

SUPPLEMENTAL TEXT DR1: TAXONOMY

Brachiopods (arranged in order of appearance)

1. *Bruntonia maynci* (Dunbar, 1955) (see Angiolini and Long [2008, Fig. 5A-G; Fig. 6A-C, F-G; Fig. 7A-C]). Large, plano-convex, quadrate outline but with extended triangular ears (therefore strophic), well developed sulcus in pedicle valve, weak rib ornament, densely spinose. *B. rudis* (Dunbar, 1955) has more extended and enrolled ears, most perhaps all specimens encountered here belong to *B. maynci*. Similar to *Horridonia* but lacks ventral hinge spines.

2. *Dyoros (Dyoros) spitzbergianus* (Toula, 1874) (see Shen et al. [2005, Fig. 5K-O]). Chonetid with wide wings, sulcus originates at beak and broadens and deepens anteriorly. This species has a more quadrate outline than *D. (D.) mucronata* Shen et al. 2005. Shen et al. (2005) placed these Spitsbergen chonetids in this genus because it is less convex and has a shallower sulcus than the otherwise similar *Chonetina*.

3. *Kuvelousia weyprechtii* (Toula, 1874) (see Angiolini and Long [2008, Fig. 2K-L]). Medium-sized, plano-convex, strophic hinge, with broad, medium V-shaped sulcus in pedicle valve. Fine rib ornament. Previously most specimens of this taxon have been assigned to *Megousia* but this is more heavily ribbed. Angiolini and Long (2008) place the Spitsbergen specimens in Waterhouse's (1968) genus *Kuvelousia*. The strength of ornament varies in specimens seen in our study suggesting that those with stronger ornament have affinities with *K. kulikii* (Fredericks, 1925) and some have a shallower sulcus suggesting affinities with *K. harlandi* (Gobbett, 1964). Further taxonomic work may reveal the *Kuvelousia* populations of Spitsbergen to be a single, highly variable species or a series of closely related species.

4. *Paeckelmanella* sp. Broad, strophic hinged, with well-developed medial sulcus that widens rapidly towards anterior. Well-developed costae that become weaker away from umbo.

5. *Waagenoconcha* sp. (Fig. DR6L-M). Large, planoconvex, widest part of shell in central part of shell substantially anterior to the hinge line. Weak, broad shallow medial sulcus develops anteriorly of umbone. Surface ornament dominated spine bases (pustulose). *W. irginae* (Stuckenberg, 1898) described from the Vøringen Member by Gobbett (1964) differs from our specimens in having a stronger sulcus.

6. *Haydenella* sp. (Fig. DR6E-F). Small, concavo-convex, rounded oval outline, fine ribs, a few spines.

7. *Spiriferellina* sp. Small spiriferid with well developed, narrow sulcus in pedicle valve. Large, coarse plicae.

8. *Tumarina* sp. (see Angiolini and Long [2008, Fig. 8D-E]). Large spiriferid, strophic, with deep sulcus in pedicle valve, high ventral interarea, ribs are faint. We agree with Angiolini and Long (2008) that the *Licharewia* described by Waterhouse (1968) from Spitsbergen belong to this genus.

9. *Fasiculatia striatoplicata* (Gobbett, 1964). Large spiriferid, with near-strophic hinge and broad, widening sulcus in pedicle valve. Valves covered in strong, fine ribs grouped in fascicles (see Angiolini and Long [2008, pls. 8A-B, F-H]).

10. *Krotovia* sp. Small, plano-convex, sub-circular non-strophic, non-sulcate, both valves have well developed rows of spine bases. Supposedly restricted to the Carboniferous according to the *Treatise*, but their presence amongst our Spitsbergen specimens indicates it continued to thrive in the Permian.

11. *Linoproductus* sp. Medium sized, plano-convex, quadrate, strongly convex, widest point somewhat dorsal of hinge line, well developed, broad, shallow sulcus in pedicle valve, fine costellae and spines. Biernat and Birkenmajer (1981) discuss and illustrate three closely similar species of *Linoproductus* found in the Vøringen Member and speculate that they may belong to one variable species.

12. *Anemonaria* sp. (see Biernat and Birkenmajer [1981, Fig. 10G]). Small, quadrate, plano-convex, strophic with fine ribs with clear sulcus throughout ontogeny, fine ribs. Resembles *A. horridonia* (Wiman, 1914).

