is applied to the tissue edges.

Wood bundles that have been radially detached by lateral pressure and displaced into the open pith cavity (Fig. 2), as well as the significantly more frequent occurrence of longitudinal fractures compared with *Arthropitys*, suggest that *Calamitea* trunks have lower fracture resistance. Possible causes include the generally less robust wood structure and the markedly heterogeneous wood composition. In *Calamitea*, the parenchyma is predominantly concentrated in the interfascicular primary medullary rays and is therefore

Fig. 8: Anatomically preserved *Calamites* fragment in a chert from Linda (Leipzig district, Saxony); the broad interfascicular rays and wood segments are typical of Calamites; Roderer Collection, BB approx. 25 mm

Fig. 9: Detail from Fig. 8, interfascicular rays, W approx. 3 mm

Fig. 10: Detail from Fig. 8, rows of tracheids, W approx. 3 mm

less evenly distributed than in *Arthropitys*. Together with the radial segmentation and the presence of different tracheid types, this is likely to have reduced the mechanical stability of the wood and facilitated its decay along specific structural planes (Rössler & Noll 2007).

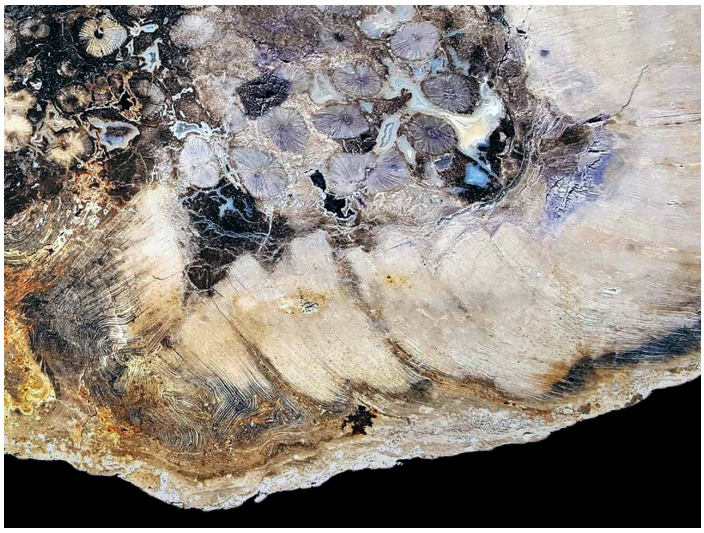


Fig. 11: Wing-like structures can also form as a result of the disintegration of medullosae, as seen here in the lower half of the image: Medullosa stellata (Chemnitz, Saxony), Moore Collection, W approx. 10 cm

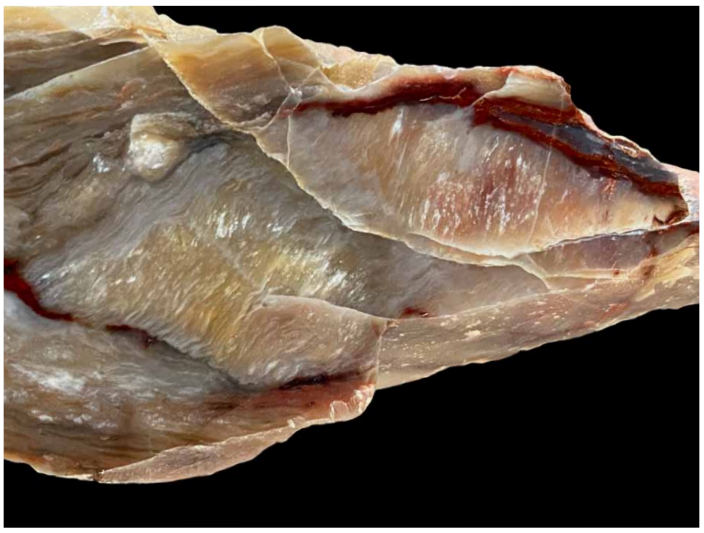


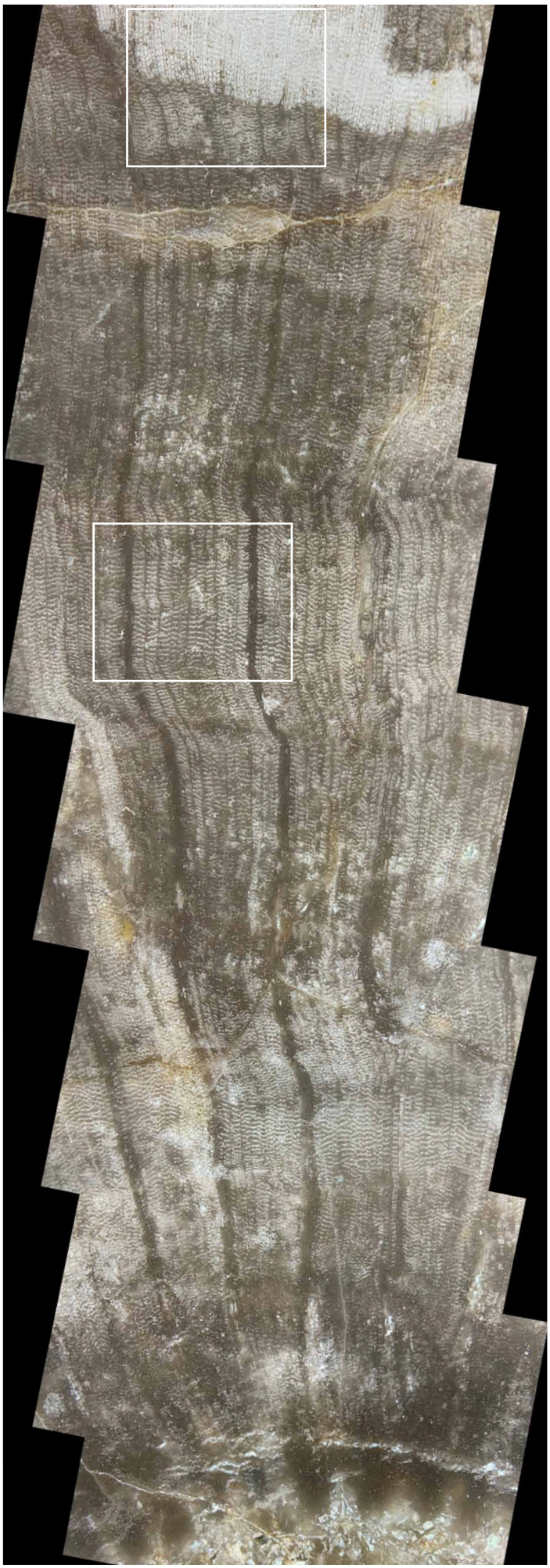
Fig. 12: Heavily decomposed Calamites fragment in a chert from Priefel, with only rudimentary wood structures and interfascicular rays remaining, W approx. 50 mm, #0594

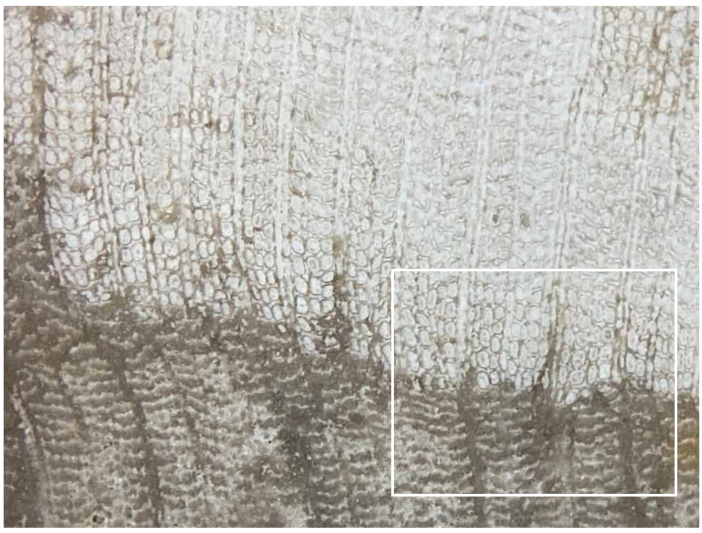
The fact that certain preservation patterns can enable a fossil to be classified as a *Calamites* even in the absence of clear diagnostic features is particularly evident in the specimen shown in Figures 13–16. The state of preservation of the cells varies considerably within the fossil, with the outer regions being significantly better preserved than the inner ones. This difference is particularly evident when comparing Figures 14 and 16 with Figure 15: whilst the former still show largely preserved cell structures, the cells in Figure 15 are largely degenerated; presumably, only the former intercellular spaces or their impressions have survived there. Such rudimentary preservation is characteristic of numerous calamite fragments in the cherts examined here and almost always involves the depiction of interfascicular rays without cell preservation. The specimen shown can therefore serve as a reference for the taxonomic classification and interpretation of other, similarly preserved calamite fragments (Figs. 12 & 20–24).

