

*Supplemental Materials***Data Repository Figures**

Figure DR1: **A:** Geological map of the Proterozoic Coal Creek and Tatonduk inliers in the western Ogilvie Mountains in the Yukon Territory, Canada, modified from Macdonald and Roots (2010). **B,** Stratigraphy and carbon isotope chemo-stratigraphy of the Fifteenmile Group (formerly Lower Tindir Group) near Tindir Creek showing the position of fossiliferous horizons. See Macdonald *et al.* (2010) for more information.

Figure DR2: Details of *Characodictyon* sp. **A,** SEM image of shield-fringing spines and spines protruding from intersecting nodes of the lattice in an unaltered scale. **B,** SEM image of apatite crystallites in a slightly altered scale. **C,** SEM image of inter-woven apatite crystallites in a more highly altered scale. This diagenetic sequence provides information on the original construction of the scales. A possible scenario is that sub-micron scale apatite granules were deposited along an organic template, forming microcrystalline collophane. Post-depositional alteration caused recrystallization of this microcrystalline phase, leading to micron-scale apatite crystallites aligned along the orientation of the original organic template. The variation seen in the quality of preservation of individual fossils is due to small-scale variations in the diagenetic regime. The absence of such crystallinity in *Archeoxybaphon* (Figs. 1, H and I) likely reflects the greater recalcitrance of imperforate scales to such diagenetic alteration due to their smaller surface area. Scale bar in a represents 2µm for a, 1µm for b, and 3µm for c.

Figure DR3: Fluorescence and Raman spectra of *Characodictyon* sp. Photomicrograph (inset) of a perforated scale and its anchor; the white rectangle encloses Raman-analyzed areas. Fluorescence and Raman spectrum of the anchor compared with adjacent kerogen detritus, showing the presence of samarium (fluorescence) in the anchor, but not in the kerogen detritus.

Figure DR4: Raman analysis of organic-walled microfossil. **A,** light microphotograph of organic-walled microfossil from a scale-bearing thin section, showing area examined with Raman. **B,** Raman signal of examine cross-section.

Figure DR5: An EDS spectrum of a specimen of *Characodictyon* sp. (shown in the inset, in which the white "x" denotes the area analyzed), that documents the presence of carbon (C), phosphorus (P), and calcium (Ca). The rectangular gap in the fossil, an incision produced by focused ion beam SEM, does not affect the analysis. Peaks labeled Au, Pt, and Pd are due to coating of the sample for SEM study; the Cu peak is derived from mounting material; the Si peak is due to siliceous detritus on and adjacent to the fossil.

Figure DR6: An EDS spectrum of a specimen of *Characodictyon* sp. (shown in the inset, in which the white "x" denotes the area analyzed), where the top micron of the surface has been milled away using a focused ion beam SEM. The EDS spectrum documents the presence of carbon (C), phosphorus (P), and calcium (Ca). Peaks labeled Au, Pt, and Pd are due to coating of the sample for SEM study; the Cu peak is derived from mounting material; the Ga peak is

derived from the gallium ion beam used in focused ion beam milling; the Si peak is due to siliceous detritus on and adjacent to the fossil.

Figure DR7: SEM images showing clusters of microfossils in limestone macerates. A: cluster of *Charactodictyon* from the horizon of the unit at meter height 312. B: cluster of an unidentified taxon, from the horizon at meter height 256. Scale bar in B represents 8 μ m in A and 15 μ m in B.

References Cited

Macdonald, F.A., Cohen, P.A., Dudas, F.O., and Schrag, D.P., 2010, Early Neoproterozoic scale microfossils in the lower Tindir Group of Alaska and the Yukon Territory: *Geology* (Boulder), v. 38, no. 2, p. 143-146.

Macdonald, F.A., and Roots, C.F., 2010, Upper Fifteenmile Group in the Ogilvie Mountains and correlations of early Neoproterozoic strata in the northern Cordillera, *in* McFarlane, K.E., Weston, L.H., and Blackburn, L.R., eds., *Yukon Exploration and Geology 2009: Whitehorse, YT*, Yukon Geological Survey, p. 237-252.