13. *Rhynchopora variabilis* (Stuckenberg, 1889) (see Biernat and Birkenmajer [1981, Pl. 7, Figs. 1-11; Pl. 8, Figs. 1-7]). Small, pentagonal shell. A few strong plicae on the sulcus/fold element but earlier (umbonal) parts of shell are smooth. A long-lived species that appears in the Gipshuken Formation. *Rhynchopora* sp. figured by Gobbett (1964, pl. 16, 22-25) also resembles this species.

14. *Spiriferella* spp. (e.g. Angiolini and Long [2008, Fig. 9A-H; Fig. 9I-J; Fig. 10A]). Large, thick-shelled spiriferid, near strophic hinge line. Deep sulcus develops in pedicle valve and widens anteriorly with “v” shaped section. Ornament consists of strong, rounded ribs (plicae) and finer intercalated ribs. Angiolini and Long (2008) note the presence of both *S. keilhavii* (von Buch, 1846) and *S. loveni* (Diener, 1903) in the Kapp Starostin Formation. Both species are likely present in our analysis but it proved difficult to achieve species-level diagnosis with our specimens and so they are grouped together in our range chart.

15. *Svalbardoproductus* sp. Large, plano-convex, rounded outline with prominent umbone, extended triangular ears (therefore strophic), very weak sulcus in anterior of pedicle valve, dense rib ornament. Very similar to *Thamnousia* but lacks ear spines and has more prominent, extended ears.

16. *Chaoiella* sp. Small, quadrate, concavo-convex, strongly inflated pedicle valve. Fine ribs and weak reticulate ornament. Shallow sulcus developed late in ontogeny.

17. *Composita* sp. (see Biernat and Birkenmajer [1981, Pl. 9, Fig. 1]). Small terebratulid, smooth with rounded-pentagonal outline that strongly resemble the specimen illustrated by Biernat and Birkenmajer (1981).

18. *Kochiproductus* sp. Large, broad, near strophic hinge, weak sulcus in pedicle valve, strong, fine ribs and comarginal ornament give reticulate pattern, spinose. Similar to *K. plexicostatus* Dunbar (1955) but the numerous long spines seen in Dunbar's illustrations were not seen in our study.

19. *Derbyia grandis* (Waagen, 1884). Large *Derbyia*, valves can be 10 cm in width or occasionally greater. Pedicle vales are flattened, no convincing brachial valve seen in this study. Dense covering of abundant, fine radial costae.

20. *Thuleproductus* (very similar to *Thuleproductus* cf. *crassauritus* figured by Biernat and Birkenmajer [1981, Pl. 1, Fig. 2; Pl. 3, Figs. 1-2]). Large, plano-convex, non strophic, weak sulcus develops later in ontogeny. Covered in strong striae. Differs from the closely similar *Thamnousia* in details of its ears (Angiolini and Long, 2008).

21. *Cleiothyridinia* sp. Large athyrid, broad, pentagonal outline, small umbo, weak comarginal ornament.

22. *Bathymyonia* sp. Large, narrow productid, concavo-convex, clear sulcus, dense spines, strong growth lines on brachial valve, ribs weak to absent.

23. *Cancrinella* sp. Medium-sized, plano-convex, short ears at end of strophic hinge, well developed spine bases give pustulose appearance to shell surface. Biernat and Birkenmajer (1981) assign the specimens from the Vøringen Member to *C. spitsbergiana*

(Gobbett, 1964) and it is possible that the specimens from higher in the Kapp Starostin Formation also belong to this long-lived species.

24. *Dielasma* cf. *plica* (Kutorga, 1842) (see Biernat and Birkenmajer [1981, Pl. 2, Fig. 7; Pl. 8, Fig. 8-9; Pl. 9, Fig. 2]). Small, oval, narrow terebratulid.

25. *Lingula freboldi* (Gobbett, 1964). Elongate, sub-rectangular valves, covered in ultra-fine growth lines. Phosphatic shell material.

26. *Archboldia impressa* (Toula, 1875) (see Biernat and Birkenmajer [1981, Fig. 2B-J; Fig. 3A-B]). Large, concavo-convex, quadrate outline, broad strophic hinge, weak sulcus in pedicle valve. Valves covered in costellae.

