

Lee, S., Shi, G.R., Nakrem, H.A., Woo, J., and Tazawa, J.-I., 2022, Mass extinction or extirpation: Permian biotic turnovers in the northwestern margin of Pangea: GSA Bulletin, <https://doi.org/10.1130/B36227.1>.

Supplemental Material

Supplementary Material 1. Illustrations of Permian brachiopod fauna from the Kapp Starostin Formation in Spitsbergen (Figures S1–S6).

Supplementary Material 2. Detailed stratigraphic ranges of brachiopod species from the Kapp Starostin Formation in each of the studied sections in Spitsbergen.

Supplementary Material 1. Illustrations of Permian brachiopod fauna from the Kapp Starostin Formation in Spitsbergen (**Figures S1–S6**).

Many of the figured specimens have been fully described in Lee (2013) and Lee et al. (2016, 2019). Nakamura et al. (1992) also illustrated various taxa (some of which are omitted in these figures), based on a part of the same collections.

The specimens illustrated are housed in multiple places. The previously published specimens are stored either in the Museum Victoria, Melbourne, Australia (with the prefixes NMV P) or in the Korea Polar research Institute (with the prefixes KOPRIF). The labelled with 'DUES-SL' and 'KOPRI-SL' as well as unregistered specimens are currently deposited in the Palaeontology Lab of the University of Wollongong.

References.

- Lee, S., 2013, An integrated multidisciplinary palaeontological study of selected Permian Arctic brachiopods [Ph.D. thesis]: Melbourne, Australia, Deakin University, 397 p.
- Lee, S., Shi, G.R., Park, H., and Tazawa, J.-I., 2016, Antitropicality and convergent evolution: A case study of Permian neospiriferine brachiopods: *Palaeontology*, v. 59, p. 109–138, <https://doi.org/10.1111/pala.12213>.
- Lee, S., Shi, G.R., Woo, J., Park, T.-Y.S., Oh, J.-R., Kim, N.K., Nakrem, H.A., and Tazawa, J.-I., 2019, Permian spiriferellid brachiopods from northern Pangea: Taxonomy, biostratigraphy, macroevolution and implications for palaeoenvironmental and palaeobiogeographical reconstructions: *Journal of Systematic Palaeontology*, v. 17, p. 1871–1925, <https://doi.org/10.1080/14772019.2019.1570569>.
- Nakamura, K., Tazawa, J.-I., and Kumon, F., 1992, Permian brachiopods of the Kapp Starostin Formation, West Spitsbergen, *in* Nakamura, K., ed., *Investigations on the Upper Carboniferous-Upper Permian Succession of West Spitsbergen 1989-1991*: Sapporo, Japan, Hokkaido University, p. 77–95.

