**Fullerene-like structures of Cretaceous crinoids reveal topologically limited skeletal possibilities**

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**Supporting Information**

**Table S1. Specimens of *Marsupites* and *Uintacrinus* examined in this study with museum collection and stratigraphic information.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Genus** | **species** | **Numbers** | **Collection** | **Formation** | **Articulated** | **Figured** |
| *Marsupites* | *testudinarius* | B24289 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Marsupites] Upper Chalk, UK | Yes | Figure 1 |
| *Marsupites* | *testudinarius* | B65206 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Marsupites] Upper Chalk, UK  Locality Haldon Hill, Devon | Yes | No |
| *Marsupites* | *testudinarius* | B3871, B3874, B3875, B3877, B3878 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Marsupites] Upper Chalk, UK  Locality Sussex | Yes | No |
| *Marsupites* | *testudinarius* | B3915, B3917 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Marsupites] Upper Chalk, UK  Locality Yorkshire | Yes | No |
| *Marsupites* | *testudinarius* | B65210-29 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Marsupites]  Locality Alresford | No | No |
| *Marsupites* | *testudinarius* | NHMUK  E1831 | Natural History Museum, London | [Subzone Marsupites] Upper Chalk, UK | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK E5966 | Natural History Museum, London | [Subzone Marsupites] Upper Chalk, UK | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK E5482a7b | Natural History Museum, London | [Subzone Marsupites] Late Santonian, Brighton, Sussex | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK E57705 | Natural History Museum, London | [Subzone Marsupites] Upper Chalk, Kent | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK E22474 | Natural History Museum, London | [Subzone Marsupites] Late Senonian, Blandford, Dorset | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK EE6304 | Natural History Museum, London | [Subzone Marsupites] Late Santonian, Beverley, Yorkshire | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK E14261 | Natural History Museum, London | [Subzone Marsupites] Late Santonian, Brighton, Sussex | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK E22089 | Natural History Museum, London | [Subzone Marsupites] Late Santonian, Sussex | Yes | No |
| *Marsupites* | *testudinarius* | NHMUK-E14261 | Natural History Museum London | [Subzone Marsupites] Late Santonian, Brighton, Sussex | Yes | Figure S2 |
| *Marsupites* | *testudinarius* | BMNH-009665 | Booth Museum of Natural History, Brighton | [Subzone Marsupites] Upper Chalk, Sussex | Yes | No |
| *Marsupites* | *testudinarius* | BMNH-007931 | Booth Museum of Natural History, Brighton | [Subzone Marsupites] Upper Chalk, Sussex | Yes | No |
| *Marsupites* | *testudinarius* | BMNH-007932 | Booth Museum of Natural History, Brighton | [Subzone Marsupites] Upper Chalk, Sussex | Yes | No |
| *Marsupites* | *testudinarius* | BMNH-007933 | Booth Museum of Natural History, Brighton | [Subzone Marsupites] Upper Chalk, Sussex | Yes | No |
| *Marsupites* | *laevigatus* | BMNH-007936 | Booth Museum of Natural History, Brighton | [Subzone Marsupites] Late Santonian, Brighton, Sussex | Yes | No |
| *Marsupites* | *testudinarius* | BMNH-124A | Booth Museum of Natural History, Brighton | [Subzone Marsupites] Late Santonian, Brighton, Sussex | Yes | No |
| *Uintacrinus* | *socialis* | B5035-40 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Uintacrinus]  Little Woodcote Pit Surrey | No | No |
| *Uintacrinus* | *socialis* | B5042-3 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone  Uintacrinus]  West Clandon Pit Surrey | No | No |
| *Uintacrinus* | *socialis* | B5046 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Uintacrinus]  West Clandon Pit Surrey | No | No |
| *Uintacrinus* | *socialis* | B74830-9 | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Uintacrinus]  Margate Kent | No | No |
| *Uintacrinus* | *socialis* | B11572, | Sedgwick Museum of Earth Sciences, University of Cambridge | [Subzone Uintacrinus] Niobrara Chalk, USA | Yes | Figure 2. |
| *Uintacrinus* | *socialis* | NHMUK EE8058 | Natural History Museum London | [Subzone Uintacrinus] Upper Santonian, Upper Chalk, Isle of Wight | Yes | Figure S1. |
| *Uintacrinus* | sp. | NHMUK-E6927 | Natural History Museum London | [Subzone Uintacrinus] Late Santonian, Upper Chalk, Margate | Yes | Figure S2 |
| *Uintacrinus* | *socialis* | NHMUK E 26100a | Natural History Museum, London | [Subzone Uintacrinus] Niobrara Chalk, USA | Yes | Figure S3-4 |
| *Uintacrinus* | *socialis* | NHMUK E 26100b | Natural History Museum, London | [Subzone Uintacrinus] Niobrara Chalk, USA | Yes | Figure S3-4 |
| *Uintacrinus* | *socialis* | NHMUK E 22402 | Natural History Museum, London | [Subzone Uintacrinus] Niobrara Chalk, USA | Yes | Figure S3 & S5 |