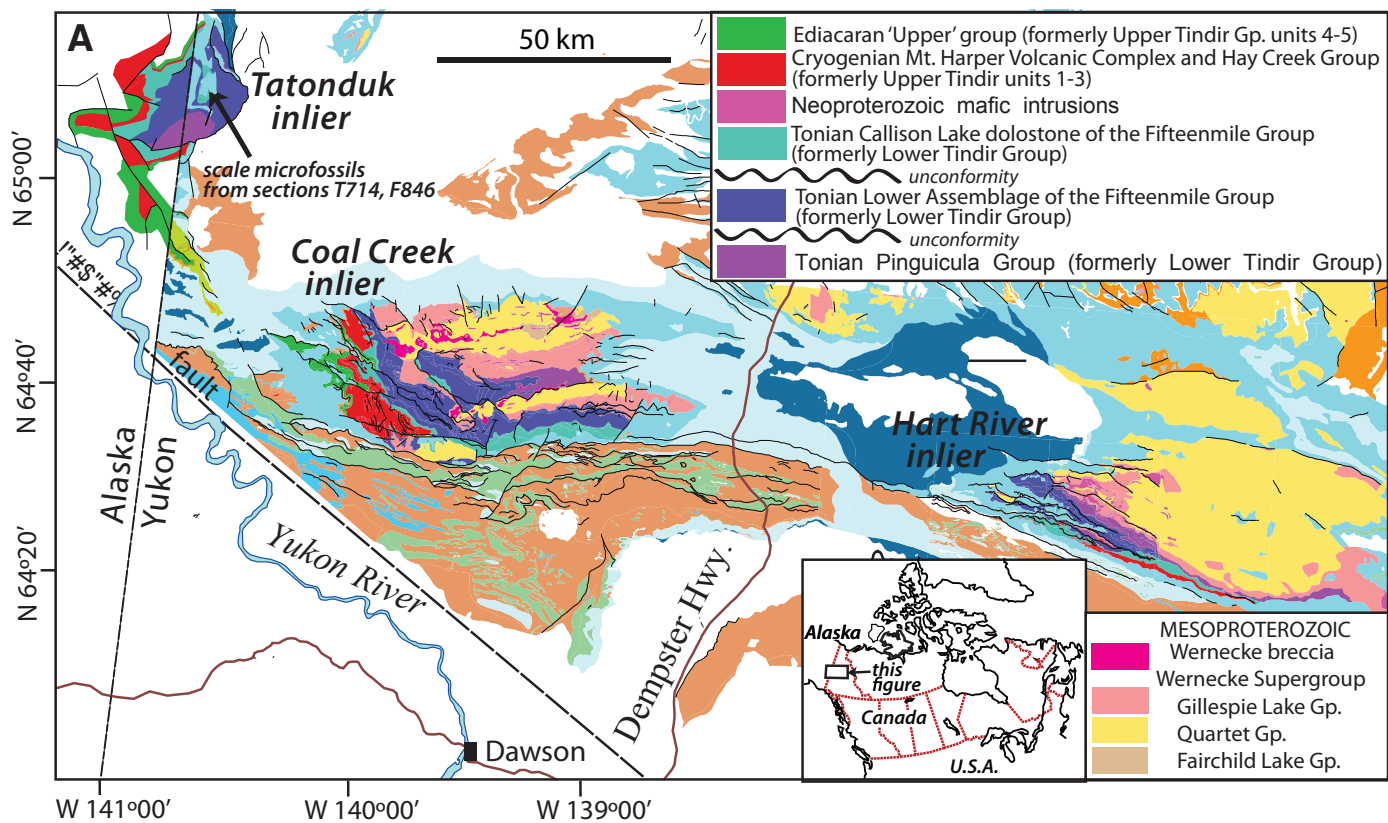
Materials and Methods

Samples were collected from measured stratigraphic sections in June and July of 2007. Limestones were dissolved in 30% acetic acid and resulting macerates were filtered through a 30 micron mesh and dry-mounted on copper tape. Some samples were cut with a gallium ion beam using a Nanovision FIB-SEM. Ion beam current used during milling by FIB-SEM was commenced at 1.5 nA and lowered to 800 pA and 80 pA to polish the surface for better viewing. FIB-SEM milling voltage was 30kV. SEM images were taken with either a Zeiss Supra or Ultra FE-SEM, or a Nanovision FIB-SEM. Specimens were coated with Pt/Pd or Au to reduce charging. SEM Images were taken at 20kV. EDS was performed using standard EDAX software. All EDS maps and spectra were taken at 5 kV. Spectral collection times were 60 seconds; map collection times were 30-60 minutes.

