Northumbria Research Link

Supplemental Information

Pre-Columbian fire management and control of climate-driven floodwaters over 3500 years in southwestern Amazonia

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Phytolith extraction method
Sediment samples were dried in a low temperature oven ~40°C, then ground and sieved through 16-mesh to remove large particles. One gram of soil per sample was weighed out for processing. Carbonates and oxides removal and organic digestion was performed using an Anton Paar Multiwave GO with 10ml nitric acid, 2ml hydrochloric acid, and 1ml of hydrogen peroxide and run on the Organic A program (180°C for one hour). Samples were then transferred to test tubes and acids rinsed out. Humic colloids were then removed using 10% solution of potassium hydroxide. Deflocculation of the samples was then performed using 5% sodium hexametaphosphate. The samples were sieved at 250μ-mesh and clays were removed using centrifuge sedimentation. Phytoliths were isolated from the sediments using lithium metatungstate at a specific gravity of 2.3, rinsed, and allowed to dry. Slides were prepared using Canada balsam as the mounting medium and scanned using a Zeiss Axio Imager.A1 microscope at 400x. Phytolith identifications were made using the University of Missouri's online phytolith database (1) and Pearsall Phytolith Comparative Collection housed at the Paleoethnobotany and Environmental Archaeology Laboratory at the University of Central Florida.

Additional proxy sampling resolution and effort information
Phytoliths - Phytoliths were sampled in 5cm sections throughout each of the cores (ME and QM). 182-233 (mean = 220) phytoliths were counted per sample for ME and 108-233 (mean = 200) phytoliths were counted per sample for QM. Counts of only 87 (85-90 cm) and 34 (90-95 cm) phytoliths were made for two samples in QM due to poor preservation.
Pollen - Pollen samples were analysed at 3-5 cm intervals though each core (ME and QM). Due to the high proportions of grass (Poaceae) and sedge (Cyperaceae) pollen, counts were undertaken until a minimum of 100 non-Poaceae/Cyperaceae pollen grains were identified. 343-1495 (mean = 936) pollen grains were counted per sample for ME and 315-654 (mean = 511) pollen grains were counted per sample for QM. Due to poor pollen preservation (< 5000 pollen grains per cm^3) pollen was not counted below 36 cm in ME and 58 cm in QM.
Diatoms - Six depths through each of the cores (ME and QM) were selected to gain a broad understanding of the diatom assemblage (Supplementary Figures 7a and 7b). 250-260 diatoms were identified for each sample. Samples at 59 cm and 81 cm in core ME and the sample at 83 cm in QM contained only broken fragments of diatoms and were excluded.

Supplemental Table 1 Accelerator mass spectrometry (AMS) radiocarbon (^{14}C) dating of bulk organic sediments for QM18-2 and MERC18-02-01. *Modelled mean calibrated ages represent those produced using a mixed (50:50) 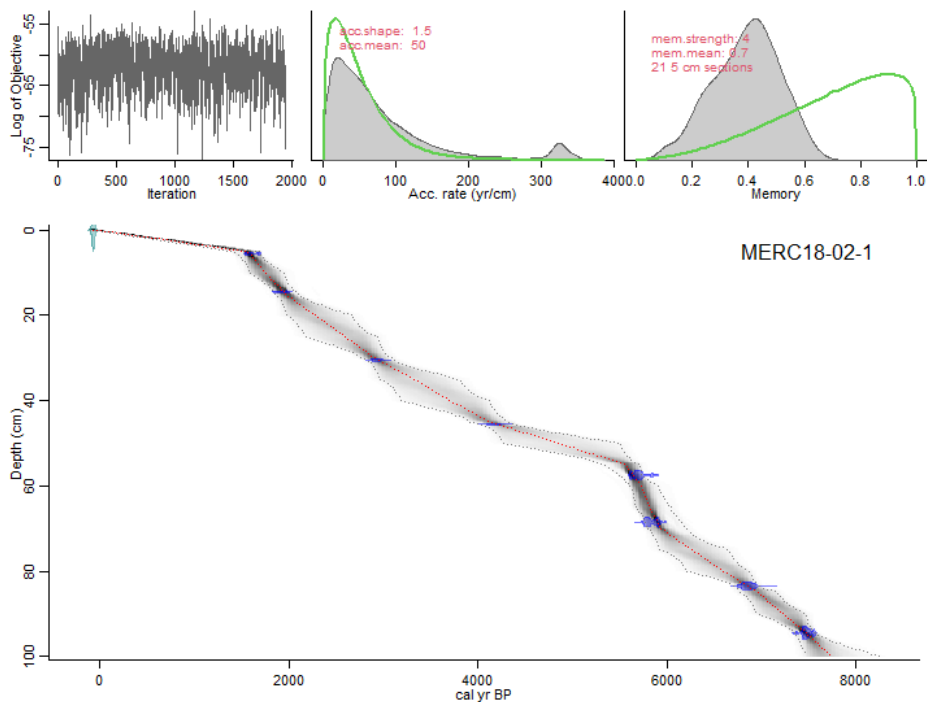IntCal20 (2) / SHCal20 (3) atmospheric curve using the package Bacon (4) in the 'R' statistical computing environment (5). Modelled minimum (Min) and maximum (Max) 95% confidence ranges are based on 2.5% and 97.5% quantiles.

