The *Beothukis/Culmofrons* problem and its bearing on Ediacaran macrofossil taxonomy: evidence from an exceptional new fossil locality

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SUPPORTING INFORMATION APPENDIX S1

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SUPPLEMENTARY TEXT 1: Sedimentology and stratigraphic setting of the MUN Surface

The Catalina Dome, north-eastern Bonavista Peninsula, Newfoundland, documents a ~650 m-thick siliciclastic sedimentary succession that has been lithostratigraphically correlated to the late Ediacaran Conception and St. John’s Groups of the Avalon Peninsula (Hofmann et al. 2008). The upper horizons of the marine Drook Formation form the core of the anticlinal Catalina Dome (O’Brien and King 2006; Fig. 1), with strata conformably younging and shallowing upwards towards the shallow-marine-to-deltaic Renews Head Formation (Hofmann et al. 2008).

The MUN Surface lies near the base of the Port Union Member of the Trepassey Formation (cf. O’Brien and King 2005; Fig. 1), within an interval dominated by medium- to thick-bedded buff-grey sandstones, often containing soft-sediment deformation, rounded intraclasts, and zones of carbonate cementation (Supplementary Fig. 1). Beds are interpreted to represent T_{(a)(b)cd} units of turbidites (cf. Bouma 1962), with current ripples indicating a downslope palaeoflow direction broadly towards the south-east. The Port Union Member has most recently been interpreted to document slope deposition in a submarine channel/channel lobe environment (Mason et al. 2013; see Supplementary Figs 1–2).

The main fossil-bearing surface dips at an angle of 24° to the ESE, and covers an area of ~120 m² at low tide (Supplementary Fig. 2). It sits above an upward-fining 13 cm-thick bed of grey fine-sandstone to siltstone, with a noticeable ~1 cm-thick green-grey siltstone horizon directly beneath the fossil surface, interpreted as a hemipelagite (Supplementary Fig. 3). Fossils are preserved as casts and moulds beneath a ~6 mm-thick fine-grained tuff layer (Supplementary Fig. 3), which itself is overlain by a number of 3–100 cm-thick grey to grey-green siltstone beds and coarse sandstones (Supplementary Figs 1–2). The surface suffers from modern wave erosion and freeze-thaw action, and possesses substantial areas of
unweathered tuff, tectonic cleavage affecting the sediment just beneath the fossil surface, and
natural variation in the colour of the surface (Fig. 2C; Supplementary Fig. 2). Despite these
obstacles to observation, a significant proportion of the surface is conducive to
palaeontological study.

The best-preserved fossils lie adjacent to the cliff-face at the up-dip edge of the
surface, where they have been protected from modern weathering and wave erosion to a
greater extent than specimens located closer to the tidal zone. This sheltered area of the
bedding surface has a golden hue (e.g. Fig. 2A). In contrast, much of the bedding plane
down-dip is stained red, considered to result from modern weathering and oxidation of pyrite
inferred to have been present at the substrate–tuff interface following burial (Gehling 1999;
Mapstone and McIlroy 2006; Supplementary Figs 2–3). Sedimentary grains directly beneath
the fossils are consistently <20 µm in diameter, while grains in the tuff overlying it are more
heterogeneous in grain size, ranging from 5–110 µm. A second faulted outcrop of the same
surface 50 m to the southwest of the main site remains almost entirely covered by
unweathered tuff, and is thus currently unavailable for palaeontological study.

Lithostratigraphic correlation reveals that the surface is also visible in the Little Catalina
section ~2km to the north. However, that outcrop is relatively small, and modern wave action
has effaced the fossils there almost beyond recognition.

Almost all unipolar frondose taxa on the surface are aligned with their distal tips
oriented in a north-to-northwesterly direction, suggesting that they were tethered to the
seafloor at the time of burial (Supplementary Fig. 4). This orientation is significantly
different to the southeasterly direction of downslope flow indicated by ripple marks
immediately above this surface, or the easterly flow direction inferred from ripples in the
lower portion of this Member (Mason et al. 2013), suggesting other marine currents (e.g.
contourites) may be responsible for the observed alignment.
SUPPLEMENTARY FIGURE 1. Log through the cliff section containing the MUN Surface. Lower Port Union Member, Trepassey Formation, Bonavista Peninsula, Newfoundland. Vertical scale of the log is in metres.
SUPPLEMENTARY FIGURE 2. A photograph of the MUN Surface bedding plane. Note the variable coloration of the surface, and particularly the red staining inferred to be caused by oxidation of pyrite at the substrate-tuff interface. J. Matthews at upper left for scale.
SUPPLEMENTARY FIGURE 3. The sedimentology of the MUN Surface. A) Bedding plane viewed from an oblique angle. Grey siltstones underlie the fossil-bearing surface, which is mantled by a thin, brown, fine-grained tuff – still present upon much of the bedding plane. At the interface between substrate and tuff, a thin veneer of orange iron oxyhydroxides are visible – these result from the modern oxidation of pyrite. Black coloration is due to modern lichen cover on exposed surfaces. B) Plane-polarised light view of a thin section through the same sedimentological interval as in (A).
SUPPLEMENTARY FIGURE 4. An oblique view of the MUN Surface bedding plane, showing the high densities of diverse, well preserved Ediacaran macrofossils on the surface. Note the strong current alignment of the frondose fossils, with distal ends of the fronds broadly pointing in the same direction (arrow indicates the broad direction of perceived flow). This current direction is towards the north, and differs significantly from the direction of current flow obtained from turbidite beds 1 m stratigraphically above the surface (flowing to the SE). Since the turbidites are assumed to indicate the palaeoslope direction, we infer the frond alignment to result from the influence of contour currents (cf. Wood et al. 2003). Bedding plane is naturally lit from the top. Scale bar = 50 mm.
SUPPLEMENTARY FIGURE 5. A close-up view of a partial Bradgatia specimen from the MUN Surface, preserved as a negative epirelief mould of the specimen exterior. Progressive orders of self-similar rangeomorph branching (cf. Narbonne 2004) are picked out by yellow (2°), purple (3°), red (4°) and green (5°) shading. Scale bar = 10 mm.
SUPPLEMENTARY FIGURE 6. *Beothukis plumosa* specimens on the MUN Surface, revealing the variation in taphonomic fidelity and style across the surface. A–J: Specimens of *B. plumosa*. K: Specimen similar to *B. plumosa*, note more regular primary branch angles than in other specimens, reminiscent of *Charnia*. L: *B. plumosa* (arrowed), next to a *Charniodiscus* specimen. M: Effaced frond, with a stem and disc similar to those seen in *B. plumosa*. N–P: *B. plumosa*. All stems are positive epirelief features. Scale bars = 10 mm.
REFERENCES