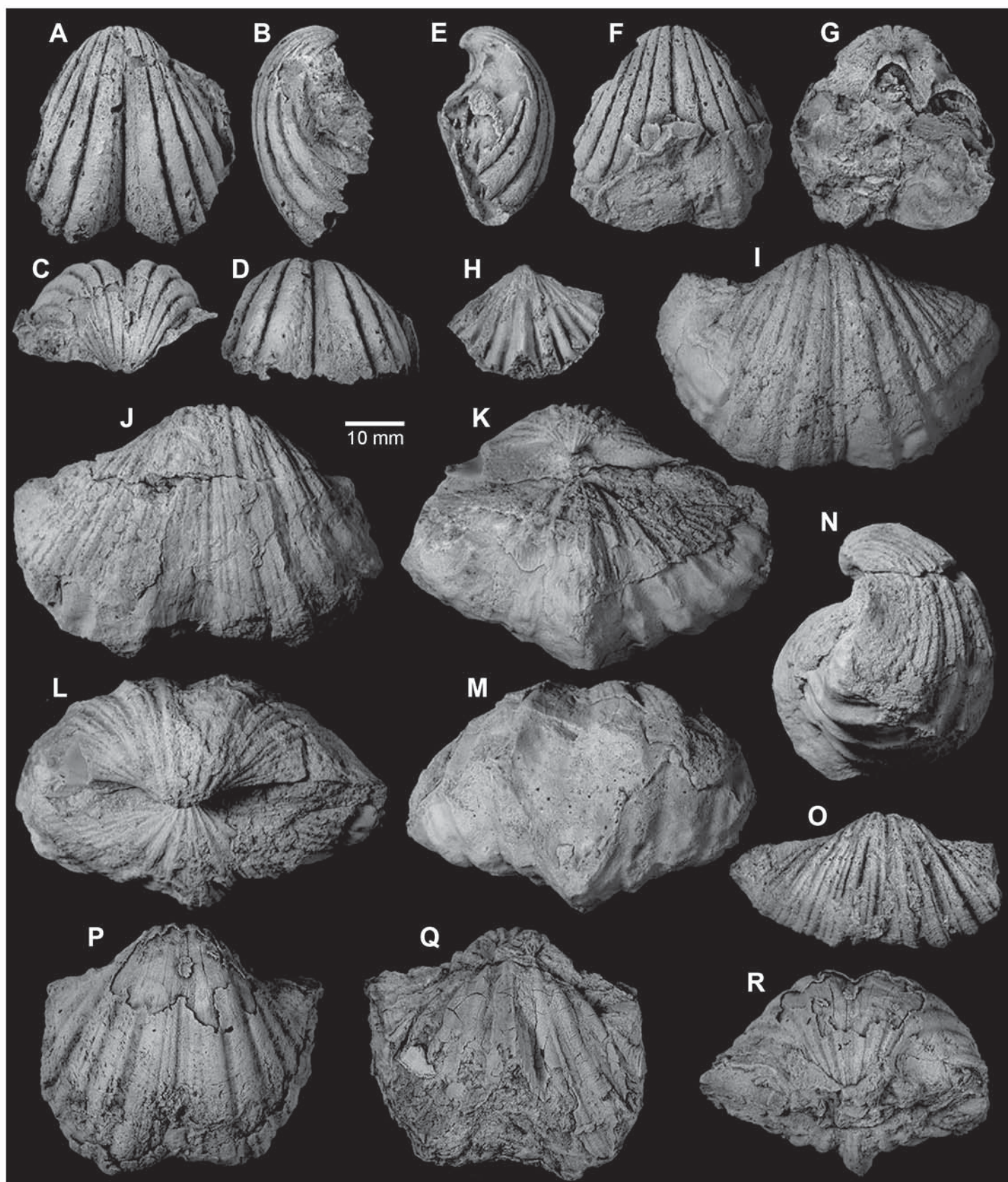


Figure S1. Brachiopod species from the Kapp Starostin Formation in Spitsbergen. **A-H, *Arcullina polaris*** (Wiman, 1914) from the Vøringen Member; **A-D**, ventral, lateral, posterior and dorsal views of a ventral valve (NMV P340498), Skansbukta (B); **E-G**, lateral, ventral and dorsal views of a ventral valve (NMV P340490), Skansbukta (A); **H**, dorsal view of a dorsal valve (NMV P340506), Skansbukta (A). **I-O, *Timaniella wilczeki*** (Toula, 1873) from the Vøringen Member; **I**, ventral view of a ventral valve (NMV P340526), Skansbukta (A); **J-N**, ventral, dorsal, posterior, dorsal and lateral views of a conjoined shell (NMV P340514), Skansbukta (A); **O**, ventral view of a ventral valve (NMV P340546), Skansbukta (B). **P-R, *Spiriferella protodraschei*** Lee and Shi *in* Lee et al. 2019, ventral, dorsal and posterior views of a conjoined shell (NMV P340474), from the Vøringen Member, Skansbukta (A).