**Table S2. Number of fixed calyx plates for *Uintacrinus socialis* inferred from 2-dimensionally preserved specimen Sedgwick Museum B11572 (Fig. 2).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plate location** | **Plate type** | **Number** | **Location total** | **Cumulative total** |
| cup | centrale | 1 |  |  |
| cup | infrabasal | 0 |  |  |
| cup | basal | 5 |  |  |
| cup | radial | 5 | 11 |  |
| brachial (arm) | primibrachial | 2 | 10 |  |
| brachial (arm) | secundibrachial | ~8 (4) | ~80 |  |
| interbrachial |  | ~41 | ~205 |  |
| interdistichal |  | ~14 | ~70 | 376 |
| Tegmen opening |  | 1 | 1 | 377 |

**Table S3. Average measured area, thickness and weight, and estimated volume and density, of disarticulated calyx plates for *Marsupites testudinarius* and *Uintacrinus socialis*.** Values measured for individual plates given in Table S3.

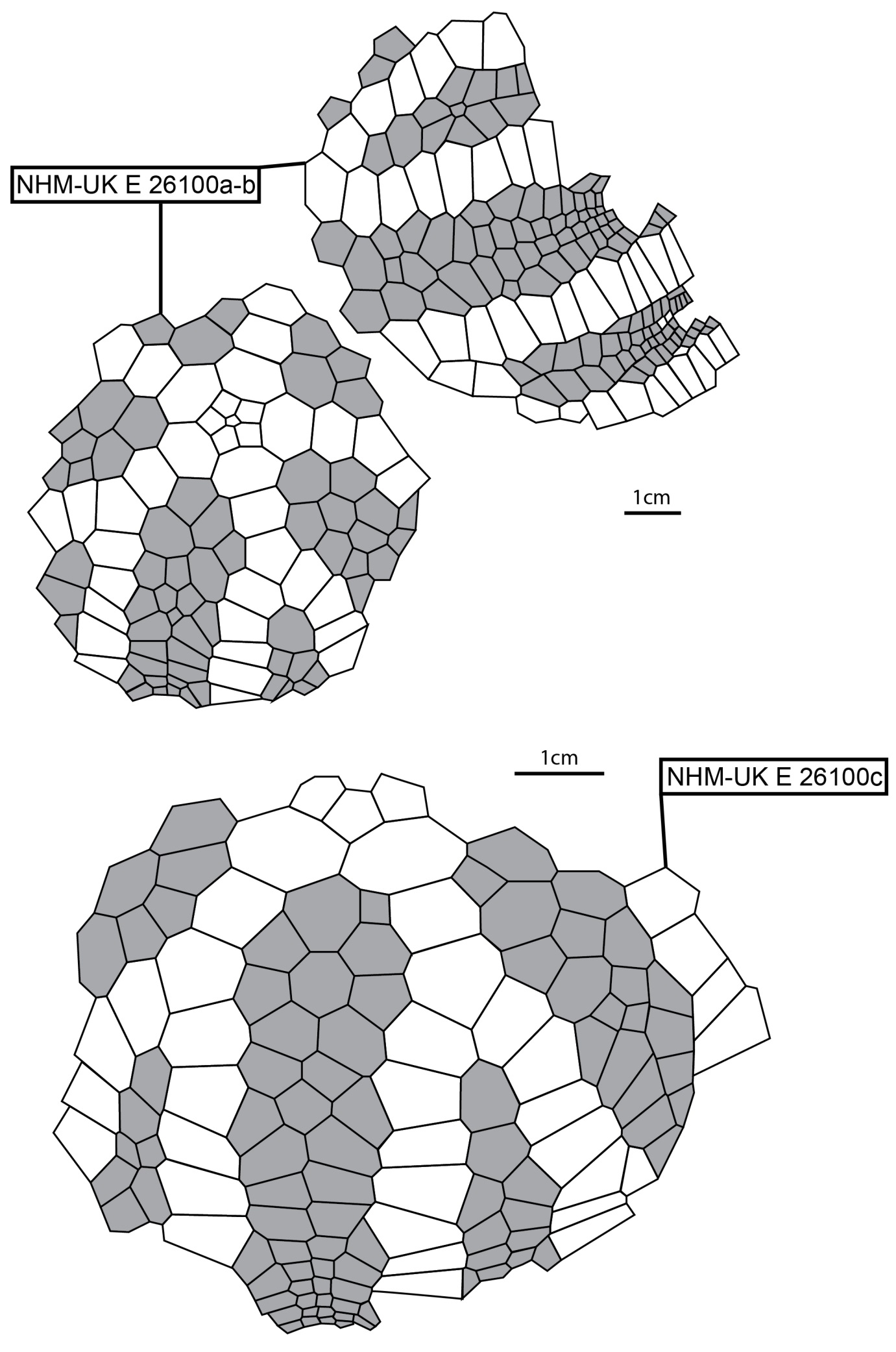
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Calyx plate variable | Average | *Marsupites* | *Uintacrinus* | Statistical test | Test statistic | Test *p* |
| Area (mm2) | Median | 228.20 | 21.10 | Mann-Whitney U | 0 | < 0.0001 |
| Thickness (mm) | Mean | 1.64 | 1.40 | T-test | 2.14 | 0.036 |
| Volume (mm3) | Median | 350.66 | 30.86 | Mann-Whitney U | 0 | < 0.0001 |
| Weight (g) | Median | 0.96 | 0.067 | Mann-Whitney U | 0 | < 0.0001 |
| Density (g/mm3) | Mean | 0.0027 | 0.0021 | T-test | 5.34 | < 0.0001 |



