Typification and morphology of *Campylodiscus costatus* W.Smith (*Surirellaceae, Bacillariophyceae*)

Ingrid Jüttner[1], Edgley Cesar[2], David M. Williams[3] & Bart Van de Vijver[4]

[1]*Amgueddfa Cymru – Museum Wales, Department of Natural Sciences, Cathays Park, Cardiff, CF103NP, United Kingdom* (correspondence: Ingrid.Juettner@museumwales.ac.uk)
[2]*The Natural History Museum, Cromwell Road, London, SW75BD, United Kingdom* (correspondence: e.cesar@nhm.ac.uk)
[3]*The Natural History Museum, Cromwell Road, London, SW75BD, United Kingdom* (correspondence: d.m.williams@nhm.ac.uk)
[4]*Meise Botanic Garden, Research Department, Nieuwelaan 38, 1860 Meise, Belgium & University of Antwerp, Department of Biology – ECOSPHERE, Universiteitsplein 1, B-2610 Wilrijk, Belgium* (correspondence: bart.vandevijver@plantentuinmeise.be)

Smith (1851: 6) described *Campylodiscus costatus* from freshwater *'Valves orbicular, costæ distinct, radiate, about 44, centre of the disc smooth or minutely punctate. Average diameter of valve 1/250 of an inch. v.v.'*, listing four localities where he observed the species: the 'river Froome near Dorchester, May 28, 1849', the 'Bramley spring near Guildford, J. R. Capron, Esq.!', 'Fossil, in deposit from Lough Mourne, co. Antrim, Ireland…' [a locality already described in Smith 1850], and 'In deposit at Peterhead, Aberdeenshire [Scotland], described by Dr. Dickie in 'Ann. Nat. Hist' for August 1848' (discussed in Dickie 1848). Dickie only listed *Campylodiscus clypeus* (Ehrenberg) Ehrenberg ex Kützing but Smith could have been referring merely to the collection locality. Smith (1851: 6) was uncertain about his findings in the Lough Mourne deposit as he added that he had identified the species first as *Campylodiscus noricus* Ehrenberg, but he was unsure about the latter's conspecificity given the absence of illustrations of *C. noricus*, adding '[I] shall on this and other occasions prefer giving a new specific name rather than run the risk of creating confusion by trusting to a verbal description merely.' In later publications, additional locations where the species was found were mentioned (Smith 1853: 29, 1859: 10, Figs 1–5).

Smith (1851: pl. 1, figs 1a, b, reproduced here as Figs 6, 7) illustrated the new species with two line drawings showing one specimen in valve view and another at an angle to indicate the arching of the valve. Two years later, Smith (1853) provided additional illustrations of two specimens in valve view and in an oblique view of the valve surface and girdle (pl. VI, figs 52 a, b, here Figs 8, 9). Two valves of variety ß were shown in an oblique view of the valve surface and in girdle view showing the valve curvature (pl. VII, figs 52′, 52b″, shown here as Figs 10, 11). The new locations were 'near Lewes' and 'Norfolk' both in England, 'Dolgelly' in Wales, and for var. ß 'Cantyre Peat' in Scotland.

For the present contribution, we examined five slides and materials of *Campylodiscus costatus* from the diatom collection at the Natural History Museum, London (**BM**), which contained specimens of *C. costatus* from the locations mentioned in the protologue (Smith 1851): deposit at Peterhead, Aberdeenshire (**BM** 23202 'Annals of N.H. August 1848 Dr Dickie'), and Bramley spring near Guildford (**BM** 23510 'Guildford JR Capron Esq *misit* Nov 4 1850'), and specimens collected in 1854 in Edinburgh (**BM** 23195, 23196, 23197). **BM** 23202 contained only two frustules, both in valve view, one partly obscured by detritus, the other one imaged and illustrated here as Figs 12–17. **BM** 23510 contained a frustule in girdle view, illustrated here in Figs 18–23. In his 'List of the British Diatomaceæ in the Collection of the British Museum', Smith (1859) mentioned three localities: 'a. (Scotland), Dr Dickie, 1848', presumably the fossil material from Peterhead, 'b. (Scotland), Dr. Greville, 1854', and 'c. Edinburgh, April 1854'. The latter is likely from the same