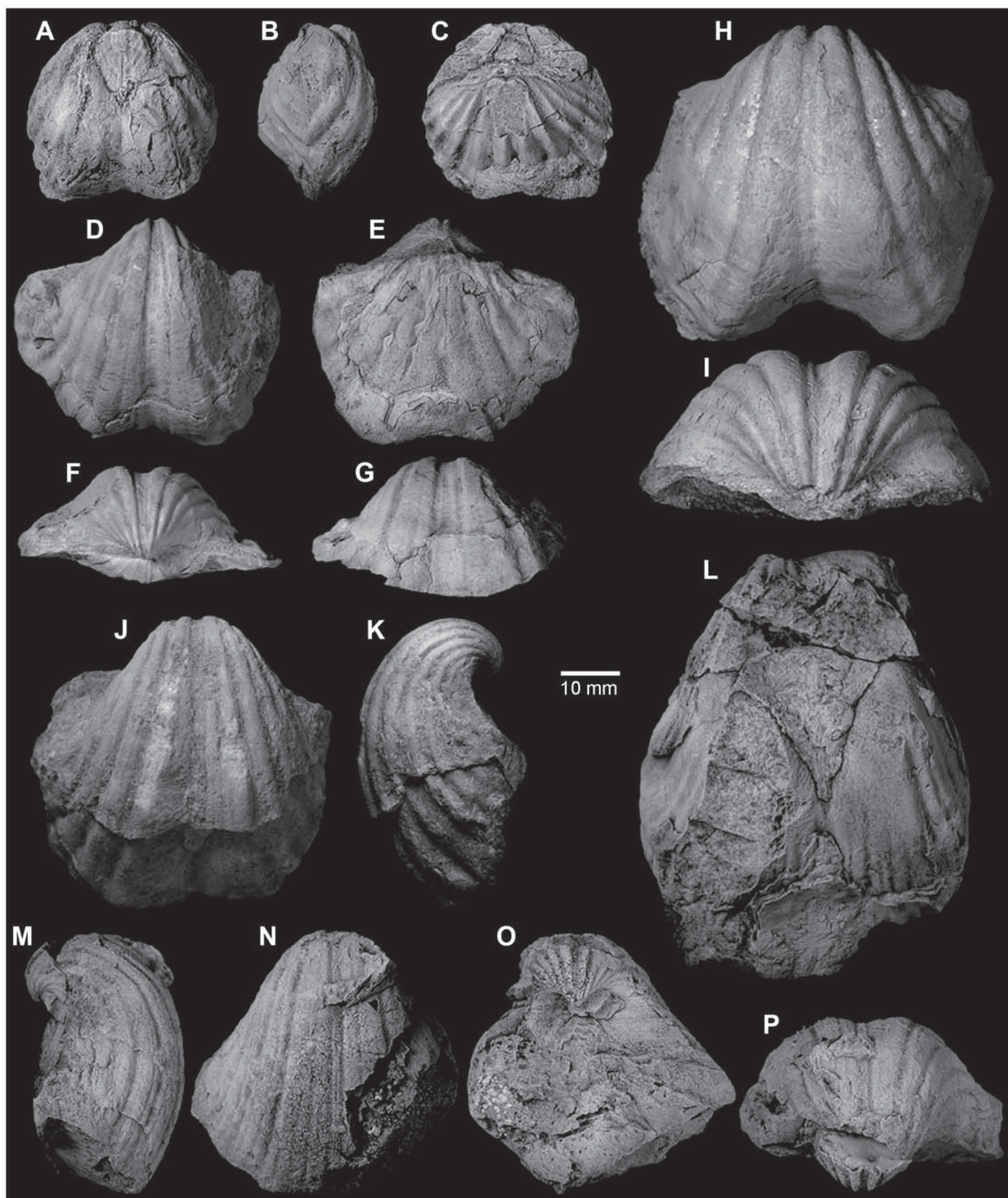


Figure S2. Brachiopod species from the Kapp Starostin Formation in Spitsbergen. **A-I**, *Spiriferella loveni* (Diener, 1903) from the Hovtinden member; **A-C**, ventral, lateral and dorsal views of a conjoined shell (NMV P340300), Trygghamna; **D-G**, ventral, dorsal, posterior and anterior views of a conjoined shell (NMV P340298), Festningen; **H-I**, ventral and posterior views of a ventral valve (NMV P340325), Festningen. **J-L**, *Spiriferella draschei* (Toula, 1875) from the Vøringen Member; **J-K**, ventral and lateral views of a ventral valve (KOPRIF10010), Skansbukta (A); **L**, ventral view of a ventral valve (NMV P340473), Skansbukta (B). **M-P**, *Spiriferella* sp., lateral, ventral, dorsal and posterior views of a ventral valve (NMV P340477), Ahlstrandodden.

