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SUPPLEMENTARY ONLINE MATERIAL FOR

First three-dimensional skull of the Middle Triassic ichthyosaur *Phalarodon fraasi* (Mixosauridae) from Svalbard, Norway

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Supplementary Online Material

Phylogenetic information

Table S1. A summarising table over the different concretionary slabs of PMO 235.393 and what they contain.

Fig. S1. Slab B of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the skull roof in venteromedial view.

Fig. S2. Slab C of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the skull roof in dorsal view.

Fig. S3. Slab C of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the orbit internal view.

Fig. S4. Slab D of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the rostrum in partial medial view (elements split posteriorly).

Fig S5. The backside of slab D of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing teeth in the anteriormost part of the rostrum in left lateral view.

Phylogenetic information

New character (164): presence of heterodonty in the maxilla.

The presence of this feature is exclusively a *Phalarodon* synapomorphy. This should not be confused with anterior – posterior heterodonty, i.e. heterodonty between the premaxilla and maxilla, or throughout the dentary.

Presence of heterodonty in the maxilla; (0) absent, (1) present. This is scored as present in only *Phalarodon* taxa and is absent in all other taxa where this is scorable, this was checked using the available descriptions for included taxa (see Ji et al., 2015 for more information).

Note that the heterodonty present in *Phalarodon atavus* is not as pronounced as in *Phalarodon callawayi* and *Phalarodon fraasi* (Schmitz et al. 2004, Liu et al. 2013).

Phylogenetic methods and script

The data matrix was modified in Mesquite v3.04 from the updated data matrix from Økland et al., (2018), which in turn was modified from Ji et al. (2015). No taxa were pruned from the data set. The phylogenetic analyses were done with the following commands in TNT 1.5 beta Willi Henning Society Edition (Goloboff and Catalano 2016)

xmult = level 10 < hits 100 < replications 1000 < drift 10 < hold 400

Bremer support was completed using the function in TNT, using the TBR algorithm from the existing consensus tree. Trees were retained suboptimal by 10 steps. Consistency index (CI) and retention index (RI) was calculated using the script “stats.run”. Note that this script only works if less than 400 trees are held in the memory.

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Table S1. A summarising table over the different concretionary slabs of PMO 235.393 and what they contain.

Slab	Includes
A	Main part of skull and postcranial elements. This slab was CT scanned.
B	Dorsal part of the skull including part of the sagittal crest.
C	Counterslab to the left orbit on slab A. Preserves lateral parts of prefrontal and postfrontal visible in dorsal view. Includes part of the postorbital complex, quadrate and articular. Post cranial fragments and impressions.
D	Rostral tip, includes most of the left side of the rostrum, part of the lacrimal, nasal and prefrontal. Visible teeth on anterior, left lateral surface.
E	Ventral portion of left angular and surangular. Hyoids. Partial vertebrae and appendicular elements.

Slab B



Fig. S1. Slab B of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the skull roof in venteromedial view. The anterior direction is marked by an arrow. N = nasal, prf = prefrontal, pof = postfrontal, p = parietal, tf = temporal fenestra, st = supratemporal.