Thin sections were made at thicknesses of 60 or 100 μ m. Three-dimensional confocal fluorescence images of thin sections were obtained by use of an Olympus Fluoview 300 confocal laser scanning biological microscope system equipped with two Melles Griot lasers, a 488 nm 20mW-output argon ion laser and a 633 nm 10mW-output helium-neon laser (Melles Griot, Carlsbad CA). The images shown were acquired by use of a 60x oil-immersion objective (numerical aperture = 1.4), using the fluorescence-free microscopy immersion oil, with the use of filters in the light-path of the system to remove wavelengths >510 nm (for 488 laser excitation) and >660 nm (for 633 nm laser excitation) from the kerogen-derived fluorescence emitted by the specimens. Some images were subsequently processed by use of the VolView v2.0 three-dimensional-rendering computer program (Kitware Inc., Clifton Park, NY) that permits their rotation in three dimensions.

Raman spectra of the kerogenous components of the fossils here illustrated were obtained by use of a T64000 (JY Horiba, Edison NJ) triple-stage laser-Raman system having macro-Raman and confocal micro-Raman capabilities. This system permitted acquisition both of individual point spectra and of Raman images that display the two-dimensional spatial distribution of molecular-structural components of the specimens studied and their associated mineral matrices, with the varying intensities in such images corresponding to the relative concentrations of the molecular structures detected. Due to the confocal capability of the system, use of a 50x objective (having an extended working distance of 10.6 mm and a numerical aperture of 0.5) provided a horizontal resolution of $\sim 1.5 \mu\text{m}$ and a vertical resolution of 2-3 μm . Use in this system of a Coherent Innova (Santa Clara, CA) argon ion laser to provide excitation at 457.9 nm permitted data to be obtained over a range from <500 to $>3100 \text{ cm}^{-1}$ by use of a single spectral window centered at 1800 cm^{-1} and, thus, simultaneous acquisition of spectra of the major bands (at ~ 1365 and $\sim 1604 \text{ cm}^{-1}$) and the second-order band (at $\sim 2800 \text{ cm}^{-1}$) of the kerogen comprising the fossils as well as of the major bands of associated quartz (at $\sim 465 \text{ cm}^{-1}$) and apatite (at $\sim 965 \text{ cm}^{-1}$).

For Raman mapping, the region of a thin section containing a specimen to be analyzed was covered by a thin veneer of the fluorescence-free microscopy immersion oil noted above (the presence of which has been shown to have no discernable effect on the Raman spectra acquired) and the area of the fossil studied was centered in the path of the laser beam projected through the microscope of the system. The laser power used was $\sim 1\text{-}8 \text{ mW}$ over a $\sim 1 \mu\text{m}$ spot, an instrumental configuration well below the threshold resulting in radiation damage to specimens such as those here studied.