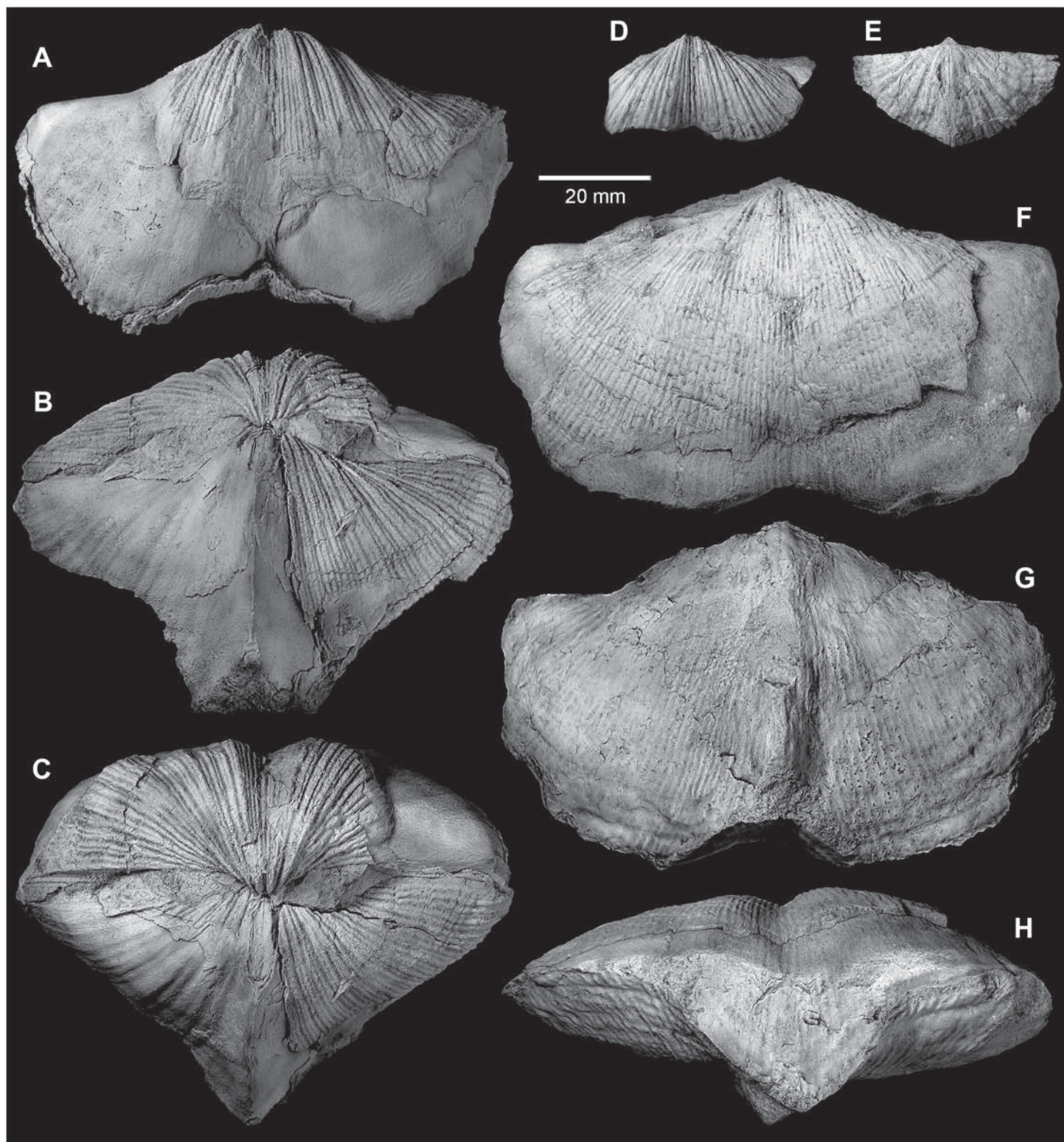


Figure S3. Brachiopod species from the Kapp Starostin Formation in Spitsbergen. **A-C**, *Fasciculatia groenwalli* (Dunbar, 1962), ventral, dorsal and posterior views of a conjoined shell (NMV P309996), from the Vøringen Member, Trygghamna. **D-H**, *Fasciculatia striatoparadoxa* (Toula, 1873), collected from the Hovtinden member, Festningen; **D**, ventral view of a juvenile ventral valve (NMV P309985); **E**, dorsal view of a juvenile dorsal valve (NMV P309994); **F-H**, ventral, dorsal and anterior views of a conjoined shell (NMV P309970).

