SUPPLEMENTARY MATERIAL FOR

**Chemical preservation of tail feathers from *Anchiornis huxleyi*, a theropod dinosaur from the Tiaojishan Formation (Upper Jurassic, China)**

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SUPPLEMENTARY TABLES

# Supplementary Table 1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | [S] | Global Uncertainty (wt. ppm) | Counting Statistics (%) | Fit Error (%) | Uncertainty from BCR-126A analysis (%) | Uncertainty on cross-sections | Global Uncertainty |
| (wt. ppm) | (%) | (%) |
| Fossil Feather #1 | 1739 | 221 | 4.4 | 6.8 | 9.8 | 5 | 13.7 |
| Fossil Feather #2 | 1946 | 196 | 1.2 | 1.9 | 9.8 | 5 | 11.2 |
| +1.7 mm | 1162 | 143 | 4.3 | 6.1 | 9.8 | 5 | 13.3 |
| +3.2 mm | 801 | 82 | 1.8 | 2.5 | 9.8 | 5 | 11.4 |
| +4.8 mm | 893 | 107 | 4 | 5.7 | 9.8 | 5 | 13.0 |
| Remote sediment | 98 | 35 | 19.2 | 25.6 | 9.8 | 5 | 33.8 |
| Rachis | 37,142 | 3652 | 0.2 | 0.4 | 9.8 | 5 | 11.0 |
| Barbs | 43,070 | 4236 | 0.2 | 0.5 | 9.8 | 5 | 11.0 |

Results of the Proton-induced X-ray Emission (PIXE) analyses. The table shows the global uncertainty calculations for sulphur concentration in the fossil feathers (duplicate analysis), “host” sediment (three successive analysis spots at 1.7 3.2, and 4.8 mm away from the fossil feathers), “remote sediment”, and modern bird feathers (barbs and rachis). BCR-126A is the lead glass reference material used to calibrate the detectors.

Supplementary Table 2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Samples | **Al** | **Si** | **Ca** | **Fe** | **Cu** | **Zn** |
| **Modern barb** | 3469 (± 271) | 3868 (± 387) | 1807 (± 91) | 291 (± 16) | 395691 (± 19790) | 2011 (± 177) |
| **Modern rachis** | 2714 (± 188) | 18207 (± 1821) | 729 (± 37) | 73 (± 4) | 1483 (± 75) | 151 (± 9) |
| **Fossil feathers (tail)** | 50093 (± 2544) | 413592 (± 41360) | 21730 (± 1088) | 21524 (± 1077) | 865 (± 43) | 259 (± 13) |
| **Remote sediment** | 139605 (± 7059) | 438434 (± 43843) | 17210 (± 862) | 19487 (± 975) | 3238 (± 162) | 341 (± 17) |

Proton-induced X-ray emission (PIXE) analyses of modern and fossil samples. The elemental composition of modern bird feathers (brown barbs and white rachis) is compared to that of *Anchiornis* feathers and the sedimentary matrix. The values are expressed in wt.ppm and the errors are shown in parentheses. The abnormally high Cu value in the modern barbs is not taken into account here because a copper tape was used to fix the samples (see Supplementary Fig.2). This is likely that, due to the large beam-size – 0.5 mm – relative to the barb thickness, these results are due to the contribution of the copper tape. They are therefore not relevant for our study.