B

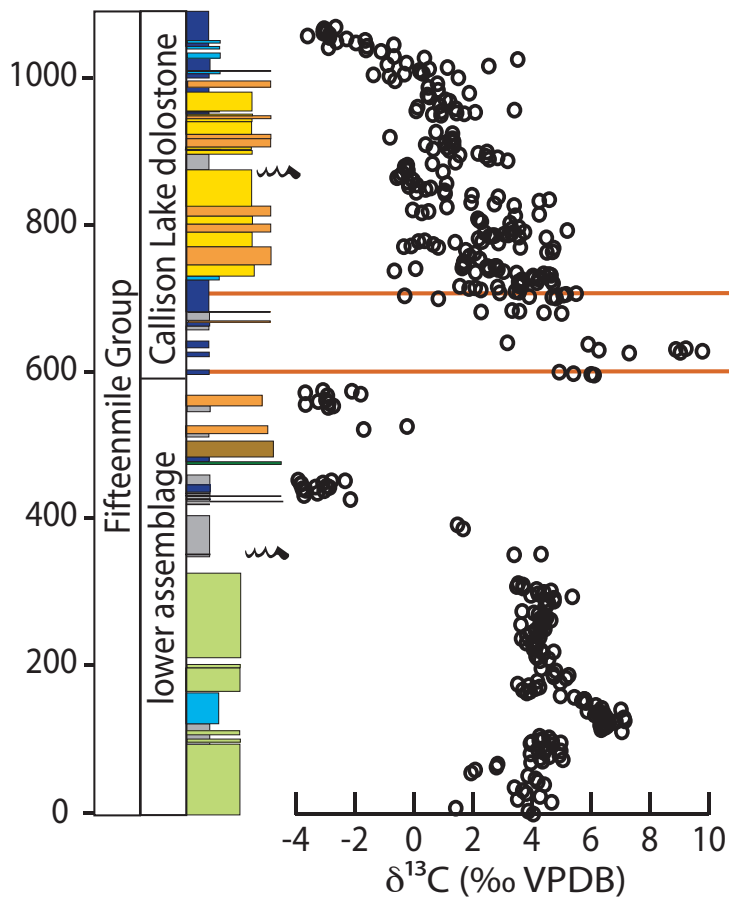


Fig. DR 2

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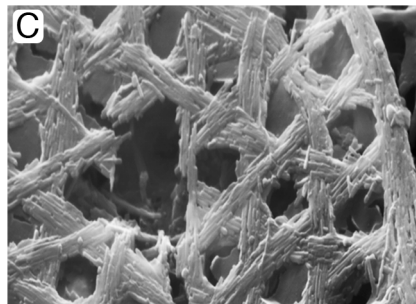
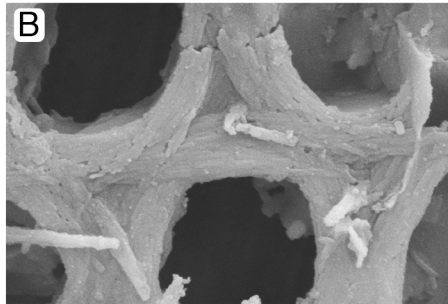
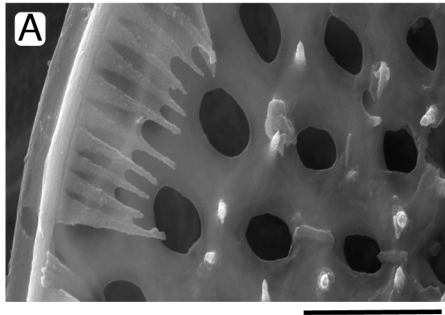