27. *Orbiculoidea winsnesi* (Gobbett, 1964). Sub-circular outline, fine concentric ridges, oval pedicle opening extends from apex to near margin of shell. Phosphatic shell material.

28. *Liosotella* sp. Small, broad, sub-quadrate outline, widest part of shell just dorsal of hinge line (i.e. near-strophic). Narrow and shallow medial sulcus. In our specimens rib strength is too great to be *L. pseudohorridonia* (Wiman, 1914), they most closely resembles *L.? robertiana* (de Koninck, 1850) as figured by Gobbett (1964, pl. 4, 1-7).

29. *Costiferina arctica* (Whitfield, 1908). Planoconvex, strongly inflated, medium sized. Strophic hinge with well-developed, prominent wings. Well-developed ribs, the strongest of any productid in this study.

30. *Pterospirifer* sp. Ultra strophic spiriferid, with well-developed smooth, sulcus in pedicle valve, rest of shell covered in fine costae.

31. *Stenocisma* sp. nov. 1. Rhynchonellid with biconvex shell of triangular outline. Pedicle valve geniculation begins at mid length and widens anteriorly. This genus is not usually regarded to be geniculate and so this may be a new genus. A few, strong ribs develop

in the mid-part of the shell. Gobbett (1964) described *S. spitzbergiana* from the Vøringen Member but the specimens found here are from the uppermost Kapp Starostin Formation and are considered to belong to an undescribed species.

32. *Neophricadothyris* sp. (see Biernat and Birkenmajer [1981, Pl. 10, Figs. 1-2]).

Large, pentagonal, biconvex shell. Weak growth lines are the only ornament.

33. *Stenocisma* sp. nov. 2 (Fig. DR6I-J). Small, pentameral shell, anteriorly smooth, rounded plicae develop later in ontogeny, clearest in medial part less prominent on the flanks. Like *Stenocisma* sp. nov 1 above but without a geniculation.

34. *Brachythyris* sp. (Fig. DR6A). Non-sulcate spiriferid, moderately wide. Well developed, rounded plicae. One good brachial valve seen. The specimen resembles *Spiriferina*.

35. *Dyoros* (*Dyoros*) *mucronata* (Shen et al., 2005) (see Shen et al. [2005, Fig. 5A-J]). See *D. (D.) spitzbergianus* above for discussion.

36. indet. echinoconchoid (Fig. DR6C-D). Rounded productid with widest point anterior to hinge line, rows of spines cover valves, no ribbing. Specimens too incomplete to consider generic identification but they clearly belong to Echinoconchoidea superfamily. A group common in the Mississippian but not previously known from the Late Permian.

37. *Lissochonetes superba* (Gobbett, 1964) (Fig. DR6G-H). Weakly sulcate chonetid, slightly concavo-convex, with fine capillae ornament. The few specimens collected in this study are smaller than the *L. superba* (Gobbett, 1964) figured by Shen et al. (2005), they are more quadrate than *L. geinitzianus* (Waagen, 1884) and less sulcate than the *L. spitzbergensis* (Toula) figured by Gobbett (1964, pl. 15, 19-21).

38. *Rhynchopora* sp. nov. See *R. variabilis* above. The uppermost Kapp Starostin Formation specimens differ from *R. variabilis* in having plicae that begin earlier in ontogeny.

39. *Cancrinella spitsbergiana* (Gobbett, 1964) (Fig. DR6B) (also see Biernat and Birkenmajer [1981, Pl. 5, Figs. 1-8; Pl. 6, Figs. 1-6]). Medium-small, moderately inflated, short hinge line, valves covered in fine, low costellae with common spine bases. Biernat and Birkenmajer (1981) consider this species to range from the Gipshuken Formation and throughout the Kapp Starsotin Formation.

Bivalves (arranged in order of appearance)

1. *Streblopteria winsnesi* (Nakazawa, 1999) (Fig. DR7G-H). Medium-sized, circular disc with small posterior auricle and large anterior auricle. Surface of has finely cancellate ornament. Nakazawa (1999) records this species from the uppermost Kapp Starostin Formation whereas we encountered it throughout the Formation.

2. *Vorkutopecten svalbardensis* (Nakazawa, 1999) (Fig. DR7J-K?). Tall shell, several orders of plicae that increase in number by insertion, slightly inflated left valve, flat right valve. Right anterior auricle well developed.