Core	Lab Code	Depth Sampled (cm)	Uncalibrated age (years BP)	δ13C (‰)	Modelled min calibrated age (years BP)*	Modelled max calibrated age (years BP)*	Modelled mean calibrated age (years BP)*
QM18-2	Beta-548593	13-14	180 ± 30	-27.8	62	286	198
QM18-2	Beta-548594	29-30	630 ± 30	-25.3	538	650	596
QM18-2	Beta-524488	45-46	1040 ± 30	-20.0	819	1045	933
QM18-2	Beta-548595	57-58	1440 ± 30	-26.1	1274	1457	1335
QM18-2	Beta-524489	70-71	2610 ± 30	-17.7	2428	2804	2657
QM18-2	Beta-548596	83-84	3260 ± 30	N/A	3366	3624	3464
QM18-2	Beta-515675	96-97	4540 ± 30	N/A	4912	5300	5125

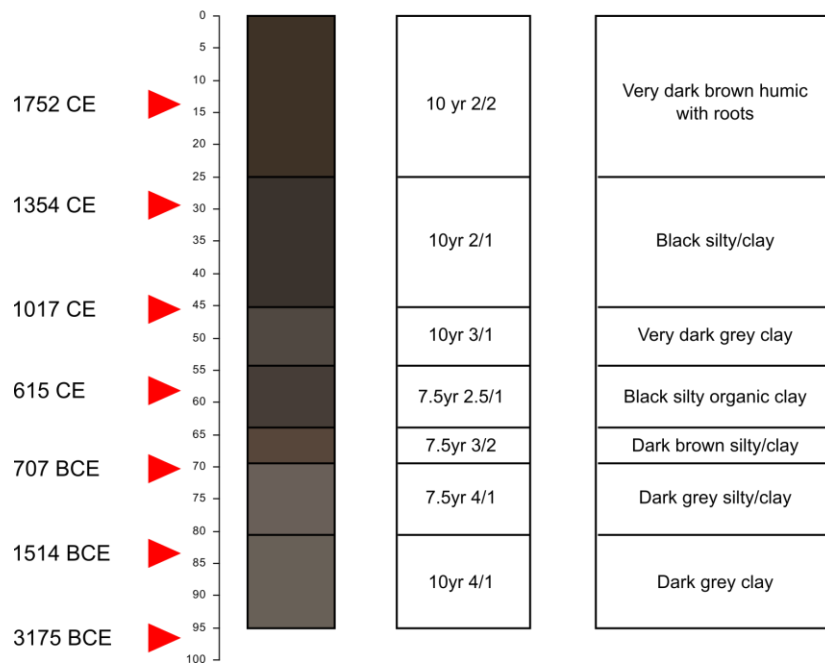| Core	Lab Code	Depth Sampled (cm)	Uncalibrated age (years BP)	δ13C (‰)	Min calibrated age (years BP)*	Max calibrated age (years BP)*	Modelled mean calibrated age (years BP)*
MERC18-02-1	Beta-548597	5-6	1720 ± 30	-28.4	1436	1693	1585
MERC18-02-1	Beta-524484	14-15	2010 ± 30	N/A	1838	2071	1943
MERC18-02-1	Beta-524485	30-31	2850 ± 30	-28.1	2812	3123	2948
MERC18-02-1	Beta-524486	45-46	3810 ± 30	-24.1	4010	4383	4191
MERC18-02-1	Beta-548598	57-58	4990 ± 30	-16.4	5496	5743	5642
MERC18-02-1	Beta-524487	68-69	5120 ± 30	-20.9	5766	6153	5886
MERC18-02-1	Beta-548599	83-84	6030 ± 30	-20.4	6707	6980	6849
MERC18-02-1	Beta-515677	94-95	6580 ± 30	-21.4	7341	7562	7465

Supplementary Figure 1a Age-depth model for the QM18-2 core (QM). Model created in the 'R' statistical computing environment (5) using the package Bacon (4). Dates calibrated using a mixed (50:50) IntCal20 (2) / SHCal20 (3) atmospheric curve.