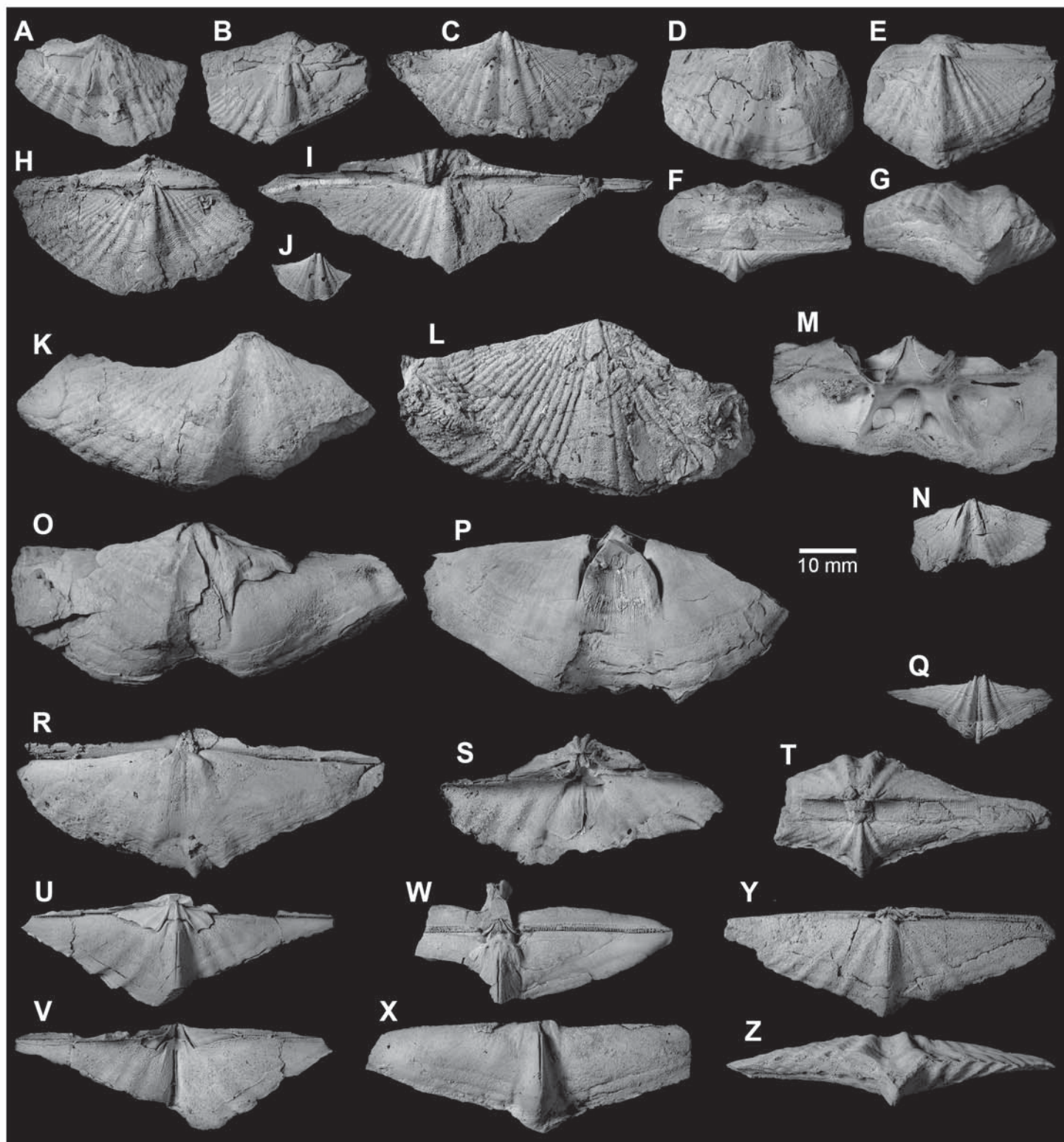


Figure S4. Brachiopod species from the Kapp Starostin Formation in Spitsbergen. **A-J**, *Pterospirifer cordieri* (Roberts, 1845) from the Hovtinden member; **A-B**, ventral and dorsal views of a conjoined shell (DUES-SL275), Festningen; **C**, latex cast of a ventral external mould (DUES-SL283), Trygghamna; **D-G**, ventral, dorsal, posterior and anterior views of a conjoined shell (DUES-SL276), Trygghamna; **H**, latex cast of a dorsal external mould (DUES-SL284), Trygghamna; **I**, latex cast of a dorsal external mould (DUES-SL289), Festningen; **J**, a juvenile ventral valve (DUES-SL285), Trygghamna. **K-P**, *Licharewia* cf. *L. grewingki* (Netschajew, 1911); **K**, ventral view of a ventral valve (DUES-SL344), Ahlstrandodden; **L**, dorsal view of a dorsal valve (DUES-SL351), Idodalen; **M**, latex cast of a ventral internal mould (DUES-SL330), Festningen; **N**, a juvenile ventral internal mould (DUES-SL335), Festningen; **O**, ventral view of a ventral valve (DUES-SL333), Festningen; **P**, ventral view of an internal mould of conjoined shell (DUES-SL332), Festningen. **Q-Z**, *Paeckelmanella* sp. from the Svenskeegga and Hovtinden members; **Q**, a juvenile ventral valve (DUES-SL307), Festningen; **R**, a ventral internal mould (DUES-SL301), Festningen; **S**, latex cast of a ventral internal mould (DUES-SL305), Festningen; **T**, posterior view of a conjoined shell (DUES-SL294), Festningen; **U-V**, a dorsal internal mould (DUES-SL325) and its latex cast, Festningen; **W**, dorsal view of an internal mould of conjoined shell (DUES-SL292), Festningen; **X**, a dorsal internal mould (DUES-SL318), Festningen; **Y-Z**, dorsal and anterior views of an internal mould of conjoined shell (DUES-SL295), Trygghamna.