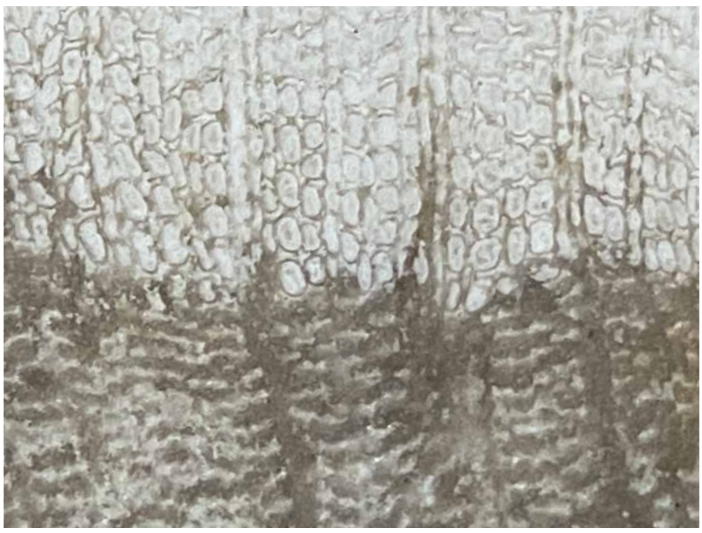
For the sake of completeness, it should be noted that medullose and stigmaria may also exhibit similar signs of decay and preservation (cf. Figs. 11 & 19). However, their significance within the fossil record of the Permian Hornsteine of Saxony remains unclear at present. In the specimens examined to date, medullose have not been identified beyond doubt.

3 Wing-shaped and feather-shaped plant fragments

During my intensive study of Permian cherts, I repeatedly noticed certain structures that seemed to recur with some regularity and were present in cherts from a wide variety of sources. These were individual wood segments split off from the original cross-section, whose cellular preservation, whilst incomplete, was nevertheless present, and which were often embedded transversely or obliquely to the horizontal stratification of the chert (Figs. 7 & 29).







Figs. 13–16: The development of medullary rays and wood fascicles of *Arthropitys bistriata* from the medullary cavity to the outer region of the secondary xylem; image height of the left-hand image approx. 25 mm, W of the top right-hand images approx. 3 mm, W of the bottom right-hand image approx. 1.3 mm, #0390.

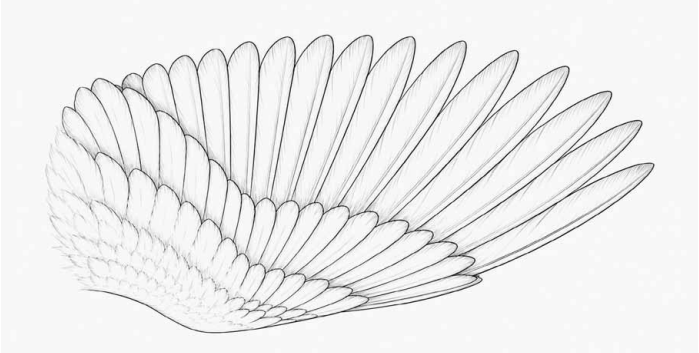


Fig. 17: Schematic diagram of a bird's wing showing primary feathers, secondary feathers and coverts

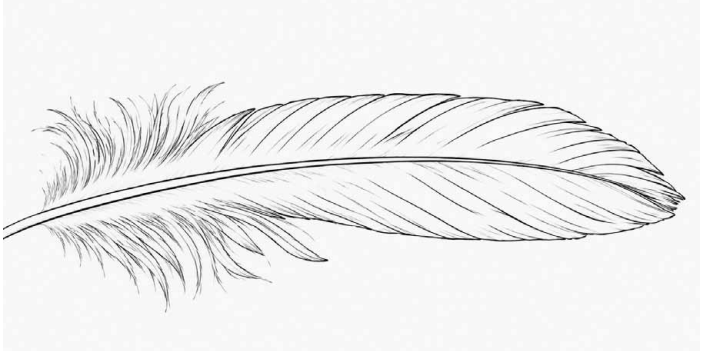


Fig. 18: Schematic diagram of a bird's feather showing the quill and individual barbs

Fig. 19: *Stigmaria* fragment from the collection of the Museum of Natural History, Chemnitz, showing typical signs of decay, W approx. 50 mm

To describe these recurring patterns, the descriptive terms 'wing-shaped' and 'feather-shaped' are used below. 'Wing-shaped' refers to uncompacted, split-off segments of wood (Figs. 17 & 3), whilst 'feather-shaped' describes elongated structures or axial cross-sections which, due to their high degree of compaction in conjunction with the typical pattern of interfascicular rays, fray out in a feather-like manner (Figs. 18 & 20, 25, 28 & 35). These terms serve solely to describe the preserved appearance and do not constitute a morphological or taxonomic interpretation.

Initial clues were provided by specimens from Priefel (Figs. 7 & 29), in which plant fragments embedded at an angle to the stratification were found, exhibiting segmentation and rudimentarily preserved cells. The structures are clearly demarcated from the surrounding finely laminated material, and the wing-shaped, cylindrically articulated structure of the individual structures preserved with cellular integrity is strongly reminiscent of *Calamites* or *Stigmaria* fragments. The former, for example, are also known from Chemnitz-Hilbersdorf and, whilst preserved in a rudimentary state, display very similar patterns there (cf. Figs. 6 and 7). Although the fossilised state of these specimens generally does not show preservation down to the cellular level, the preserved plant remains can certainly be regarded as anatomically preserved, as the individual cells have at least been preserved as rudimentary stone cores.

Figures 2–4 show fragments of calamites which demonstrate the structural disintegration of entire cross-sections due to radial ruptures along the interfascicular rays. This circumstance accounts for the preservation, typical of *Calamites*, of individual, slightly displaced segments of stem cross-sections, as seen in the cherts due to the advanced decomposition of the affected small stems (Figs. 3 & 8), and which results in the wing-like shape characteristic of this preservation as a recurring pattern. The specimen in Fig. 8, in

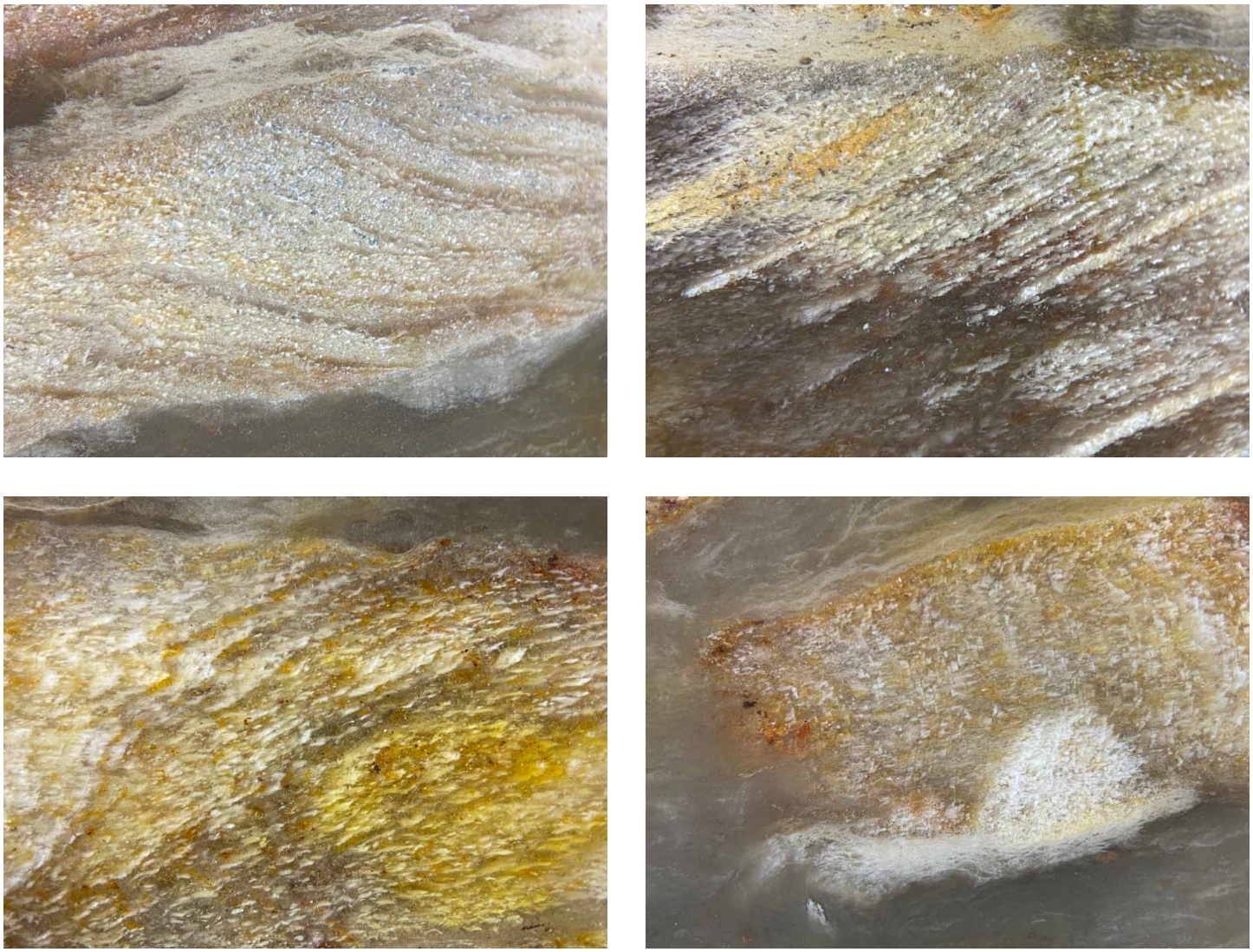
Fig. 20: Detail from Fig. 25 – clearly visible interfascicular rays and wood segments, which appear tangentially crushed at the edge of the axis, Gehlert Collection, W approx. 6 mm, D-116-28A

particular, can serve as an important guide for less well-preserved specimens, ensuring that the identification as Calamitaceae is correct.