3. *Streblochondria* sp. Medium-sized, circular disc with small posterior auricle and large anterior auricle. Fine radial costae.

4. *Acanthopecten licharewi* (Fredericks, 1915). Small, subcircular, auricles well defined in both valves. Narrow widely spaced radial ribs also broadly spaced comarginal sculpture. Nakazawa (1999) records *A. licharewi* from the uppermost Kapp Starostin Formation although we only found specimens in the mid part of the Formation on Eholmen.

5. *Etheripecten* spp. Prosocline shells, little inflated. Multicostate (primary and secondary) ornament and concentric sculpture, the latter best developed in early ontogeny. Anterior and posterior auricles clearly demarcated from main disc. Nakazawa (1999) describes five species present in the Kapp Starostin Formation including *E. keylingiformis*

(Licharew, 1927); only *E. wilczeki* (Toula, 1875) is present below the 3YLB and so the genus undergoes a radiation event above this level in the uppermost Kapp Starostin Formation.

6. *Grammatodon* sp. Small arcoid, moderately inflated, with fine radial ornament.

7. *Cassianoides crassispinus* (Chronic) (Fig. DR7H). Strongly inequivalved, left valve with strong primary costae which are spinose when crossed with comarginal ornament. Auricles present but poorly preserved in specimens available for this study.

8. *Palaeoneilo* sp. (Fig. DR7E). We regard the illustration of *Grammatodon* (*Cosmetodon*)? in Nakazawa (1999, Fig. 4, 2a-b) obtained from the same level and locality as our specimens to belong to *Palaeoneilo* because due to a short hinge line uncharacteristic of arcoids.

9. *Grammatodon* (*Cosmetodon*)? *suzuki* (Nakazawa, 1999) (Fig. DR7C). Large arcoid, poorly inflated with well-developed and numerous fine radial ribs.

10. *Palaeolima* sp. (Fig. DR7D). Distinctly opisthocline, anteroventrally extended. Umbone region not seen. Radial costae well spaced but irregularly spaced with strong and weak examples. Both bifurcation and intercalation adds new costae.

11. indet. buchiid (Fig. DR7A). The Buchiidae first appeared in the Early Triassic (Waterhouse, 1980). The Permian bivalves from Spitsbergen are too poorly preserved to be truly confident of assigning to this family but they have the characteristic strongly incurved, inflated left valves, lacking ornament; right valve is poorly preserved but appears weakly inflated indicating a strongly inequivalved condition. The close similarities between the Permian Eurydesmatidae and the post-Permian Buchiidae is discussed by Waterhouse (1980). The equivalved condition of the eurydesmatids compared with the inequivalved condition of the buchiids places the Spitsbergen specimens closer to the latter.

12. *Retroceramus* sp nov. (Fig. DR7F) Subrhomboidal, umbones protrude slightly beyond hinge line, beak appears terminal, a few coarse rugae, thick, prismatic outer shell layer. This is the oldest record of a genus (and the family Retroceramidae) hitherto only known from the late Jurassic and Cretaceous. Waterhouse (1970) identified the closely similar inoceramid *Permoceramus* from the Wordian of Australia but this differs in having a quadrate outline.