collection as the material conserved in the Van Heurck collection, **BR** (Meise Botanic Garden, Belgium), listed by Hoover (1976: 11 [Edinburgh, Dr. Greville, 11 Ap. 1854]). Slides **BM** 23195, mounted 1887 and marked as type, slides **BM** 23196 and 23197, and material (barcode: **BM** 001167240), all from 'Edinburgh, April 1854' contained several specimens and were used in addition to the specimens from 1848 and 1850 to study the morphology of *C. costatus* in light (LM) and scanning electron microscopy (SEM), illustrated here as Figs 24–41 and Figs 42–57, respectively. There is no information on why **BM** 23195 ('Edinburgh, April 1854') was labelled 'type', perhaps because the location was mentioned in Smith (1859), and the specimens collected earlier from Peterhead and Guildford could not be located in the collection at the time. These slides had been misplaced and were only rediscovered recently. Alternatively, 'type' might refer to other species present on the slide and described later. Since the *C. costatus* specimens from 'Edinburgh, April 1854' were collected three years after the species was described, they cannot be type material; given the existence of specimens that Smith (1851) examined, we **here designate** those from Peterhead (Dickie 1848) as lectotype.

Figs 1–5. Slides with *Campylodiscus costatus* W.Smith preserved in the diatom collection of the Natural History Museum, London. Fig. 1. BM 23202. 'Annals of N.H. August 1848 Dr Dickie', Fig. 2. BM 23510 'Guildford JR Capron Esq *misit* Nov 4 1850', Figs 3–5. BM 23195, 23196, 'Edinburgh, April 1854', 23197 'near Edinburgh, April 1854'.

Campylodiscus costatus W.Smith 1851, p. 6, pl. 1: fig. 1a, b.
≡ *Campylodiscus noricus* var. *costatus* (W.Smith) Grunow 1862: 439, pl. 10: fig. 6.

Lectotype (here designated): BM 23202 'Annals of N.H. August 1848 Dr Dickie', fossil deposit at Peterhead, Aberdeenshire. The lectotype is represented by Fig. 12.

Registration (of lectotypification): http://phycobank.org/106543

Description: Valves nearly circular, saddle-shaped, convex along apical axis with apical planes of both valves positioned at a right angle, concave along transapical axis, diameter (80–130 µm). External valve face with many short spines, irregularly placed in central area, located in 1–2 irregular rows on costae in distal part of valve. Central area rounded or slightly elongate with two elongate thickenings in valve centre. Costae extending from valve margin approximately half-way across valve face. Multiseriate striae composed of small, densely spaced areolae located in grooves between costae. At distal end of each costa seven short, biseriate striae extending approximately half-way up the raised marginal keel. Raphe with simple ends in canal on raised keel circulating the entire valve; three narrow ridges and grooves adjacent to raphe on both sides, converging at raphe ends; small, circular depressions adjacent to converging grooves at raphe ends. Keel with short fibulae and rounded to elongate fenestrae bridged by 5 narrowly spaced thin tubes. Internally, entire valve surface with densely spaced, irregular striae composed of small areolae and radiating from valve centre towards margin including onto fibulae. Bands externally smooth with straight margin, internally with advalvar, fringed margins, and irregular rows of small poroids interrupted half-way by hyaline area.

Note: Smith (1853, pl. 7, fig. 52, illustrated here as Figs 10, 11) mentioned *C. costatus* var. ß as 'V. somewhat elliptical, disc distinctly punctate'. His variety might belong to *C. costatus* sensu stricto, however, a larger number of specimens should be investigated to confirm this. The specimens examined here varied little in shape or punctation. Grunow's *C. noricus* var. *costatus* refers to '*C. costatus* var. ß W.Smith brit. Diat VII 52. ß'.

Campylodiscus costatus, sometimes recorded as *C. noricus* var. *costatus*, has been observed in freshwaters in Europe (Switzerland, Slovakia, Bosnia and Herzegovina, Romania, Belarus, Ukraine), in the Atlantic islands of the Azores (São Miguel), in the Middle East (Georgia, Iran), in Asia (Mongolia) and in the United States (see Guiry & Guiry 2025 for a list of records and references). For example, Meister (1912) reported the species from four large lakes in alpine and hill areas of Switzerland and northern Italy. Caraus (2017) reported it from the Danube River near its delta and from the Romanian coast of the Black Sea. In the Ukraine, *C. costatus* was typically found in the benthos of freshwaters but can also occur in waters with low salinity (Barinova et al. 2019).