Radially arranged rows of cells with segmentation – of which only collapsed or half-axial fragments are often preserved in cherts – are generally known from calamites, whose wedge-shaped segmented fragments and robust medullary rays can serve as indicative features (Lies et al. 2024). However, unambiguous characteristics of calamites, such as carinal canals or a sculptured radial tracheid wall, are absent in this specimen.

As calamites have a predetermined breaking point at the interfascicular rays and disintegrate rapidly when decomposition is advanced or under mechanical stress, it is not surprising that fragments disintegrated in this way can be found in cherts.

It should be borne in mind, however, that wood cross-sections without segmentation by interfascicular rays – as found in stigmaria, medullose species and, in principle, in all gymnosperm wood – can also



Figs. 21–24: Details from Fig. 25 – interfascicular rays and wood segments that appear radially compressed at the centre of the axis, Gehlert Collection, BB approx. 6 mm each, D-116-28A

disintegrate into similarly shaped fragments. In such cases, however, the angles formed at the edges of these fragments are usually less acute. Furthermore, the segments or wedges that have shifted relative to one another generally appear more voluminous and have softer, more rounded contours (cf. Fig. 11 for medullose specimens and Fig. 19 for stigmaria).

In such cases, the interfasicular rays constitute the most reliable characteristic for classification as *Calamites*. Although their state of preservation can vary considerably (Figs. 8–10, 13–16, 20, 25–30, 35, 37–41), in *Calamites* they are at least rudimentary and can regularly be identified in one form or another.

4 Anatomically preserved fragments of calamites

In addition to the wing-like preserved forms of disintegrated stem cross-sections, anatomically preserved longitudinal or oblique sections of smaller calamite axes also occur repeatedly in the cherts under consideration. These are virtually impossible to assign to a specific genus due to the insufficiently preserved

Fig. 25: *Calamites* fragment in a chert from the Lauta gravel pit, Gehlert Collection, W approx. 50 mm, D-116-28A

Fig. 26: *Calamites* fragment in a chert from Torno/Leippe (Senftenberg section of the Elbe), Gehlert Collection, W approx. 75 mm, D-131-06B

Fig. 27: *Calamites* fragment in a chert from the Lauta gravel pit (Senftenberg section of the Elbe), Gehlert Collection, W approx. 47 mm, D-116-07

Fig. 28: *Calamites* fragment in a chert from Bocka/Kraschwitz, Gebhardt Collection, W approx. 90 mm

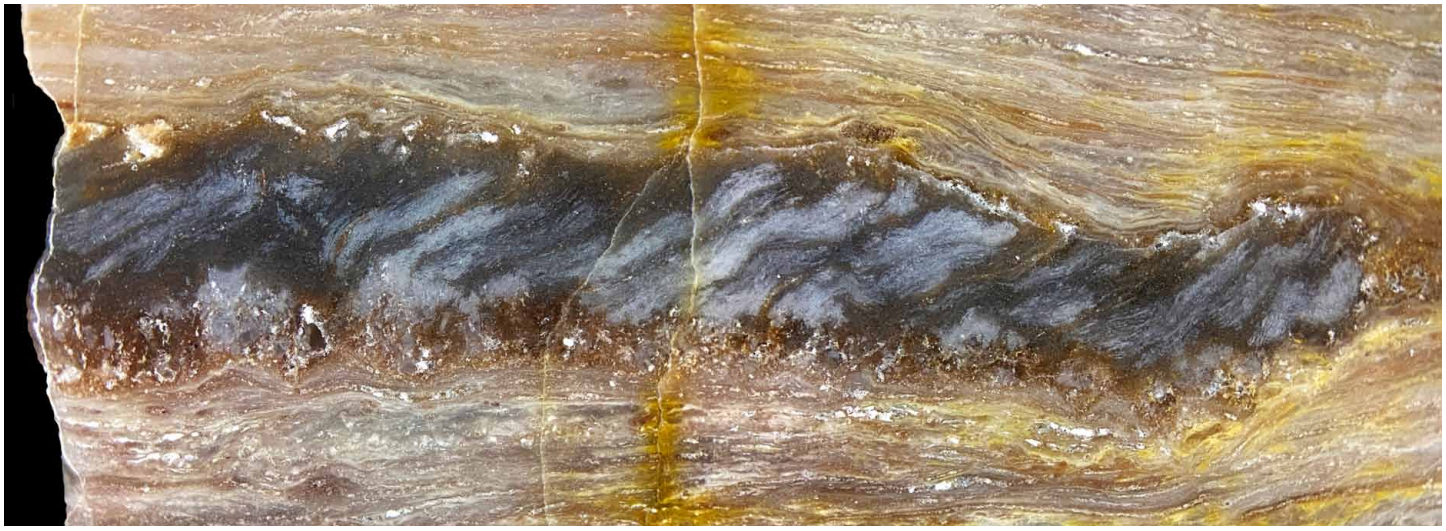


Fig. 29: (?)*Calamites* fragment in a chert from Priefel, W approx. 11 mm, #0392

Fig. 30: *Calamites* fragment in a chert from the Mausbach near Rüdigsdorf, W approx. 43 mm, #0609

Fig. 31: Partially decomposed *Calamites* fragment in hornstone, Mausbach near Rüdigsdorf, W approx. 70 mm, #0609

Fig. 32: *Calamites* fragment on the upper edge of a chert from the Laußnitz I gravel pit near Ottendorf-Okrilla, Gehlert Collection, W approx. 70 mm, D-085-09

Fig. 33: *Calamites* fragment in a chert from the Sallgast clay and gravel pit near Klingmühl, preserved in red haematite and crystalline quartz, Gehlert Collection, W approx. 28 mm, D-066-03

Fig. 34: Detail from Fig. 33; of particular note are the well-preserved pith cavity and the rudimentarily preserved wood structures/interfascicular rays, Gehlert Collection, W approx. 6 mm, D-066-03

cellular material; however, in many cases they can nevertheless be unambiguously identified as calamite remains on the basis of distinctive features, namely the interfascicular rays and their rudimentarily preserved fragments (Figs. 20–22 and 25–33).

Figures 13–16 illustrate the development of medullary rays and wood fascicles of *Arthropitys bistriata* from a very good state of preservation to a relatively poor one. In the poorer states of preservation, only fragmentary remains of cell walls have been preserved in this specimen. This form of preservation is of particular significance for the interpretation of calamite fragments in chert, as it frequently occurs there in a similar form. Across the entire woody body, only the intercellular spaces of the individual tracheid rows are preserved and stand out as white; the rest of the tissue appears as structureless, monochromatic chalcedony (Figs. 13 & 15). In the cherts, this preservation pattern also frequently occurs in a compressed or deformed form.