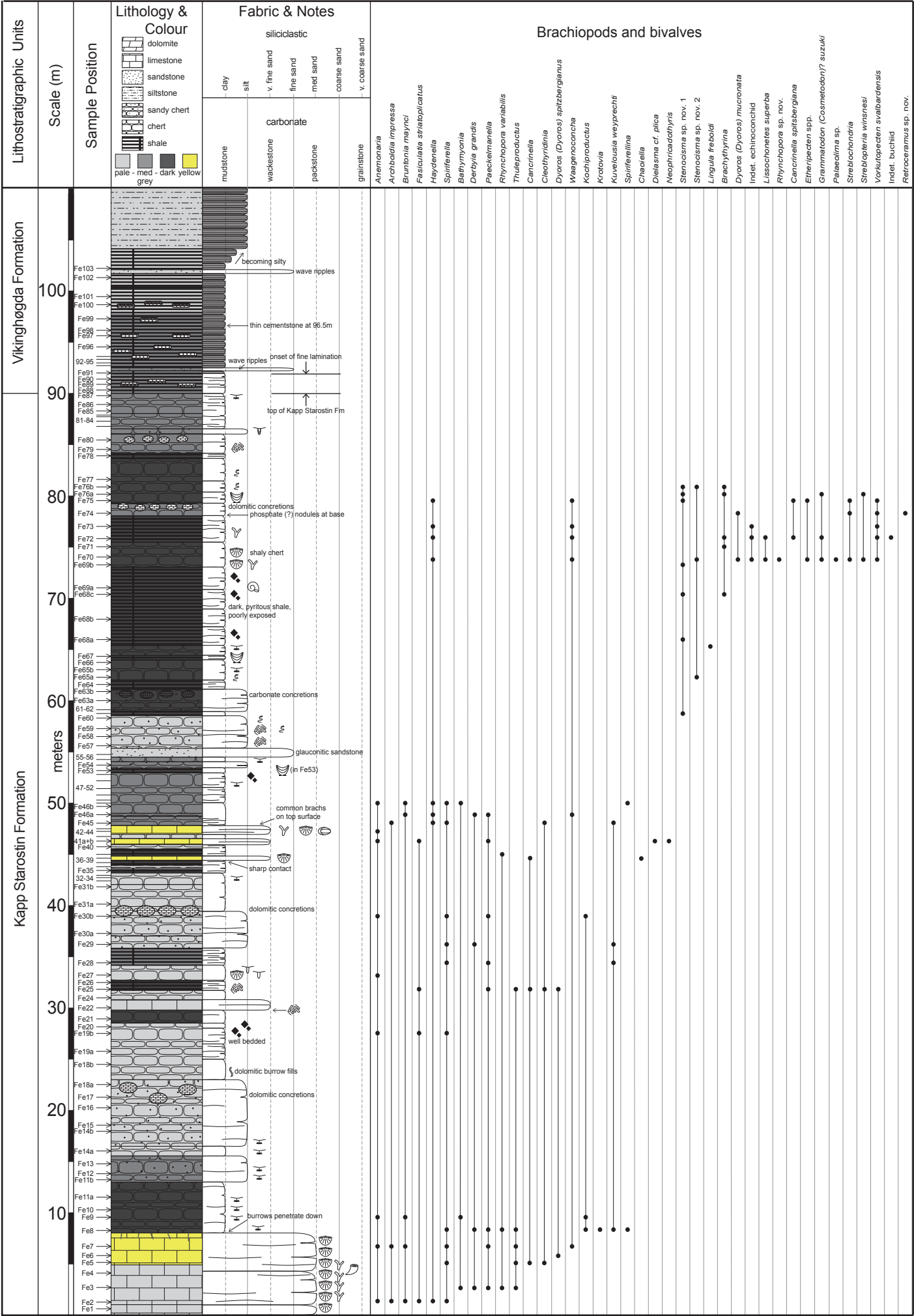
REFERENCES (articles not cited in main text)

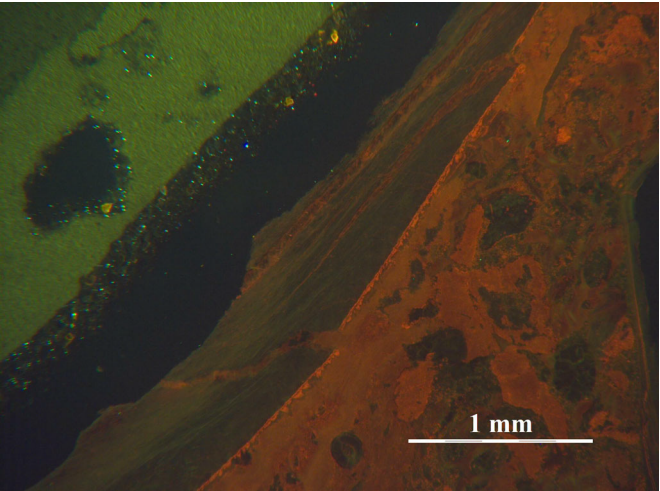
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FIGURE CAPTIONS

Figure DR1. Detailed sedimentary log of the Kapp Starostin section near Festningen, with bed-by-bed fossil brachiopod and bivalve occurrences. Lithologic symbols as in Fig. 2 (main text).

Figure DR2. Cathodoluminescence photomicrograph of non-luminescent brachiopod shell (running from bottom left to top right) from the Kapp Starostin section (sample Fe6 in Fig. DR1).





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