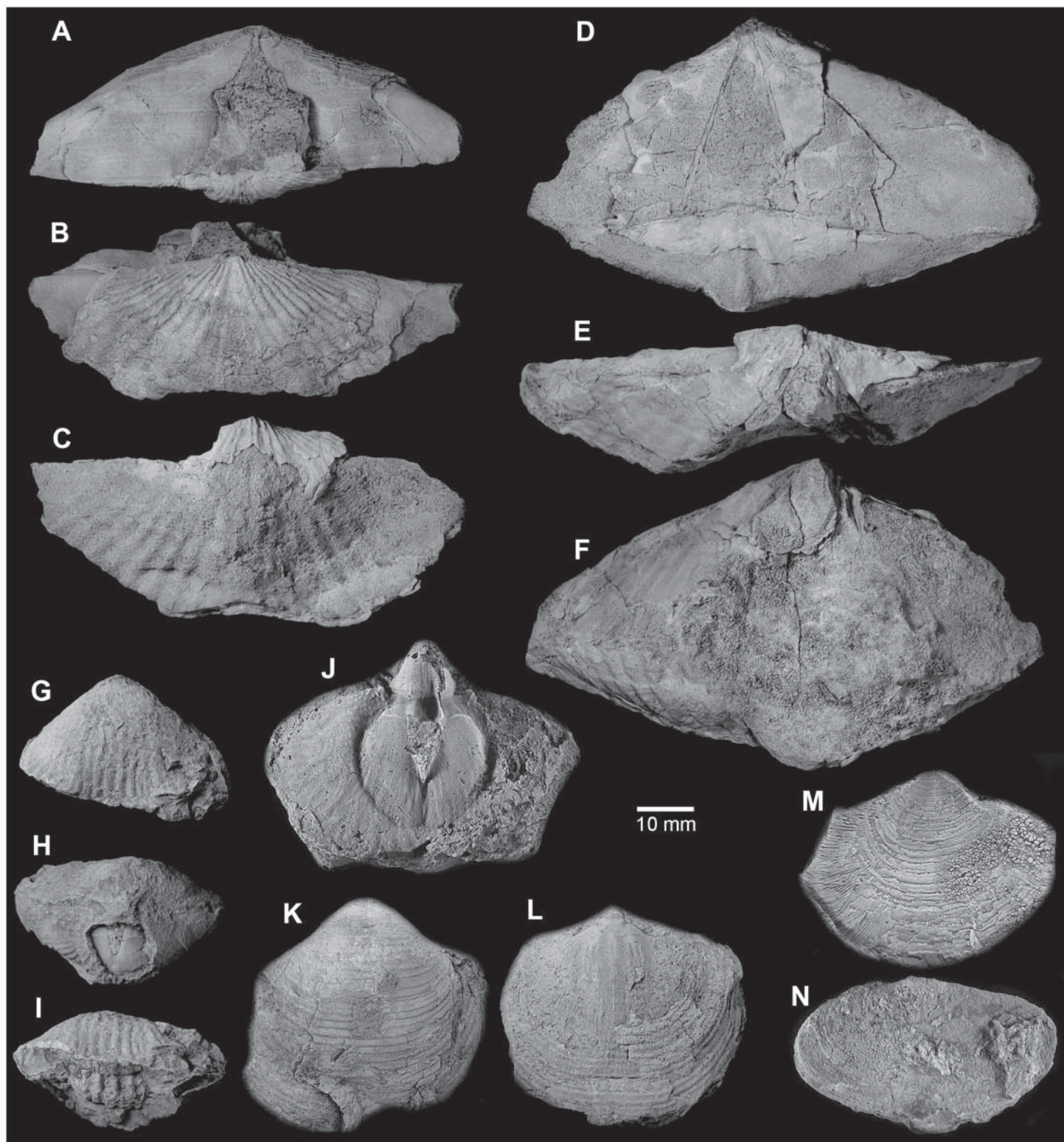


Figure S5. Brachiopod species from the Kapp Starostin Formation in Spitsbergen. **A-F**, *Pseudosyringothyris borealis* Gobbett, 1964; **A-C**, posterior, ventral and dorsal views of a conjoined shell (DUES-SL328), from the Vøringen Member, Skansbukta (B); **D-F**, posterior, ventral and anterior views of a conjoined shell (DUES-SL326), from the Hovtinden member, Festningen. **G-I**, *Stenosisma* sp. from Scheteligfjellet, ventral, posterior and anterior views of a conjoined shell (KOPRI-SL009). **J-L**, *Svalbardathyris kotlukovi* (Stepanov, 1936); **J**, a ventral internal mould (unregistered specimen), from the Hovtinden member, Festningen; **K**, ventral view of a ventral valve (unregistered specimen), Scheteligfjellet; **L**, dorsal view of a dorsal valve (unregistered specimen), Scheteligfjellet. **M**, *Cleiothyridina pectinifera* (Sowerby, 1841), a ventral external mould (unregistered specimen). **N**, *Athyris amdrupei* Dunbar, 1962 from the Vøringen Member, Skansbukta (A), ventral view of a conjoined shell (unregistered specimen).