It remains unclear whether this feature is attributable to a decomposition process that was already par-

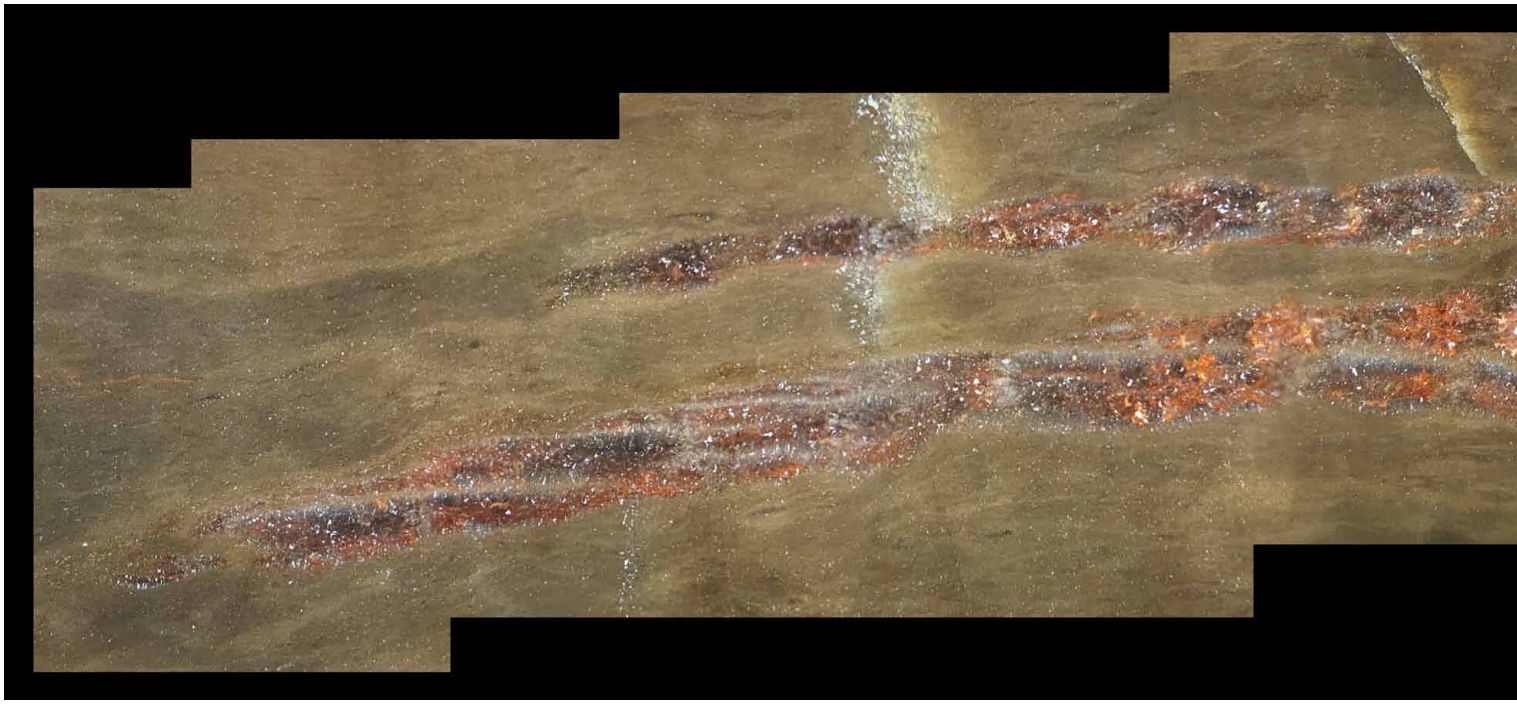


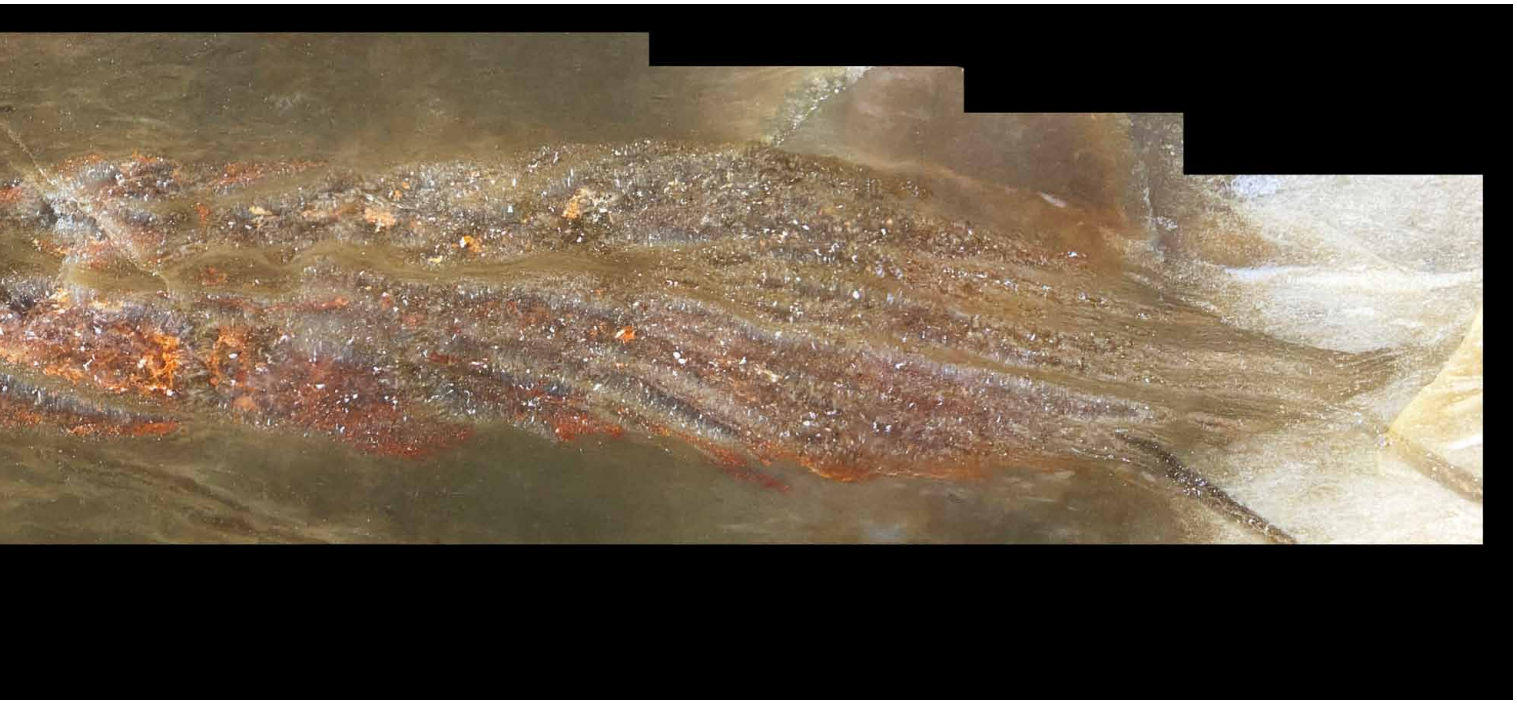
Fig. 35: *Calamites* fragment in chert from Torno/Leippe (Senftenberg section of the Elbe), preserved here mainly in coarse

Fig. 36: *Calamites* fragment in a chert from the Lauta gravel pit with a well-preserved medullary cavity (yellow) and particularly

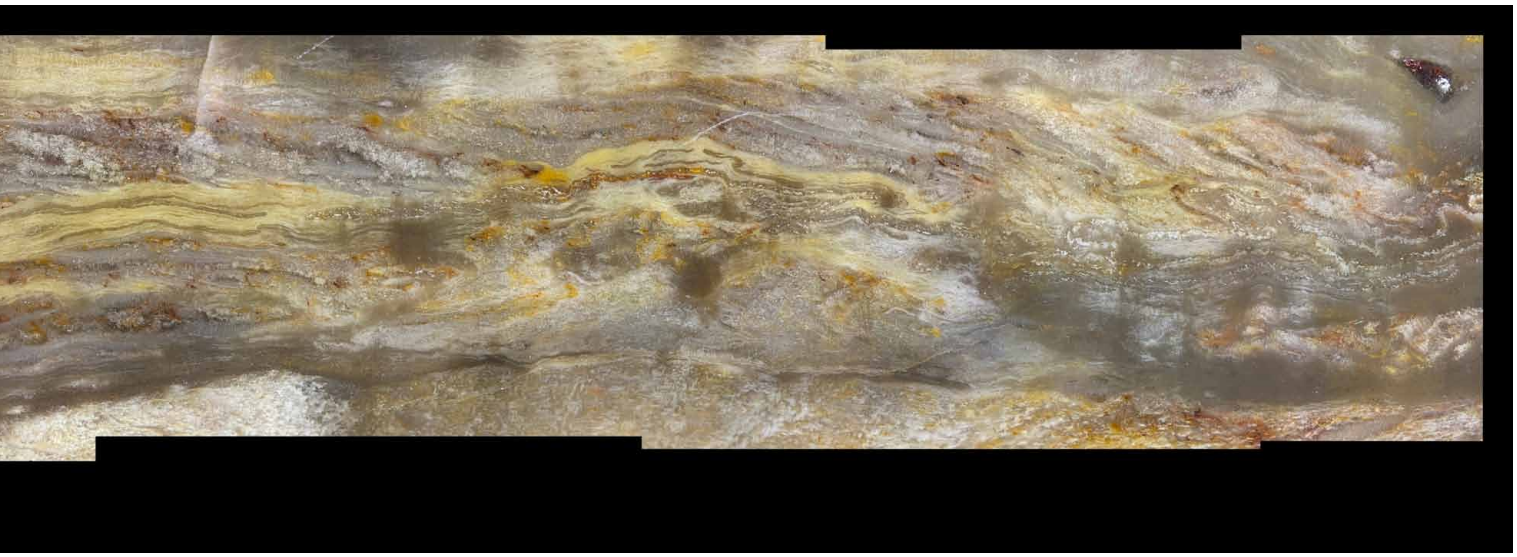
tially advanced, or whether it represents different forms of fossilisation of tissues that were originally in a comparable biological state. Nevertheless, the poorer state of preservation visible in the lower part of Fig. 13 can be traced continuously up to the better-preserved tissue structures in the upper part of the image. This transition can therefore be used as a comparative and identifying feature for similarly preserved calamite fragments.