Campylodiscus costatus is similar to *Campylodiscus hibernicus* Ehrenberg (1845: 154, no fig., 'Ex Irlandia Angliae'), and *Campylodiscus levanderi* Hustedt (1925: 328, Lojosee, Finland), which have been transferred to *Iconella hibernica* (Ehrenberg) Ruck & Nakov and *Iconella levanderi* (Hustedt) Ruck & Nakov by Ruck & al. (2016), respectively. Krammer & Lange-Bertalot (1988) listed *C. costatus* as synonym of *C. hibernicus*. The latter was illustrated in Lange-Bertalot (1993, as *C. levanderi* Hustedt, syn. *C. hibernicus* sensu auct. nonnull., pl. 130: 1–5, pl. 131: 1–7, pl. 132: 1–5), who did not find differences in LM between *C. levanderi* and some of the specimens identified as *C. hibernicus* by other authors, and in Reichardt (2018, as *C. hibernicus* Ehrenberg, pl. 442: 7-11, pl 443: 1-7). The differences between *C. hibernicus* and *C. levanderi*, including the arching and torsion of the valve, the shape and structure of the central area, and the hight and size of the keel and fenestrae, were clarified in Reichardt (1996). *Campylodiscus levanderi* has a higher keel and fenestrae than both *C. costatus* and *C. hibernicus*. Valves in *C. levanderi* are highly arched and additionally contorted, the central area is elliptic in contrast to the rounded central areas in *C. costatus* and *C. hibernicus*. In *C. costatus* the grooves adjacent to the raphe converge towards the raphe ends and terminate adjacent to circular depressions, a feature not observed in the other species, although we cannot rule out that this might be related to the preservation of the valves. Apparently, *C. hibernicus* lacks a central ridge in the central area which is present in both *C. costatus* and *C. levanderi*. The spines in *C. hibernicus* and *C. levanderi* seem longer than those in the specimens of *C. costatus* investigated here. However, the length of the spines is variable as seen in the specimens illustrated in Reichardt (2018). Internally the valves of *C. costatus* and *C. hibernicus* are very similar. Although there are small differences with respect to the raphe structure, central area and spines, it is possible that this reflects within-species variability. Further specimens from other populations should be investigated to clarify whether *C. costatus* and *C. hibernicus* are separate species or whether they are conspecific.

