Supplementary Appendix for:

**Evolutionary stasis, ecophenotypy, and environmental controls on ammonoid morphology in the Late Cretaceous (Maastrichtian) Western Interior Seaway**

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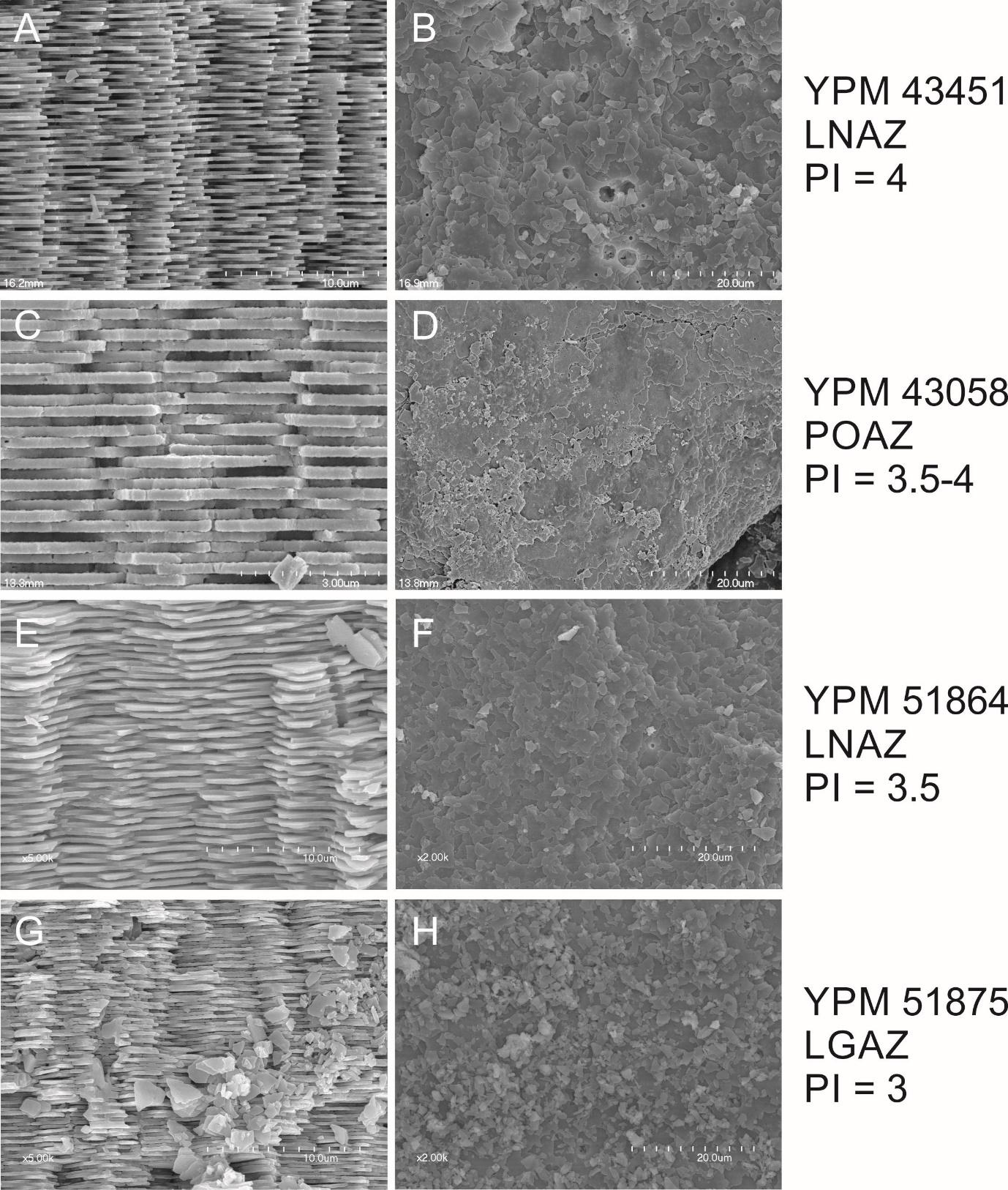
Supplementary Figure S1 – Example images of shell microstructre from specimens of *Hoploscaphites nicolletii* used to assess preservation index (PI).

Supplementary Figure S2 – Cross-plot of stable carbon (δ13C) and oxygen (δ18O) isotope data illustrated ontogenetically from specimens of *H. nicolletii* examined in this study.

Morphological description of *Hoploscaphites nicolletii* and assumed evolutionary relationships.

Full details of stable isotope methodology employed in this study.

Supplementary References



**Supplementary Figure S1**. Example SEM images of shell microstructre from specimens of *Hoploscaphites nicolletii* used to assess preservation index (PI). Images A-G are cross-sectional views showing tabulate nacreous shell structure. B-H are surface images. Only samples with a PI >3 (“Good”) as defined by Cochran et al. (2010) were used for palaeotemperature analysis.