5 Size of the plant axes and inferences about the habitat

It is striking that the cherts tend to contain smaller and medium-sized calamite cross-sections. The ac-



quartz and with an unstructured medullary cavity, Gehlert Collection, W approx. 22 mm, D-131-06B



well-preserved woody areas, Gehlert Collection, W approx. 40 mm, D-116-28A

tual size can only be given as an estimate, as when a section is cut or a fragment is broken, complete cross-sections cut horizontally to the direction of growth are rarely, if ever, encountered, and the pieces are already heavily fragmented or compressed. The actual cross-sections are likely to vary from a few millimetres to a few centimetres, with a few exceptions up to about 9 cm.

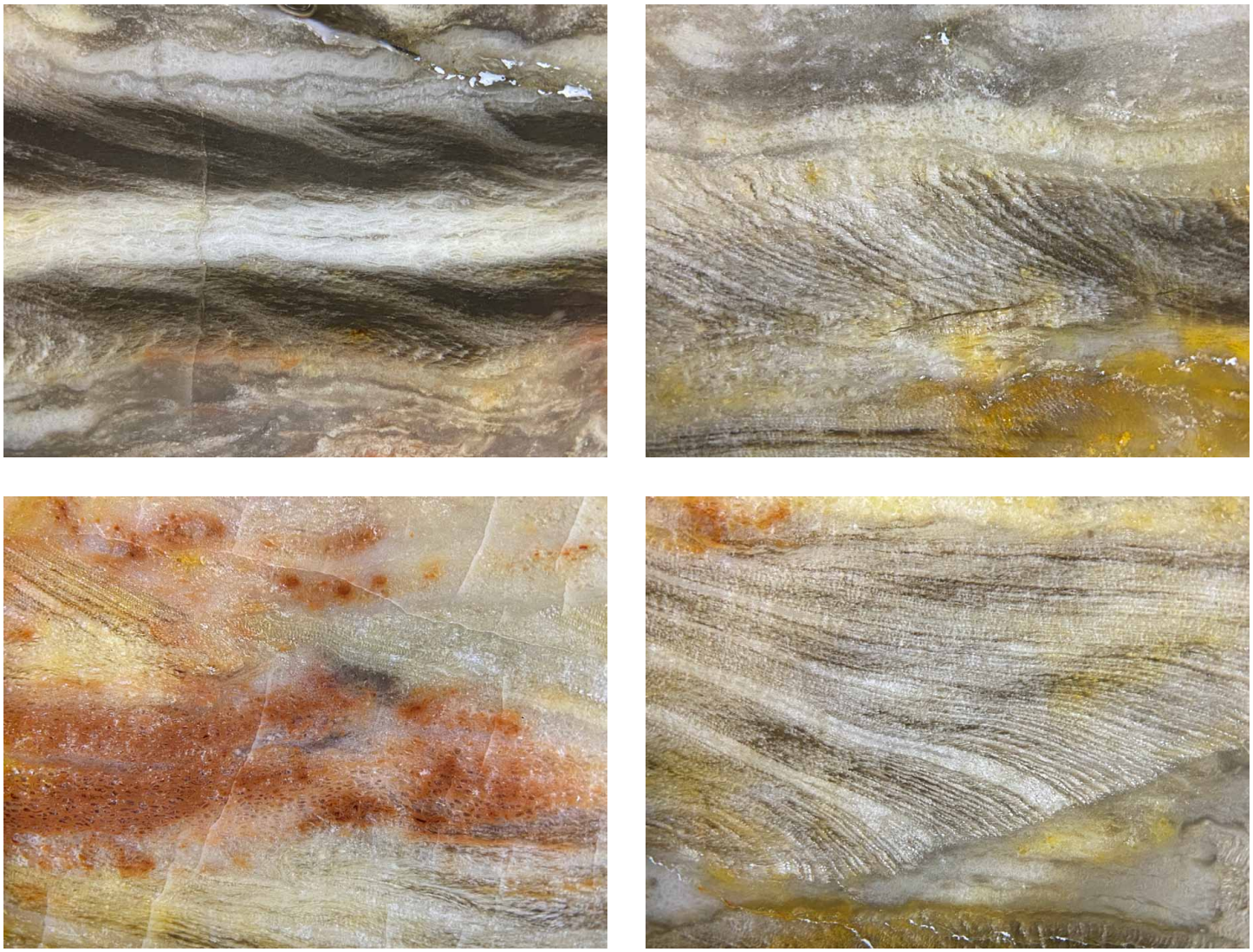
Most of the fragments are embedded in a fine-grained, compacted matrix of leaves and other dead plant parts, which is typical of chert; this generally indicates a lacustrine-fluvial facies, i.e. a depositional environment associated with small lakes, ponds and river oxbow lakes (Trümper et al. 2023a, 2023b; Lies & Rößler 2024).

Fig. 37: *Calamites* fragment in hornstone from the Lauta gravel pit (Senftenberg section of the Elbe) with interfascicular rays and wood segments, Gehlert Collection, W approx. 6 mm, D-116-07

It remains unclear why no larger stem cross-sections of calamites were found in the cherts examined, or why they did not become embedded. One possible explanation could be that the respective sites did not allow for long-term stable and continuous growth. As the specimens in question originate from depositional environments such as water bodies, riparian zones or regularly flooded areas, it is conceivable that recurring floods alternating with dry periods led to significant disturbances in site conditions. Such environmental changes may have favoured the repeated death of comparatively young plants, thereby preventing the development of older, larger stems.

6 The interpretation of individual elements

The interpretation of plant structures in chert is fraught with considerable uncertainty. As a rule, it is not possible to determine unequivocally the orientation or plane of section in which an axis was captured in the section. Furthermore, neither the plant's original growth nor its embedding in the sediment and



Figs. 38–41: *Calamites* fragment in a chert from the Lauta gravel pit with clearly visible interfascicular rays, wood segments (Figs. 39 & 41) and pith cavity filling (Figs. 38 & 40), Gehlert Collection, W approx. 6 mm each, D-116-07

subsequent compression are likely to have proceeded in an ideal-typical manner in terms of plant anatomy. This is compounded by the often highly variable state of preservation of the plant tissues. Taxonomic classification can therefore often only be carried out on the basis of multiple pieces of evidence and frequently allows only an approximation of certain conclusions. One aim of future research could therefore initially be to classify fragmentarily preserved *Calamitea* wood, based on its combination of characteristics, as being more *Calamitea*-like or more *Arthropitys*-like.

Differences in anatomical structure and the resulting pattern of decay can, in principle, be significant for such classification. The wood of *Calamitea* has a structurally heterogeneous composition, characterised by pronounced radial segmentation and the distribution of parenchyma and different types of tracheids (Rößler & Noll 2007). It therefore seems plausible that this structure influenced the way in which the wood was preserved during decomposition, burial and fossilisation. However, individual preservation features, such as interfascicular rays or radially bounded wood segments, do not in themselves allow for an unambiguous assignment to *Calamitea* or *Arthropitys*, as comparable structures occur in both genera.

Fig. 42: *Calamites* fragment in a chert from the Lauta clay and gravel pit with a pronounced and well-preserved medullary cavity, but poorly preserved wood wedges, Gehlert Collection, W approx. 8 mm, D-116-28A

The pith cavity of *Calamitea* is largely devoid of tissue; only in the perimedullary region do we frequently observe shell-shaped parenchyma plates, which were originally arranged in a ring-like pattern between the nodes (Rößler et al 2007). In some plant stems – particularly given the generally rather rudimentary fossil record in cherts – the medullary parenchyma is in places surprisingly well-preserved (see Figs. 33, 34 & 45), and more detailed investigations might potentially provide clues as to specific species affiliations.

When interpreting the fragments, it is also important to take into account the differing frequencies of the two genera in the original plant community and in the fossil record. *Calamitea* is significantly less common in the Chemnitz collection than *Arthropitys*. Assuming that the relative frequency in the collection at least approximately reflects the original frequency ratios, one would therefore also expect a smaller number of fragmentary *Calamitea* remains. This assumption is supported, at least in part, by the quantitative ratios within the collection, even though possible differences regarding preservation, transport, embedding and collection selection must be taken into account.