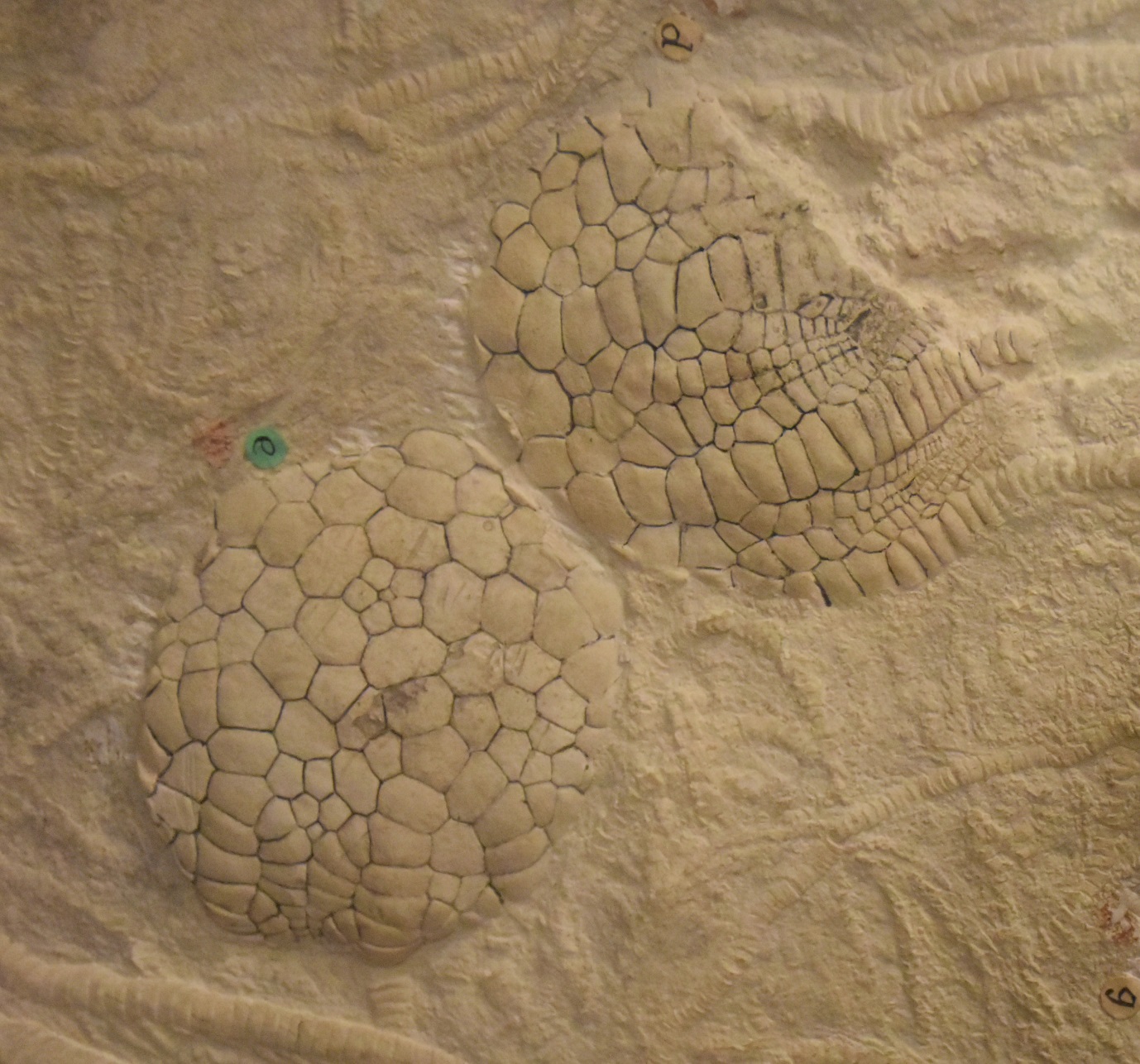
**Figure S1. *Uintacrinus socialis* Grinnell specimen NHMUK EE8058, Natural History Museum London: Lomas Collection.** Age and locality: Upper Santonian, Upper Chalk, Isle of Wight. (*a*) Calyx in aboral view. Scale bar major divisions, cms. (*b*) Detail of cup. While the central plate is dislocated, at least one small, infrabasal plate is apparent (arrow).



**Figure S2. *Marsupites testudinarius* specimen NHMUK-E14261, Natural History Museum London: Birley bequest.** Age and locality: Late Santonian, Brighton, Sussex. Calyx in lateral view. Scale bar 1 cm. At least 4 interbrachial plates are visible between adjacent arms.



**Figure S3. Plate diagrams of *Uintacrinus* specimens NHMUK E 26100a-b (photograph, Fig. S4) and NHMUK-E26100c (photograph, Fig. S5).** Cup and brachial plates shown in white.



**Figure S4. *Uintacrinus* *socialis* (Grinnell) specimen NHMUK.** Locality: Smoky Hill Member, Niobrara Formation, Logan County, Kansas, USA.

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**Figure S5.** ***Uintacrinus socialis* (Grinnell) specimen NHMUK-E26100c.** Age and Locality: Late Cretaceous, Smoky Hill Member, Niobrara Formation, Location number 1, near Elkader, Logan County, Kansas, USA.



**Figure S6. *Uintacrinus* specimen NHMUK-E6927.** Underside of partial calyx.