SUPPLEMENTARY FIGURES

# Supplementary Figure 1

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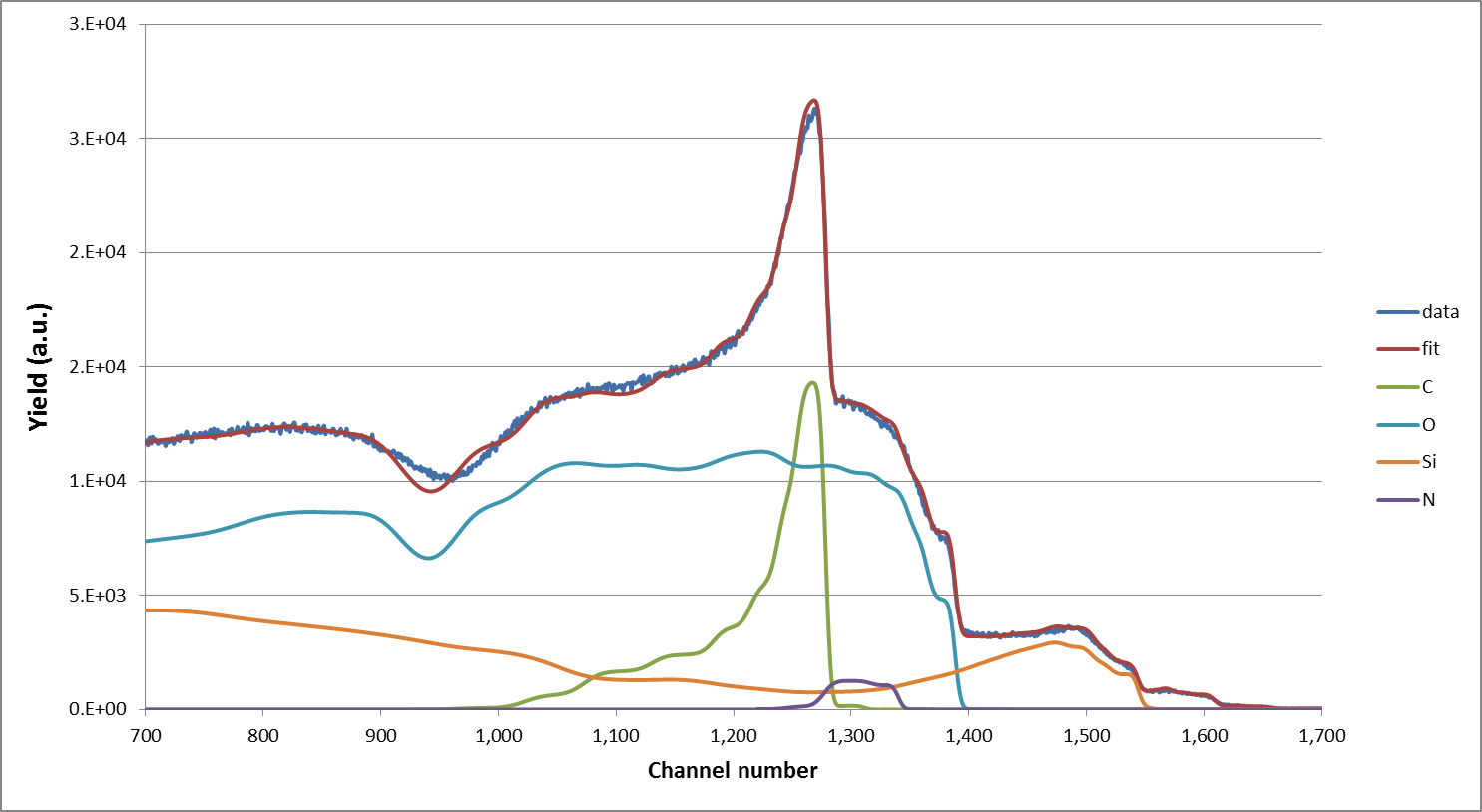
1. One of the buzzard feathers used for the chemical analyses, and (B) analytical setup of the Ion Beam Analyses (PIXE and EBS) showing: (1) the basal part of a buzzard feather, (2) lead glass reference material (BCR-126A) used for calibration, (3) remote sediment (yellow rectangle in Fig.1), and (4) *Anchiornis* fossil feather and surrounding sediment (white rectangle in Fig.1). The dark dots in (1) and (4) corresponds to the target of the proton beam after analysis.

Supplementary Figure 2

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Sample mounted on a copper tape for IBA analyses. A, fossil feather (dark brown area, on the left) and embedding sediment (light area, on the right); the four analysis points are shown by the black asterisks. B, remote sediment. Correspondence with Figure 5 in the text is as follows: 1, fossil #1 and fossil #2; 2, sediment (x = -1.7 mm); 3, sediment (x = -3.2 mm); 4, sediment (x = -4.8 mm); 5, remote sediment.