Fig. 43: Detail from Fig. 12, evidence of *Calamites* fragments: faintly preserved interfascicular rays and remnants of preserved cells, W approx. 6 mm

Fig. 44: Detail from Fig. 12, compared to Fig. 43, only a few millimetres further on – barely identifiable wood structures of a *Calamites*, W approx. 6 mm

A further indication of *Calamitea* fragments in cherts appears to be the feathery, loose fraying of some plant axes at the margins of the sections, in combination with the frequent presence of 'wood rays' and a very characteristic preservation of the pith (cf. in particular Fig. 46 and Figs. 34 & 45), which is particularly evident in specimens from Priefel (Lies & Rößler 2024, Chapter 7.5) and demonstrates a recurring and regular pattern of preservation involving narrow brown stems and light-coloured pith; given their consistently identical characteristics, these could also be highly decomposed and very strongly compressed *Calamites* fragments (Lies & Rößler 2024, Chapter 7.5). I suspect that the reasons for the poorer preservation of these axes lie in the significantly greater compression of the specimens in question—which lie deeper within the sediment—combined with the preservation pattern of individual *Calamites* axes documented in Figs. 12 & 44. However, it cannot be stated with certainty whether the plant axes in question are indeed *Calamites* axes. In principle, they could also be coniferous stems, as these too presumably exhibit a similar preservation of the pith when poorly preserved; only those stems in which interfascicular rays can still be identified with certainty can be reliably identified as *Calamites* stems.

Furthermore, many smaller or younger *Calamites* axes are often unlikely to be identified beyond doubt as such, or may easily be overlooked, as the delicate axes presumably lose their most important characteristic for visual identification when subjected to particularly severe compression: the interfascicular rays are often only rudimentary or absent altogether. Consequently, the few examples where identification is still just about possible can also serve as a guide for less well-preserved fragments.

Brown axes with a white pith are also frequently found in the chert specimens from the river pebbles described here. On some of these axes, interfascicular rays are preserved and they can be identified as calamite axes (Figs. 33, 34 & 45). In some cases, however, axes with optically and morphologically identical characteristics (preserved pith, 'wood rays' and fibrous preservation/former interfascicular rays) also

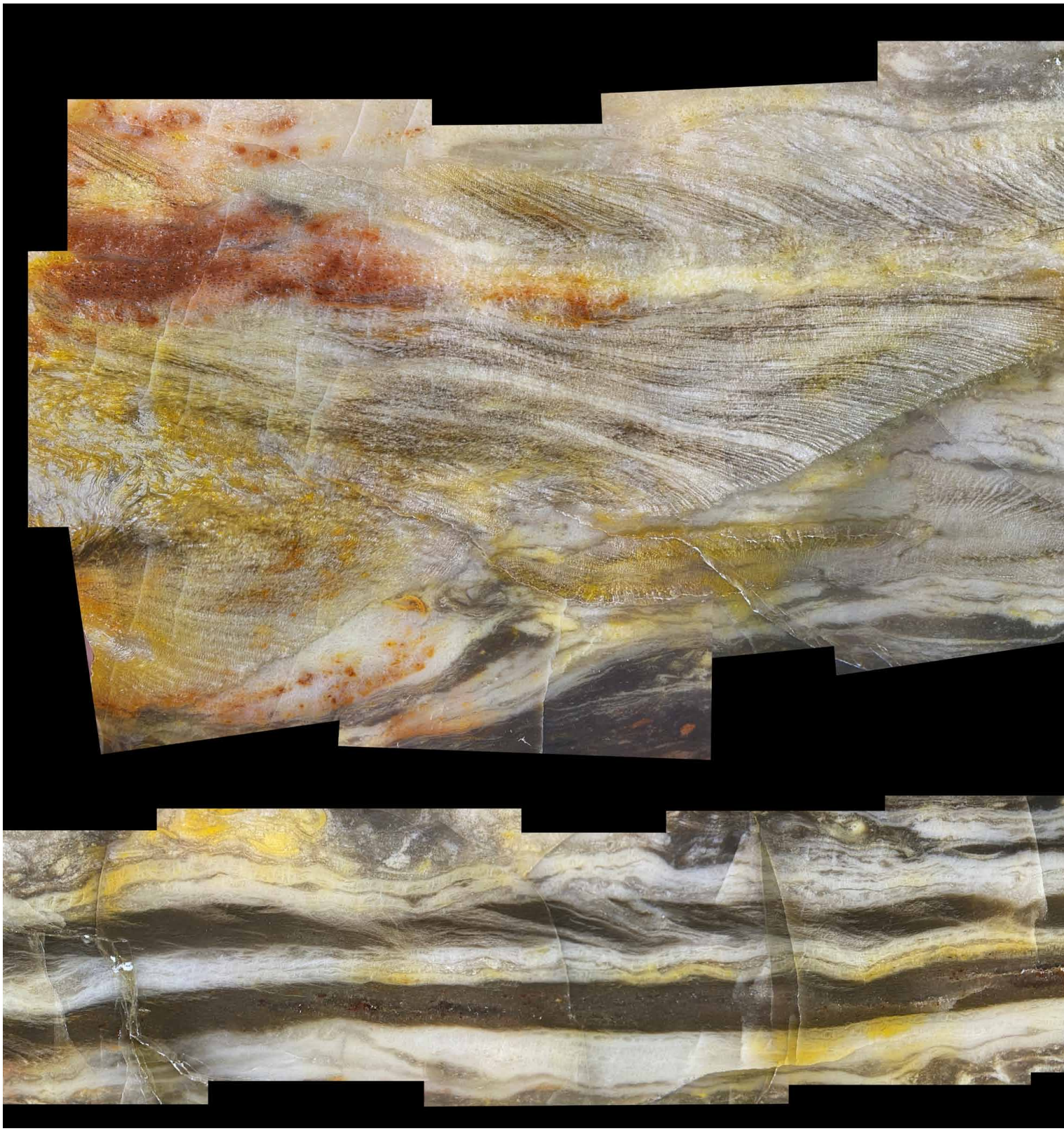
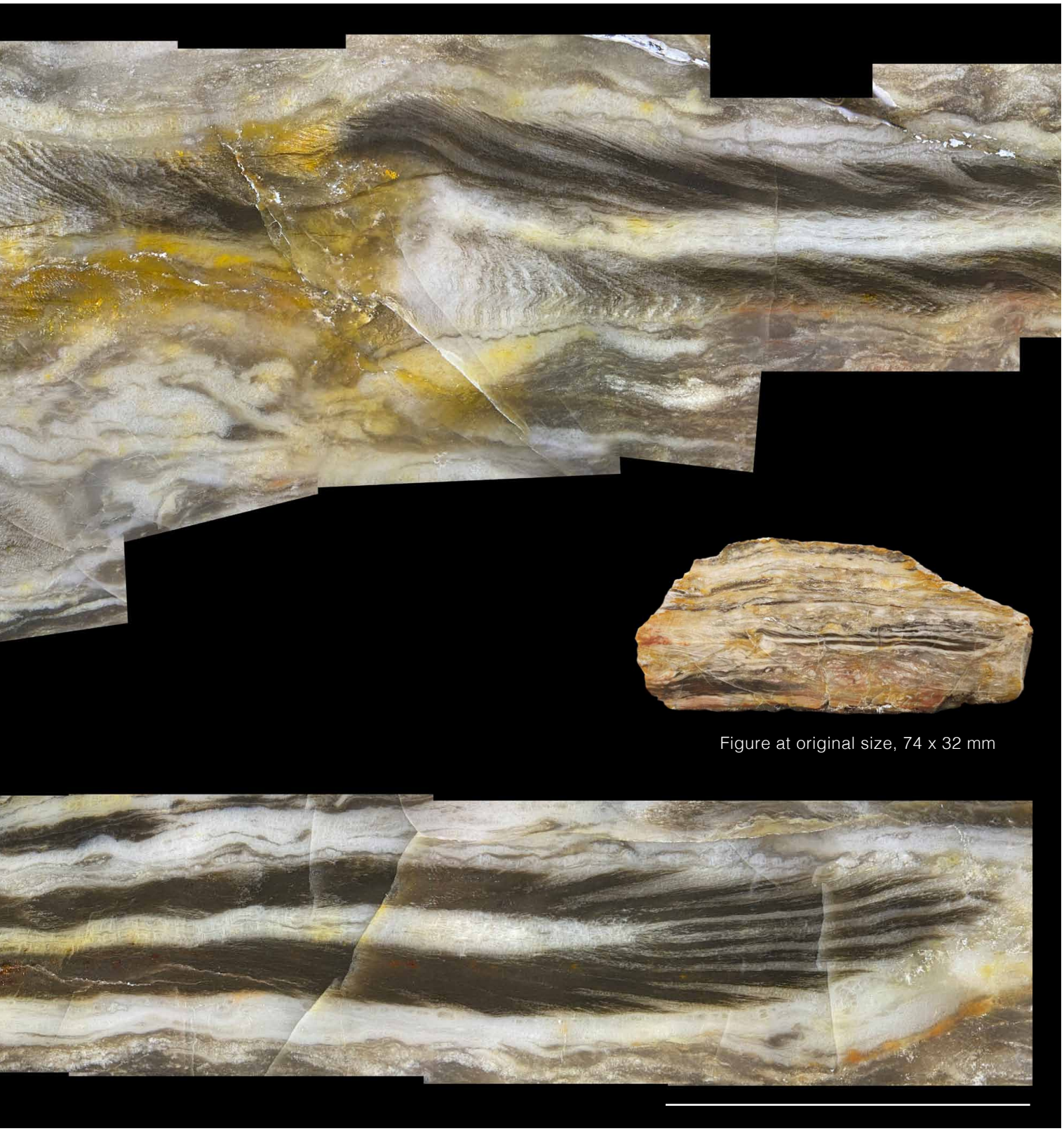


Fig. 45: A *calamites* fragment cut longitudinally or obliquely in a chert from the Lauta gravel pit (Senftenberg section of the Elbe showing interfascicular rays in two different forms of preservation, wood segments and preservation of the medullary cavity (top left, in red and at the bottom in white), Gehlert Collection, scale bar 6 mm, D-116-07

occur, in which interfascicular rays can no longer be clearly identified or can only be identified indirectly (Figs. 35 and 36).