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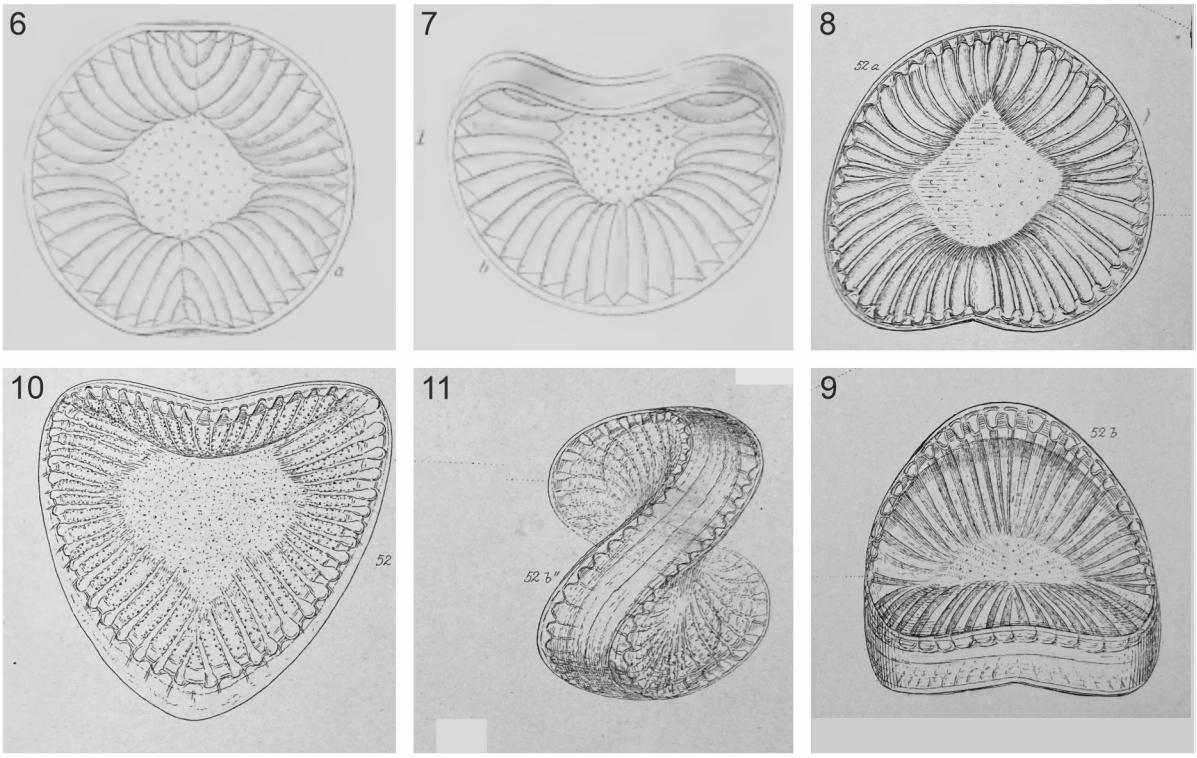
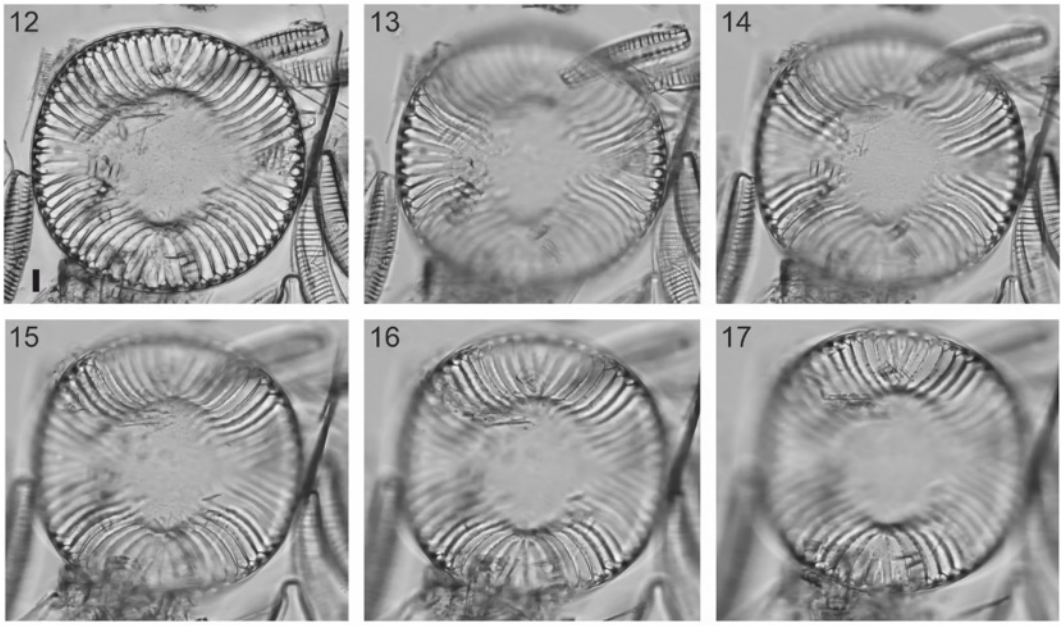
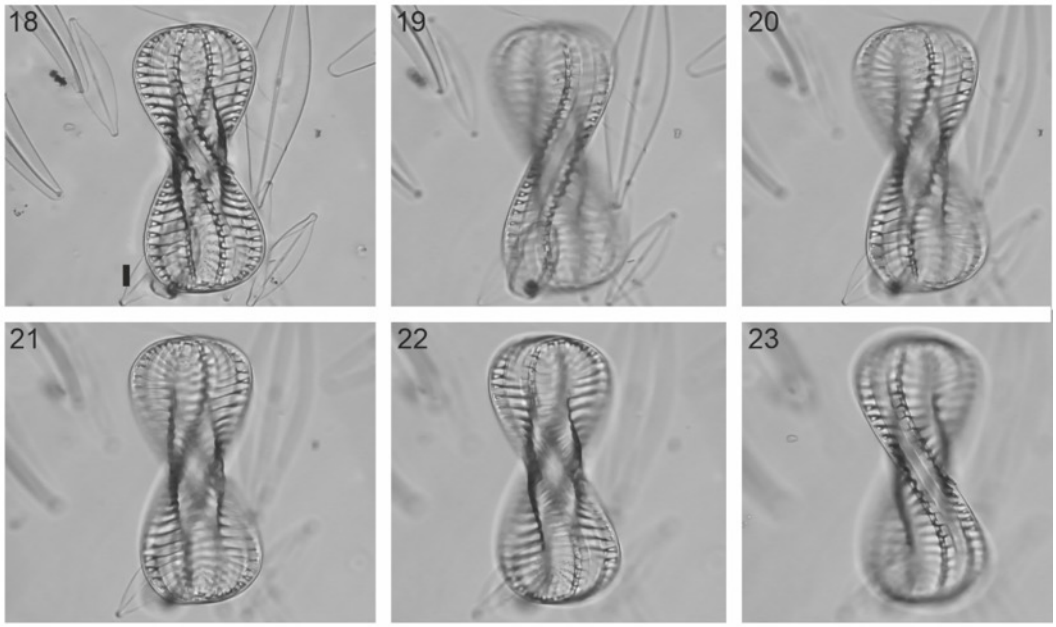