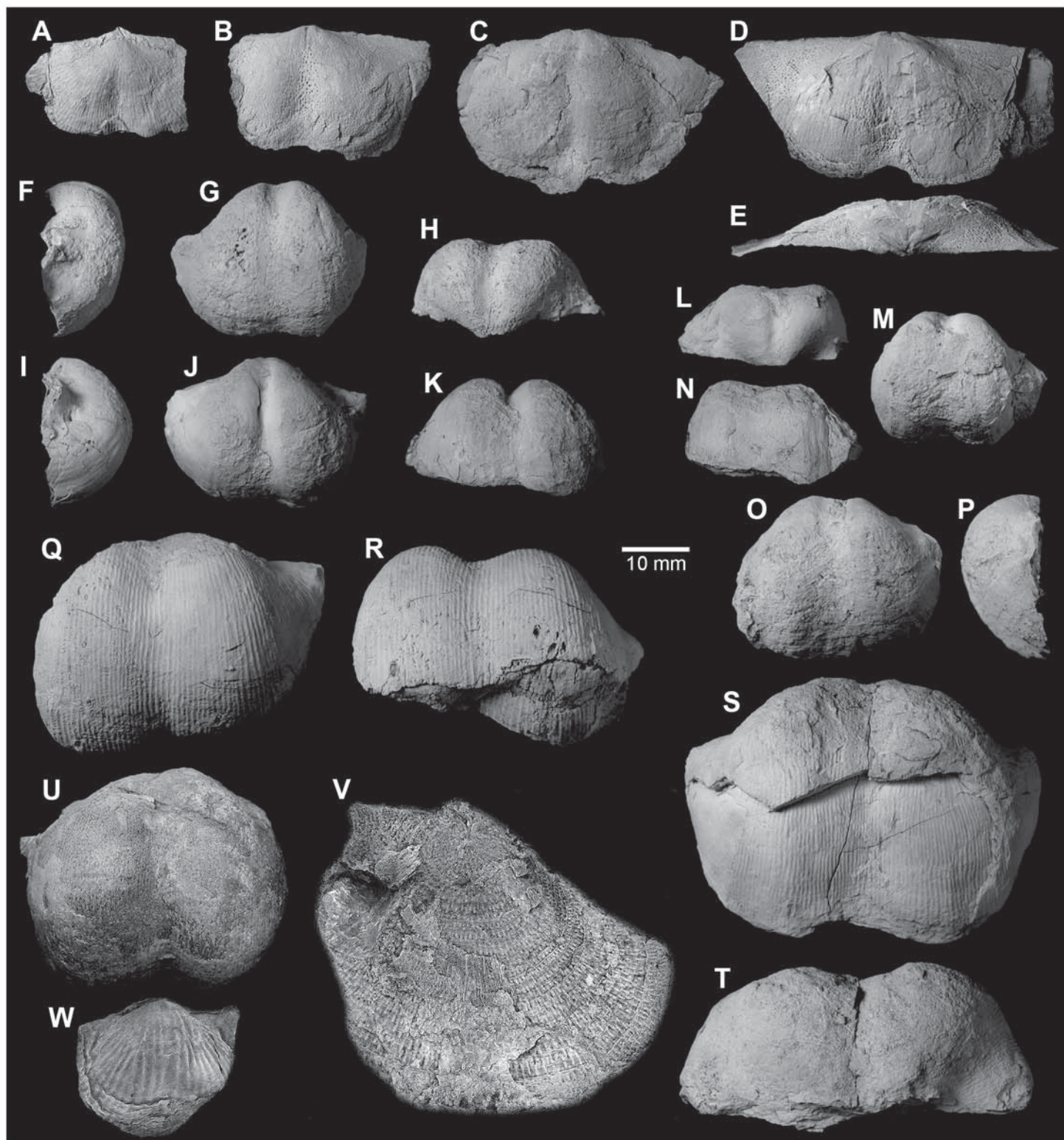


Figure S6. Brachiopod species from the Kapp Starostin Formation in Spitsbergen. **A-E**, *Lissochonetes superba* (Gobbett, 1964) from Scheteligfjellet; **A**, dorsal view of a dorsal valve (KOPRI-SL013); **B**, ventral view of a ventral internal mould (KOPRI-SL011); **C**, ventral view of a ventral valve (KOPRI-SL010); **D-E**, ventral and posterior views of a ventral internal mould (KOPRI-SL012). **F-P**, *Anemonaria pseudohorrida* (Wiman, 1914) from Scheteligfjellet; **F-H**, lateral, ventral and posterior views of a ventral valve (KOPRI-SL016); **I-K**, lateral, ventral and anterior views of a ventral valve (KOPRI-SL017); **L-N**, posterior, ventral and anterior views of a ventral valve (KOPRI-SL014); **O-P**, ventral and lateral views of a ventral valve (KOPRI-SL015). **Q-T**, *Yakovlevia duplex* (Wiman, 1914) from Scheteligfjellet; **Q-R**, ventral and anterior views of a ventral valve (KOPRI-SL018); **S-T**, ventral and posterior views of a ventral valve (KOPRI-SL019). **U**, *Kuvelousia weyprechtii* (Toula, 1873) from the Hovtinden member, Festningen, ventral view of a ventral valve (unregistered specimen). **V**, *Kochiproductus plexicostatus* Dunbar, 1955 from Scheteligfjellet, a dorsal external mould (unregistered specimen). **W**, *Haydenella wilczeki* (Toula, 1875) from the Hovtinden member, Festningen, ventral view of a ventral valve (unregistered specimen).