If the circular cross-section of a calamite is compressed to a fraction of its diameter, the interfascicular



This specimen clearly demonstrates that many smaller *Calamites* fragments in chert are probably not recognisable as such, as the preservation of the interfascicular rays deteriorates progressively or is lost entirely with advanced compression (see the lower brown area of the axis in the right-hand part of the fragment).

rays would tend to be more clearly preserved, particularly in the peripheral areas of the cross-section, which are less compressed in relation to the radius. This is because, whilst the upper and lower segments are subjected to extreme radial compression, the outer segments are compressed only tangentially or circumferentially. In this process, the cell material located in the radially compressed areas is likely to

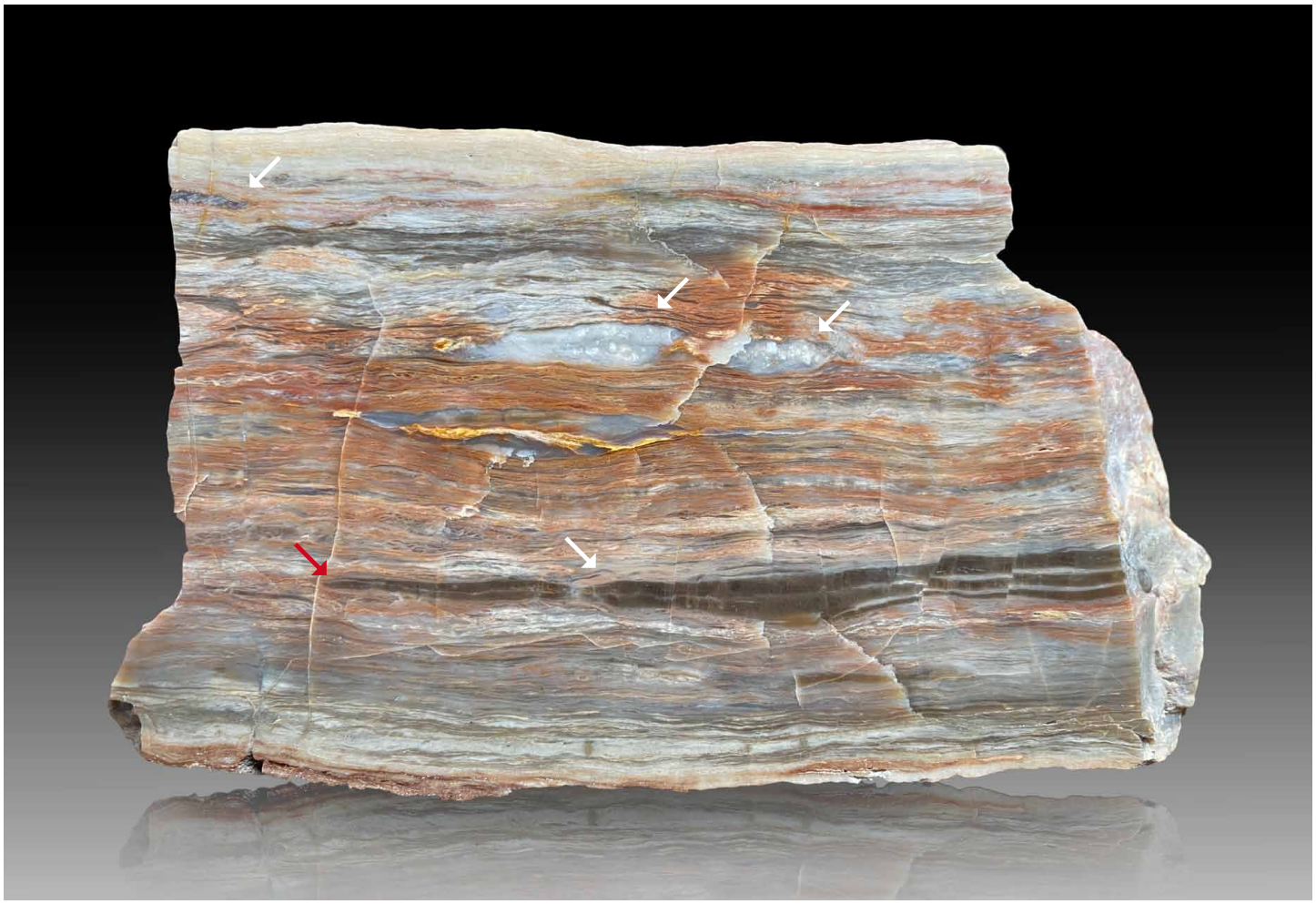


Fig. 46: Unidentified plant axes, including those on the far left (cf. Fig. 29), in the upper centre of the image and in the lower half of the image (white arrows), and the marginal area of a (?)*Calamites* fragment (red arrow, cf. Fig. 47), size. 7.5 × 13 cm, #0392

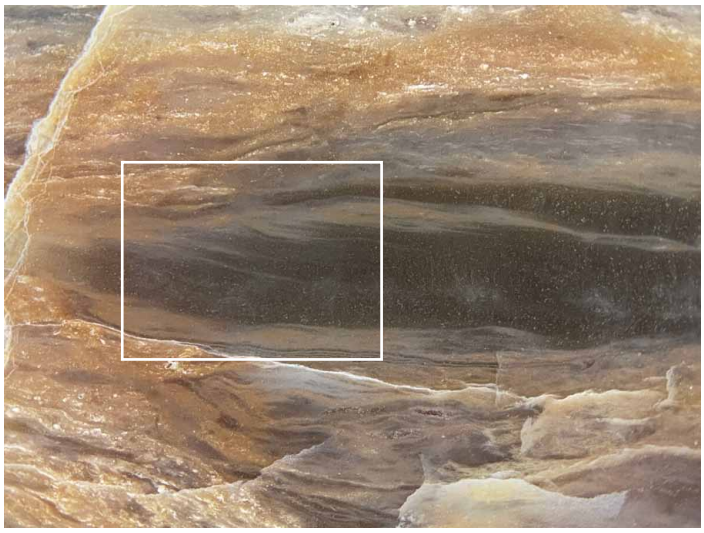


Fig. 47: Detail from Fig. 46, an indication of *Calamites* fragments: faintly preserved interfascicular rays, W approx. 6 mm

Fig. 48: Detail from Fig. 47, presumably remnants of interfascicular rays in the magnified view; cf. Fig. 44 showing a relatively certainly identified Calamites specimen, W approx. 2 mm

become more homogenised or destroyed; that is, the contrast or distinction between interfascicular rays and wood segments would diminish, whilst the material situated in the tangentially compressed area is more likely to retain its 'original contrast' or better cellular preservation (Fig. 49). Evidence supporting