Figs 6–11. *Campylodiscus costatus* W.Smith. Figs 6, 7. Drawings in Smith 1851. Fig. 6. Valve face. Fig. 7. Frustule. Figs 8–11. Drawings in Smith 1853. Fig. 8. Valve face. Fig. 9. Frustule. Figs 10, 11. Var. ß. Fig. 10. Valve face. Fig. 11. Frustule in girdle view.

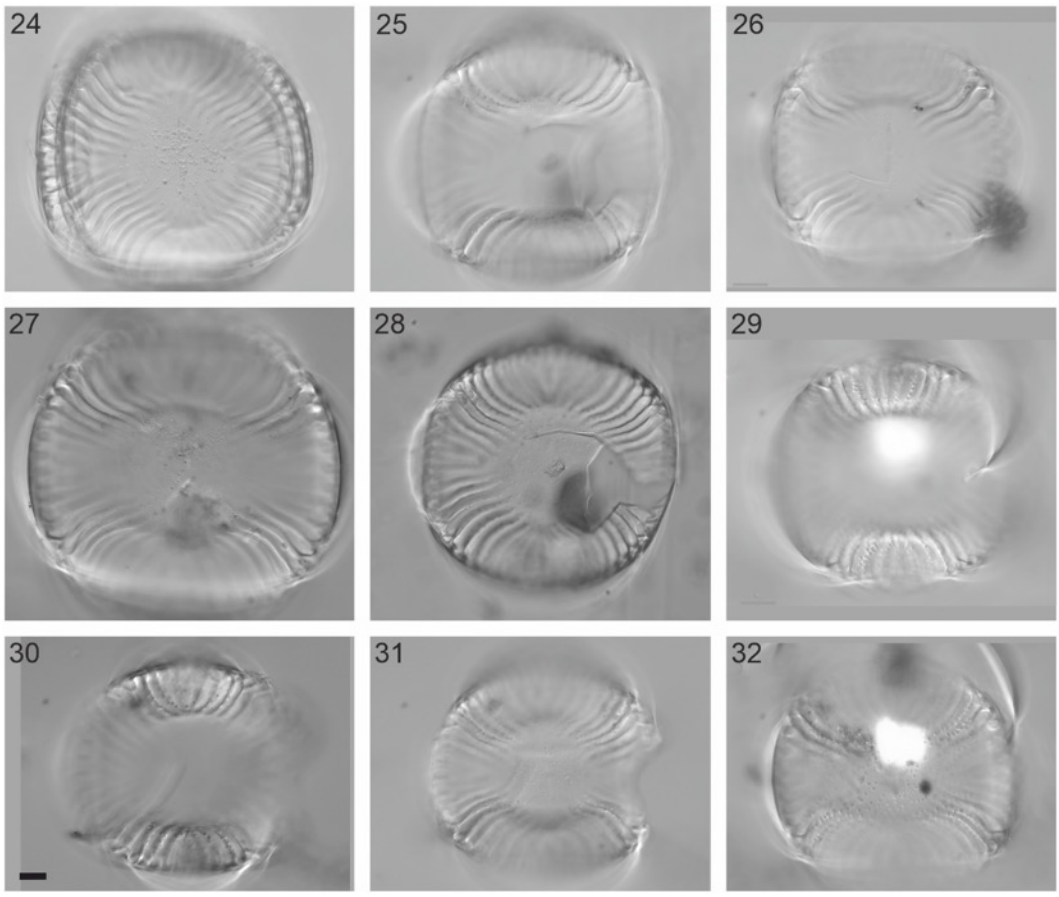


Figs 12–17. *Campylodiscus costatus* W.Smith. **BM** 23202, 'Annals of N.H. August 1848 Dr Dickie', fossil deposit at Peterhead, Aberdeenshire, valve views. Fig. 12. Lectotype, merged