Slab C

1 cm

Anterior

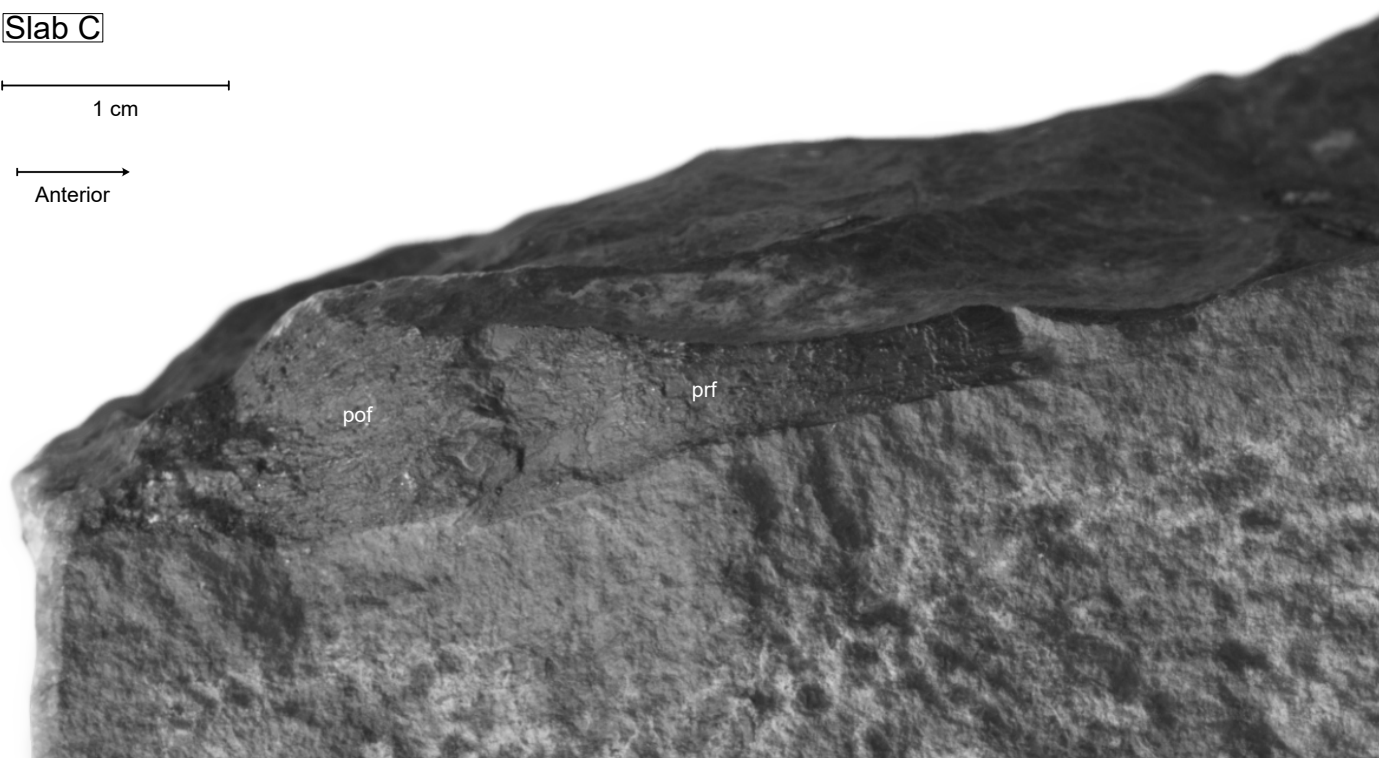


Fig. S2. Slab C of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the skull roof in dorsal view. The anterior direction is marked by an arrow. Prf = prefrontal, pof = postfrontal.