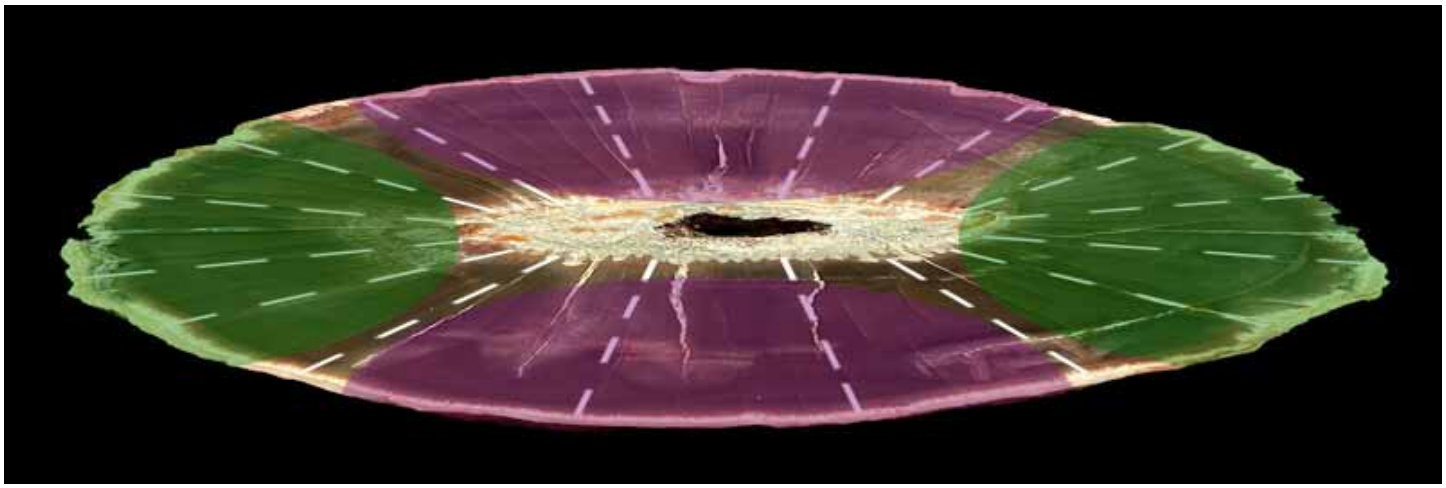


Fig. 49: Compressed *Calamites* axis; areas marked in purple appear to be compressed radially, whilst areas marked in green appear to be compressed tangentially

Fig. 50: Chert from Priefel, from which the top-bottom orientation can be deduced on the basis of evidence: a plant axis in the centre, with a largely flat, horizontal stratification below it, and above it a stratification that is most protruding directly above the centre of the axis; size approx. 6 × 11 cm, #0463

this hypothesis can be found in Figures 20–24 and 45, in which the interfascicular rays in the tangentially compressed areas are, in each case, significantly better preserved.

Of course, the position of the plant fragments within a chert lens also plays a role, as it serves as an indi-

cator of both the duration and the pressure of the compression. Pieces situated lower down were exposed to compression for much longer and inevitably experienced higher compressive pressures than those situated higher up. To assess this condition, it is, of course, essential to know where ‘top’ and ‘bottom’ are within the specimen. Here, too, only circumstantial evidence can be relied upon.

In the cherts of Priefel, variations in the volume of individual plant stems can frequently be observed, depending on the vertical position of the stems within a specimen. This means that, generally speaking, less compression is observed in higher-lying areas than in lower-lying areas. Individual plant fragments also appear to be less compressed and more fragmented in higher-lying areas (Lies et al. 2024), whilst in lower-lying areas they tend to be more uniformly compressed. Even silicification is often more patchy in higher-lying areas; the higher-lying stems tend to form cavities and undergo secondary silicification or quartzification (cf. Fig. 50 in the left-hand part of the embedded stem).

Even embedded plant fragments, where sediment bulges out in only one direction, can indicate ‘top’ and ‘bottom’ within the material. This is because a bulge is more likely to settle on top rather than being pressed down into material that is already compressed and more densely packed (Fig. 50).

7 Outlook

For the first time, cherts and siliceous peats from the Saxony and Brandenburg regions have been presented in detail and documented photographically. Particular effort was made to interpret the fossil record, which is consistently similar across this material, and to identify and describe calamite fragments in their typical state of preservation. Although classification into specific genera remains difficult due to the high degree of compaction, the assignment to the Calamitaceae is unambiguous and can thus provide a further piece of the jigsaw in understanding Permian habitats.

Collection No. D-066-03, 52 x 30 mm

Collection No. D-116-07, 74 x 32 mm

Collection No. D-085-09, 83 x 29 mm

Collection No. D-116-28A, 55 x 50 mm

Collection No. D-131-06B, 99 x 70 mm

Fig. 51: All illustrations from the Werner Gehlert collection in original size, (D – 116 KG Lauta; D – 066 KG Sallgast and D – 131 Felder Torno/Leippe; D – 085 KG Laußnitz I near Ottendorf-Okrilla)

References:

Barthel, M. (2001): Pflanzengruppen und Vegetationseinheiten der Manebach-Formation. – Beitr. Geol. Thüringen N.F., **8**: 93-123.

Barthel, M; Rößler, R & Weiß, H.J. (2001): Sächsische „Madensteine“ – Irrtümer und Fortschritte, GEOLOGICA SAXONICA 46/ 47 S. 97-202; Dresden.

Barthel, M. (2004): Die Rotliegendflora des Thüringer Waldes. Teil 2: Calamiten und Lepidophyten. – Veröff. Naturhist. Mus. Schleusingen, **19**: 19-48.

Freytet, P.; Galtier, J.; Ronchi, A.; Schneider, J.W.; Tintori, A. & WernebuRG, R. (2002): Early Permian continental biota from Southeastern Sardinia (Ogliastra and Gerrei). – Rend. Soc. Paleont. Ital., **1**: 169-176.

Henkel, Th.; Peltzer, M. (2004): Kartierbericht Erläuterungen zur geologischen Karte von Kohren-Sahlis, Universität Leipzig.

Hilton, J.; Wang, S.-J.; Galtier, J. & Li, C.-S. (2001): An Early Permian plant assemblage from the Taiyuan Formation of northern China with compression/impression and permineralized preservation. – Rev. Palaeobot. Palynol., **114**: 175-189; Amsterdam.

Lies, J.; Rößler, R. (2024): Der Hornstein von Priefel – Ein Fossilvorkommen aus dem Perm bei Altenburg. – Veröff. Mus. f. Naturk. Chemnitz, **47**: S. 15-58.

Martín-Closas, C. & Galtier, J. (2005): Plant taphonomy and paleoecology of Late Pennsylvanian intramontane wetlands in the Graissessac-Lodève Basin (Languedoc, France). – Palaios: **20**: 249-265.

Mencl, V.; Benčová, Y. (2010): Zkameněliny Novopacka, Město Nová Paka.

Kerp, H.; Noll, R. & Uhl, D. (2007): Vegetationsbilder aus dem saarpfälzischen Permokarbon. In: Schindler, T. & Heidtke, U.H.J. (Hrsg.): Kohlesümpfe, Seen und Halbwüsten. – Pollichia Sonderveröffentlichung Nr. **10**: 76-109.

Rößler, R.; Noll, R. (2006): Sphenopsids of the Permian (I): The largest known anatomically preserved calamite, an exceptional find from the petrified forest of Chemnitz, Germany. – Rev. Palaeobot. Palynol., **140**: 145-162; Amsterdam.

Rößler, R.; Thuß, K.H.; Lapp, M. & Kretzschmar, R. (2006): Zur Geologie, Stratigraphie und Fossilführung

permischer Silizite im Raum Zwickau, Veröff. Mus. f. Naturk. Chemnitz, 29: 135-156; Chemnitz.

Rößler, R.; Noll, R. (2007): Forschungsgeschichte, Paläobiologie und Rekonstruktion eines baumförmigen Schachtelhalmgewächses aus dem Perm: Calamitea Cotta 1832. – Veröff. Mus. f. Naturk. Chemnitz, **30**: S. 61-82.

Rößler, R.; Noll, R. (2010): Die Calamiten der Gattung Arthropitys Goeppert 1864 im Versteinerten Wald von Chemnitz – Veröff. Mus. f. Naturk. Chemnitz, **33**: S. 89-112.

Trümper, S.; Wernburg, R.; Schneider, J. W. (2019): Geologisches Profil und Fossilführung des Geotops am Kammerberg (Manebach-Formation, Unterrotliegend) in Manebach/Thuüringen, Veröffentlichungen des Naturhistorischen Museums Schloss Bertholdsburg Schleusingen, 34: 3–10; Schleusingen.

Trümper, S.; Hellwig, A.; Krings, M. & Rößler, R. (2023a): Mikrobengesteine aus Manebach – einzigartige Archive permischer Mikrowelten. – Semana, **38**: 57–69; Schleusingen.

Trümper, St.; Vogel, B.; Germann, S.; Werneburg, R.; Schneider, J. W.; Hellwig, A.; Linnemann, U.; Hofmann, M. & Rößler, R. (2023b): Decoding the drivers of deep-time wetland biodiversity: insights from an early Permian tropical lake ecosystem. – Palaeontology, **66** (3), e12652: 39 S.

Notes and acknowledgements:

The numbers following the illustration numbers are catalogue numbers from my private collection; that is to say, all items marked in this way (e.g. #0371) come from my own collection, whilst all items marked differently come from other collections and are labelled with the name and, where applicable, the collection number of the owner or finder.

Gehlert Coll.: Werner Gehlert Collection, Lusatia, Germany
Wiesenmüller Coll.: Wolfgang Wiesenmüller Collection, Fürth, Germany
Roderer Coll.: André Roderer Collection, Altenburg, Germany
Moore Coll.: Douglas Moore Collection, USA
Gebhardt Coll: Lutz Gebhardt Collection, Altenburg, Germany

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