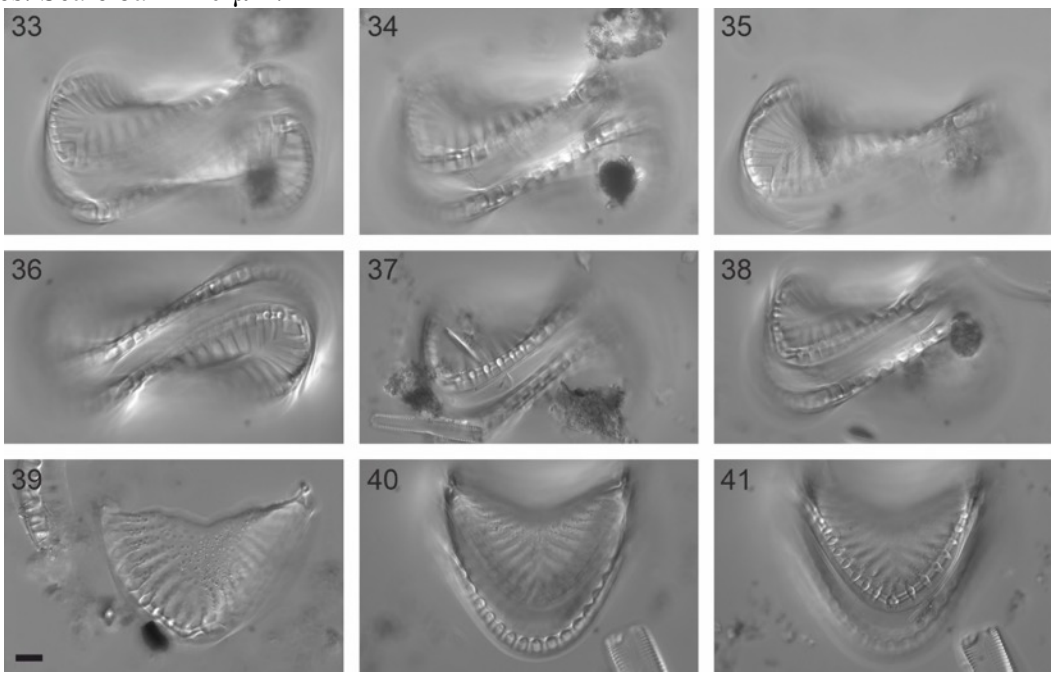
image using stacked images of the same specimen Figs 13–17, software Helicon Focus. Scale bar = 10 µm.