Slab C

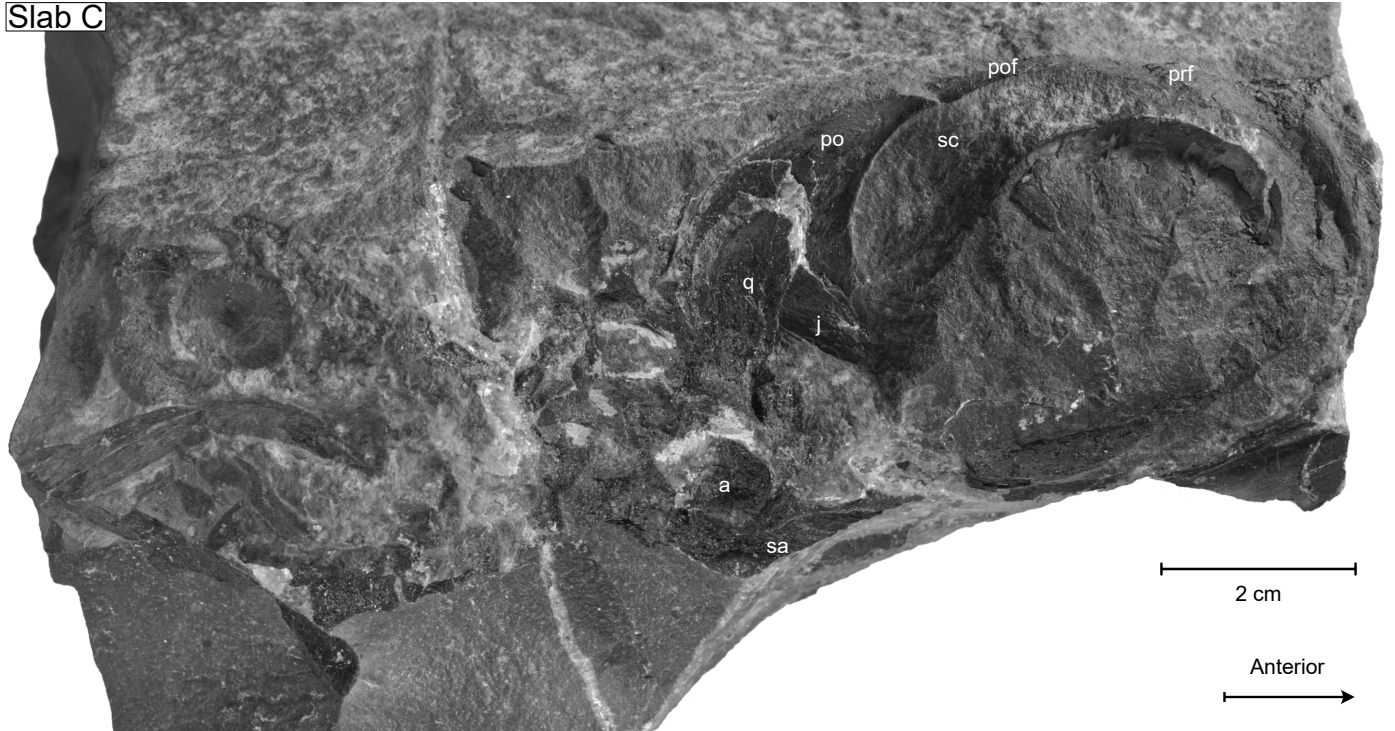


Fig. S3. Slab C of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the orbit internal view. The anterior direction is marked by an arrow. Prf = prefrontal, pof = postfrontal, sc = sclerotic ring, po = postorbital, j = jugal, q = quadrate, sa = surangular, a = articular.



Fig. S4. Slab D of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing elements of the rostrum in partial medial view (elements split posteriorly). The anterior direction is marked by an arrow. Pm = premaxilla, d = dentary, exn = external naris, m = maxilla, n = nasal, l = lacrimal.

Slab D

1 cm

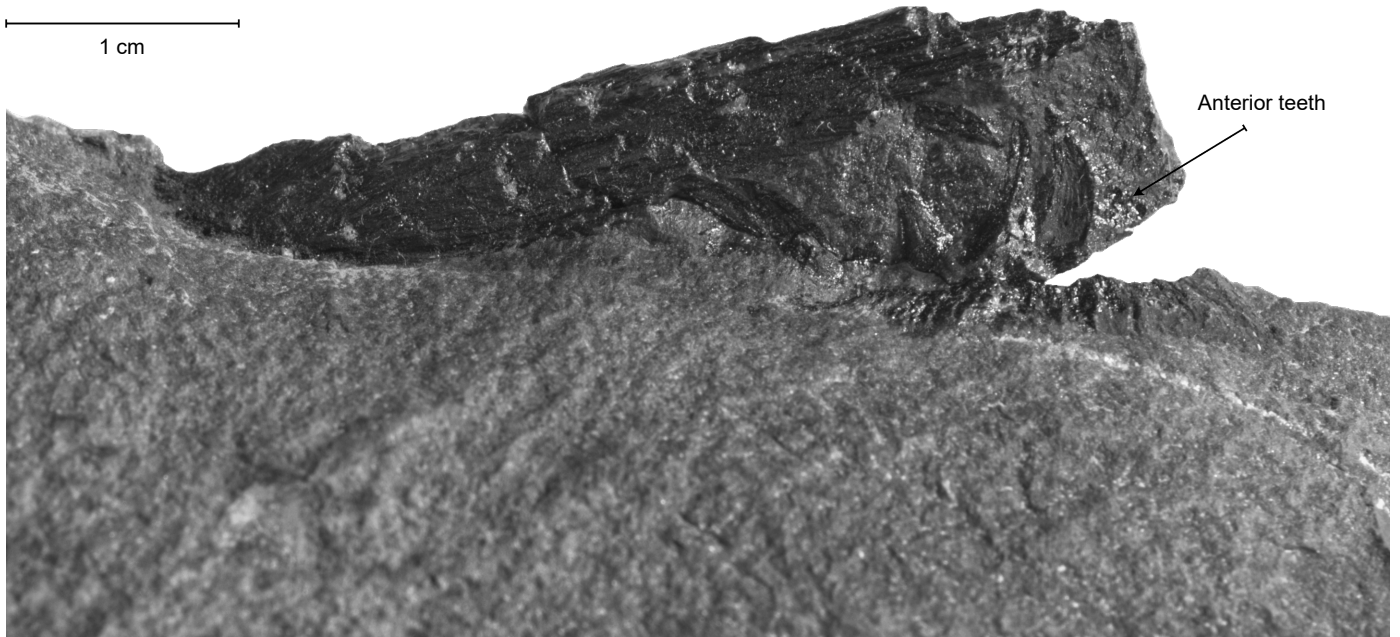


Fig S5. The backside of slab D of *Phalarodon fraasi* PMO 235.393 from Middle Triassic of Svalbard, Norway, showing teeth in the anteriormost part of the rostrum in left lateral view. The anterior direction is marked by an arrow.