A close up of a piece of paper

Description automatically generated

**Supplementary Figure S2.** Cross-plot of stable carbon (δ13C) and oxygen (δ18O) isotope data from 37 specimens of *Hoploscaphites nicolletii* from the Pierre Shale and Fox Hills Formation (Trail City Member). Samples are coded for their position (ontogenetic) on either the phragmocone, body chamber, or hook. There is no significant correlation (r2 = 0.0071) between isotopic value and sampled position, or between δ18O and δ13C, suggesting good preservation of original shell material as per. Figure S1.

**Morphological description of *Hoploscaphites nicolletii* and assumed evolutionary relationships**

A full description of this species is provided by Landman and Waage (1993), so we include only a brief summary here. See Landman *et al*. (2010) for an overview of morphological terms associated with scaphitid ammonites. *Hoploscaphites nicolletii* (Morton, 1842) is characterised by easily differentiated dimorphs, separated by morphology and in some cases, size. Adult macroconchsare moderately large, compressed, and tightly coiled. They are generally subcircular in overall outline. The shaft of the body chamber is short. As in other scaphitid macroconchs, the umbilical shoulder of the shaft is straight in lateral view, but with some variation with respect to size. In very large specimens, a dorsal swelling sometimes appears on the umbilical shoulder. In small specimens, the umbilical shoulder can be slightly concave rather than straight. There is only small gap or none between the phragmocone and hook. The anterior portion of the adult body chamber is covered by fine, closely spaced ribs. Generally, closely spaced ventrolateral tubercules occur on the adapical portion of the body chamber. They attain their maximum size at mid-shaft where they develop a clavate like appearance. The adult microconch is generally smaller than the macroconch, although the two dimorphs do overlap for part of their size range. The umbilical shoulder of the shaft in microconchs parallels the curve of the venter, forming a flat, broad dorsal shelf that slopes outward at a right or obtuse angle to the flanks. In larger specimens, there is a gap between the phragmocone and hook. The shell is strongly compressed with nearly flattened flanks. Ribs are broad on the exposed phragmocone but become finer and more closely spaced on the adoral portion of the body chamber. Umbilicolateral bullae are usually present on the adapical portion of the body chamber, and in some specimens, on the phragmocone.

*Hoploscaphites nicolletii* probably forms part of an evolutionary lineage with the older *Hoploscaphites melloi* (Landman and Waage, 1993)found in the Mobridge Member of the Pierre Shale, and the younger *Hoploscaphites comprimus* (Owen, 1852), found in the uppermost Trail City Member and overlying Timber Lake Member of the Fox Hills Formation. *Hoploscaphites melloi* differs from *Hoploscaphites nicolletii* by the greater extent of fine ribbing on the body chamber, much less pronounced adoral projection of the ventral ribs and ventral margin of the aperture, offset of the umbilicus of the coil above the umbilical shoulder of the body chamber, and paucity or total absence of ventrolateral tubercules. *Hoploscaphites comprimus* differs by its considerably more compressed whorl section, narrower venter, smaller umbilicus, dense ribbing which is confined to the anterior third of the body chamber, and the placement of fine ribs which originate on the adoral end of the shaft as opposed to midshaft as in *Hoploscaphites nicolletii*. Species-specific characters are thus generally distinct from the measured traits analysed in this study.

**Full details of stable carbon and oxygen isotope analyses**

The C and O isotope ratios of shell samples were analyzed at the University of California Santa Cruz Stable Isotope Laboratory (UCSC SIL) using the methodology outlined in Landman et al. (2018). Prior to analysis, 40-60 micrograms of solid sample were vacuum-roasted for 1 hour at 65°C. Samples were analyzed for δ18O and δ13C via acid digestion using an individual vial acid drop ThemoScientific Kiel IV carbonate device interfaced to a ThermoScientific MAT-253 dual-inlet isotope ratio mass spectrometer (IRMS). Samples were reacted at 75°C in orthophosphoric acid (specific gravity = 1.92 g/cm3) to generate carbon dioxide and water. Non-condensable gases were pumped away and the CO2 analyte was then cryogenically separated from water, finishing with the introduction of pure CO2 into the IRMS via the dual inlet.

Raw data were corrected against samples of calibrated in-house granular Carrara Marble standard reference material and granular NBS-18 limestone international standard reference material. The in-house Carrara Marble was extensively calibrated against NIST Standard Reference Materials (NBS-19, NBS-18, and LSVEC) and further calibrated in intercomparison studies with international laboratories. Raw data were also corrected for offset from the international standard PDB (PeeDee Belemnite) for δ18O and δ13C and corrected for instrument specific source ionization effects. Two aliquots of powdered Atlantis II calcium carbonate were run "as-a-sample" to monitor quality control and long-term performance. Typical precision of Atlantis II at UCSC SIL is 0.05‰ for both δ18O and δ13C.

**Supplementary References**

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