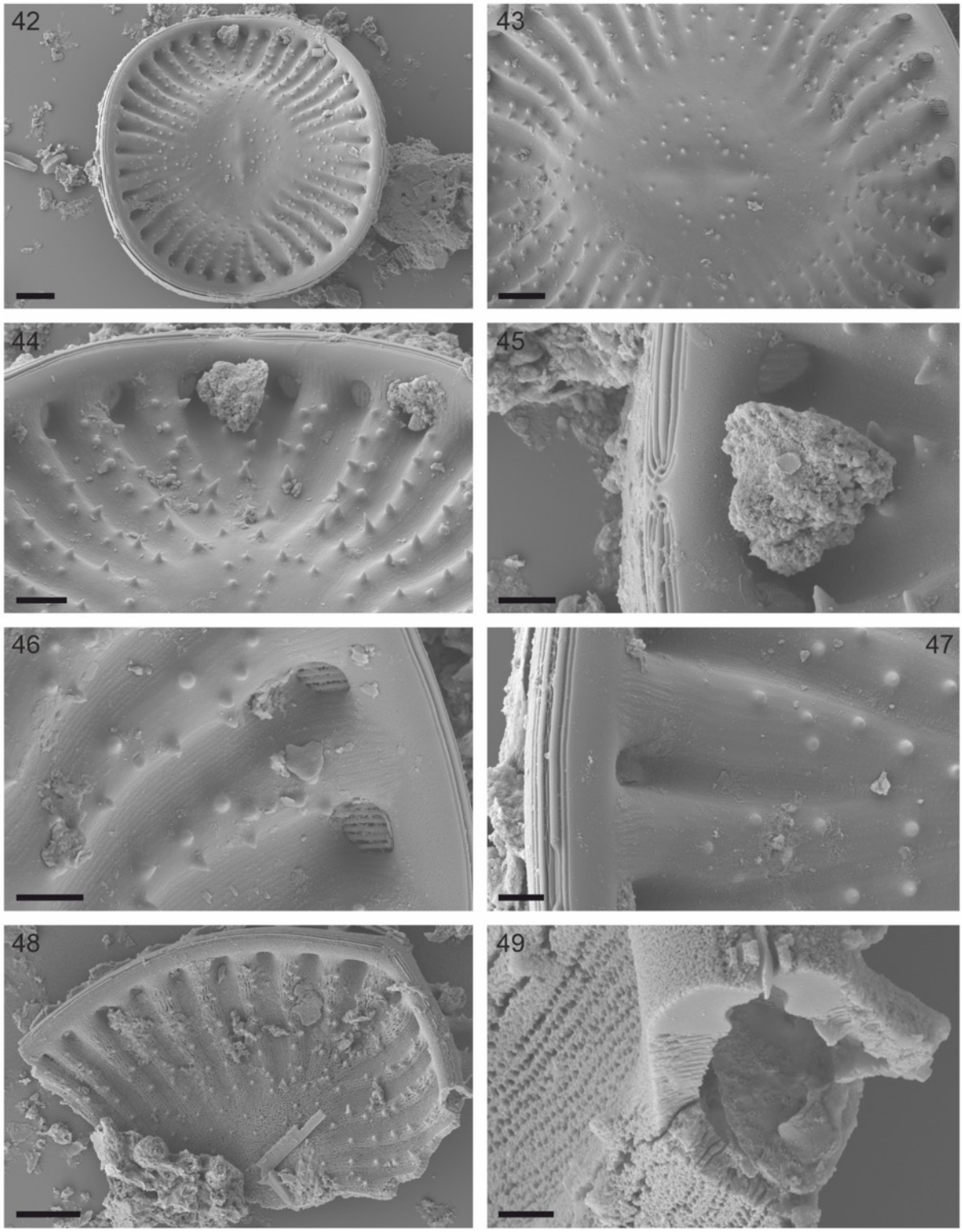
Figs 18–23. *Campylodiscus costatus* W.Smith. **BM** 23510, 'Guildford JR Capron Esq *misit* Nov 4 1850', Bramley Spring near Guildford. Girdle view of frustule. Fig. 18. Merged image using stacked images of the same specimen Figs 19–23, software Helicon Focus. Scale bar = 10 µm.