Fig. DR 3 Cohen / Fig DR3.pdf

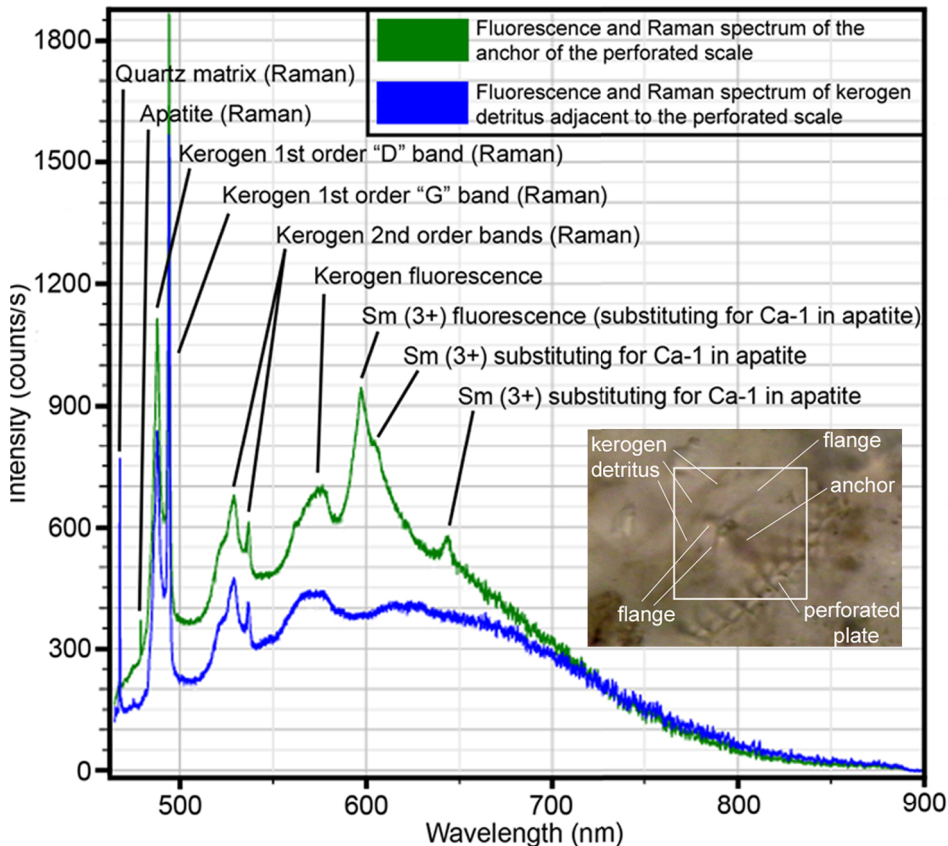


Fig. DR 4 Cohen / Fig DR4.pdf

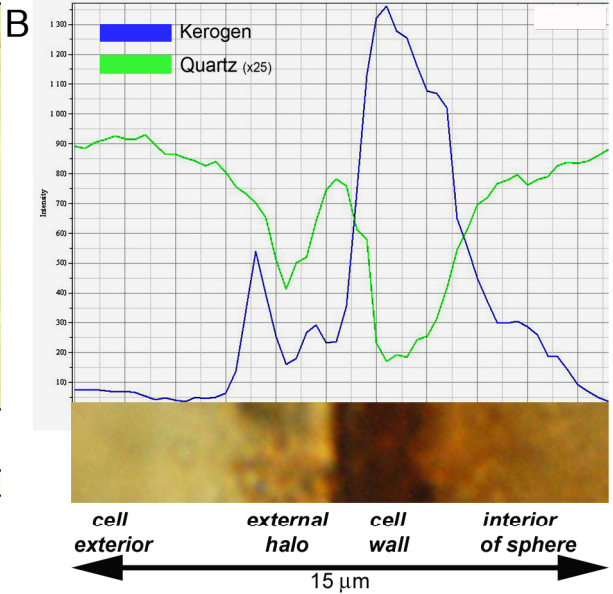
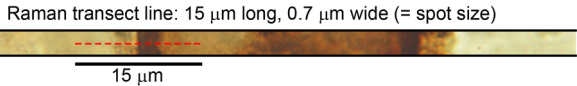
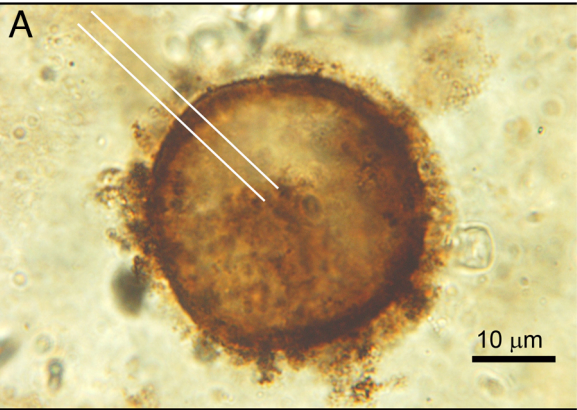


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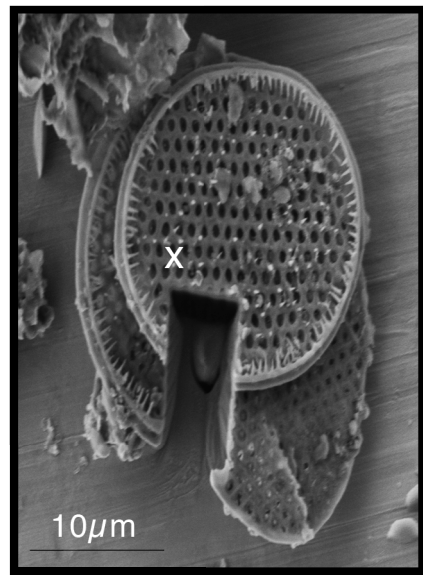
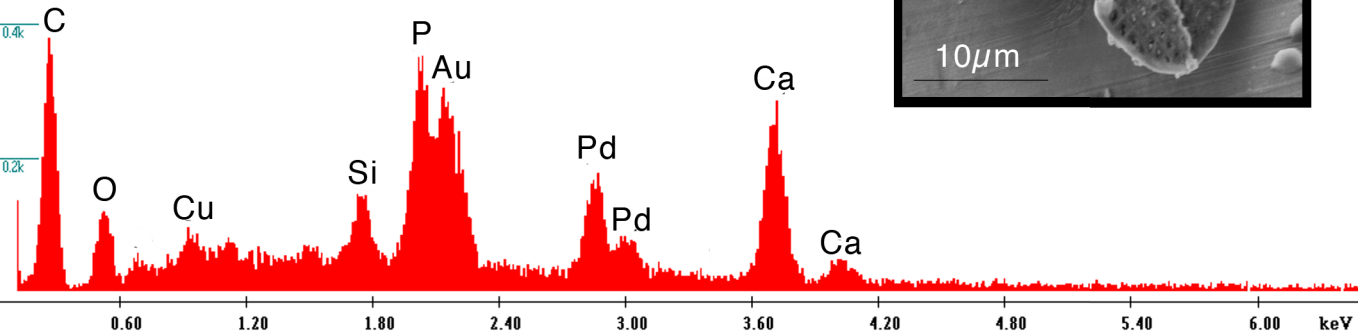


Fig. DR 6
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