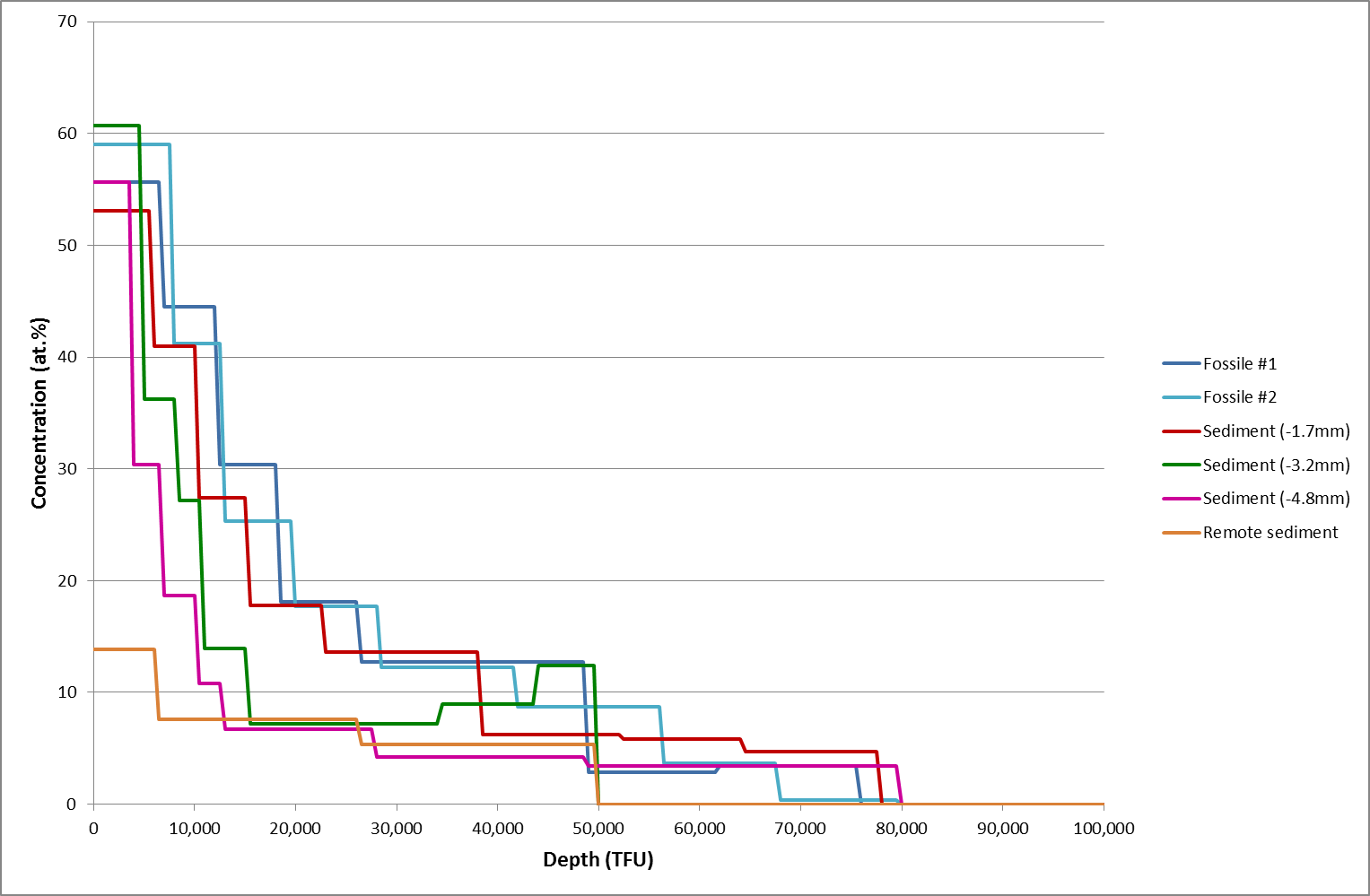
Supplementary Figure 3



Experimental (dark blue) and fitted (red) EBS curves acquired from the fossil feather during about 4 hours. The channel number is directly proportional to the energy of the backscattered protons. Knowing the stopping power of the sample (i.e. energy loss per quantity of material passed through by a particle), the abscissa can readily be converted into depth scale, going from the surface (high channel numbers) to the bulk (lower channel numbers).

Partial spectra for C (green), O (light blue), Si (orange) and N (purple) are also represented to highlight the large carbon gradient with the highest concentration near the surface rapidly decreasing into depth. Note that the nitrogen signal is rather weak but the experimental curve could not be properly fitted without its contribution. About 5 at. % of N are required to satisfactorily fit the experimental EBS spectrum acquired on the fossil feathers while there was no indication of nitrogen for the “remote” sediment. Using DataFurnace, one can invert the experimental spectrum to recover the elemental depth profile.

Supplementary Figure 4



Carbon depth profiles obtained by fitting the experimental EBS spectra acquired from different locations on the fossil (see Supplementary Figure 1) with DataFurnace. The abscissa is given in Thin Film Unit (TFU or 1015atoms/cm²). TFUs are density-independent thickness units, equivalent to mass/area, which can be converted to nanometric depth providing that the density of the analysed material is known.

Fossil #2 is a straight repeat of Fossil #1, demonstrating the reliability of the EBS technique for deriving the C elemental depth profiles.

One can observe that the carbon enrichment in the near surface region is decreasing when stepping away from the fossil feather. Carbon content is significantly lower in the remote sediment.

# Supplementary Figure 5

EBS spectra of (A) a barb and (B) the rachis of a modern buzzard (*Buteo buteo*) feather. The concentration in carbon, nitrogen, oxygen, sulphur, and calcium are given in percent. The depth profile (abscissa axis) is expressed in equivalent thickness (TFU), with 0 corresponding to the surface of the samples. The elemental concentrations are homogeneous both in the barb and the rachis of the modern feather.

Supplementary Figure 6

Formation of 12: D:\Thèse docus\articles\geochimie Anchiornis\review_palaeontology\Figures\compressed-figures\suppl.fig.6-12.tif

Formation of 13 and 14: D:\Thèse docus\articles\geochimie Anchiornis\review_palaeontology\Figures\compressed-figures\suppl.fig6-1314.tif

Formation of 19: D:\Thèse docus\articles\geochimie Anchiornis\review_palaeontology\Figures\compressed-figures\suppl.fig6-19.tif

Formation of 20 and 21: D:\Thèse docus\articles\geochimie Anchiornis\review_palaeontology\Figures\compressed-figures\suppl.fig.6-2021.tif

Formation mechanisms of diverse compounds obtained by pyrolysis of modern bird feathers in the presence of TMAH.