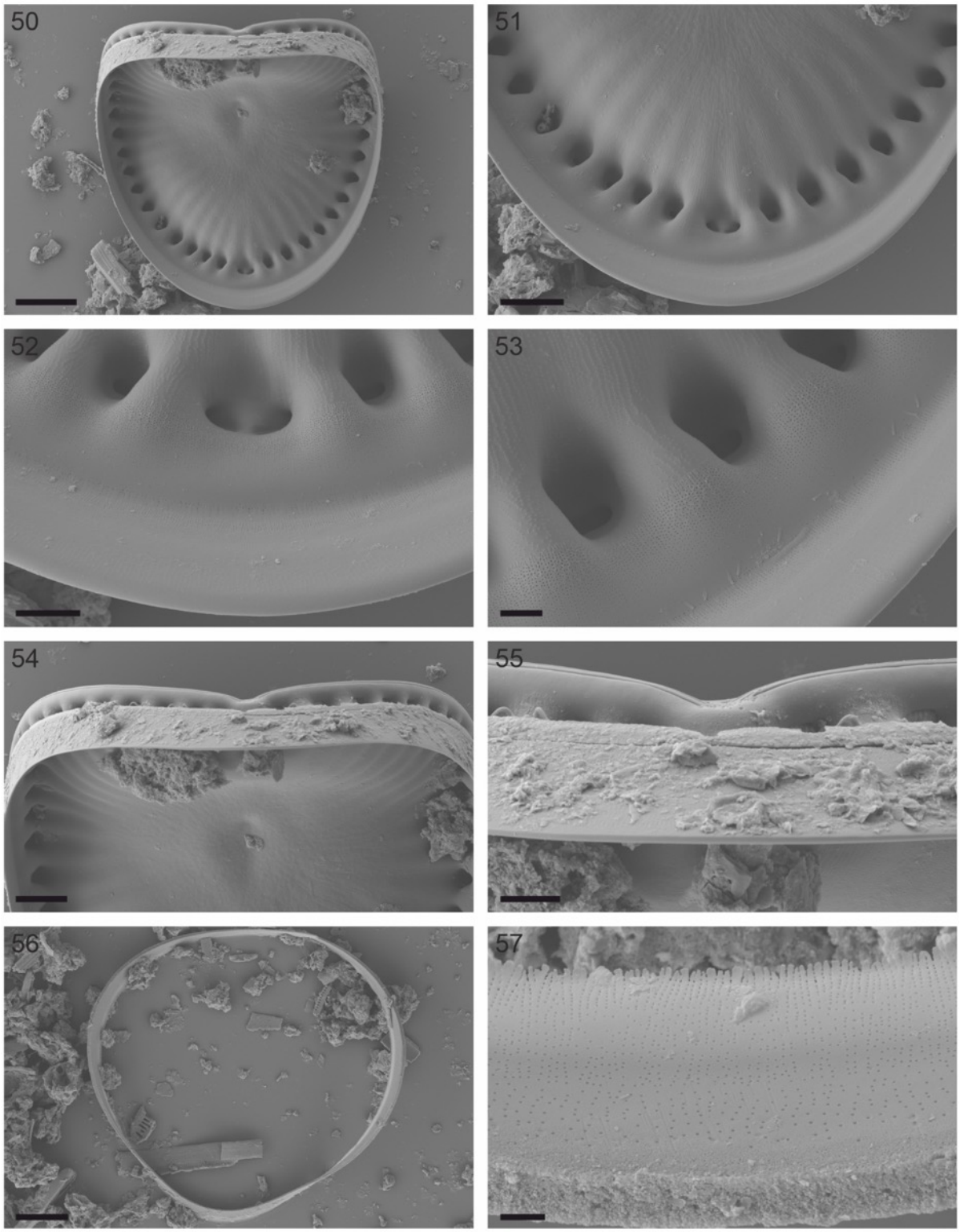
Figs 24–32. *Campylodiscus costatus* W.Smith. **BM** 23195. Edinburgh, April 1854. LM. Size diminution of valves, view of external valve face showing costae, hyaline valve centre and spines. Scale bar = 10 µm.



Figs 33–41. *Campylodiscus costatus* W.Smith. **BM** 23195. Edinburgh, April 1854. LM. View of frustules and valves in girdle view showing the saddle-shaped valves and bands. Scale bar = 10 µm.



Figs 42–49. *Campylodiscus costatus* W.Smith. **BM** 001167240. Edinburgh, April 1854. SEM. Figs 42–44. Valve views showing external valve surface with spines, costae, fibulae, fenestrae and keel with raphe. Fig. 45. Raphe ends with converging adjacent grooves and ridges. Figs 46, 47. External valve surface showing costae with spines, multiseriate striae in adjacent grooves, and keel with raphe. Fig. 48. Fragment of eroded valve showing costae with spines and raphe. Fig. 49. Section of eroded valve showing areolae. Scale bars: Figs 42, 48 = 10 µm, Fig. 43 = 6 µm, Fig. 44 = 4 µm, Fig. 46 = 3 µm, Figs 45, 47 = 2 µm, Fig. 49 = 1 µm.



Figs 50–57. *Campylodiscus costatus* W.Smith. **BM** 001167240. Edinburgh, April 1854. Figs 50–53. Internal view of valves showing striae, fibulae, internal and external view of bands, keel and raphe. Figs 54, 55. Internal view of valve, external view of bands, keel and raphe. Figs 56, 57. Bands with rows of areolae and fringed advalvar margin. Scale bars: Figs 50, 56 = 20 µm, Figs 51, 54 = 10 µm, Figs 52, 55 = 4 µm, Fig. 53 = 2 µm, Fig. 57 = 1 µm.