Supplementary Figure 1b Age-depth model for the MERC18-02-01 core (ME). Model created in the 'R' statistical computing environment (5) using the package Bacon (4). Dates calibrated using a mixed (50:50) IntCal20 (2) / SHCal20 (3) atmospheric curve.
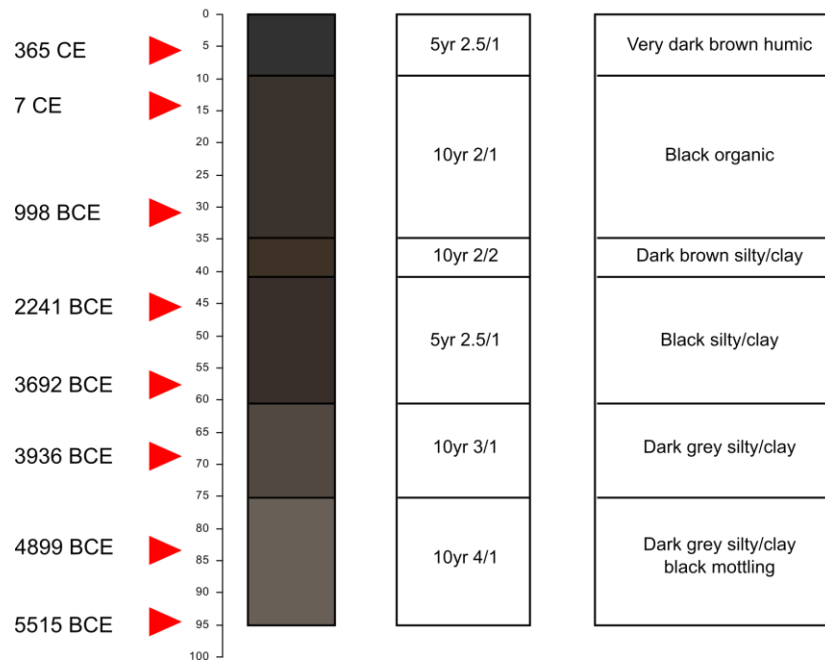
QM18-2

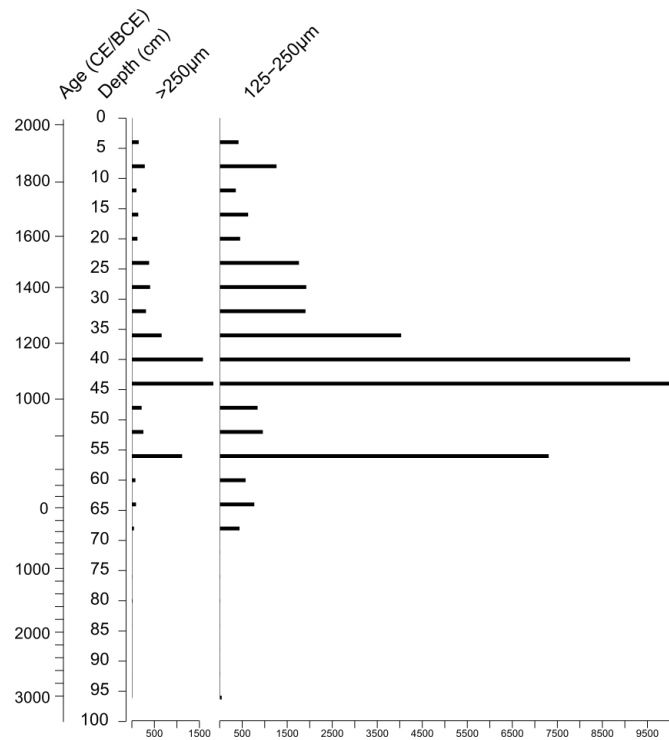| Depth (cm)	Age	Munsell	Description
			0
			5
			10
1752 CE		10 yr 2/2	15 — Very dark brown humic with roots
			20
			25
1354 CE		10yr 2/1	30 — Black silty/clay
			35
			40
1017 CE		10yr 3/1	45 — Very dark grey clay
			50
			55
615 CE		7.5yr 2.5/1	60 — Black silty organic clay
		7.5yr 3/2	65 — Dark brown silty/clay
707 BCE		7.5yr 4/1	70 — Dark grey silty/clay
			75
1514 BCE		10yr 4/1	80–85 — Dark grey clay
			90
3175 BCE			95
			100

Supplementary Figure 2a Sediment description for the QM18-02 core (QM). Red arrows indicate the location of radiocarbon dated material and the modelled mean calibrated age. Munsell colour chart codes provided at notable changes in sediment type.
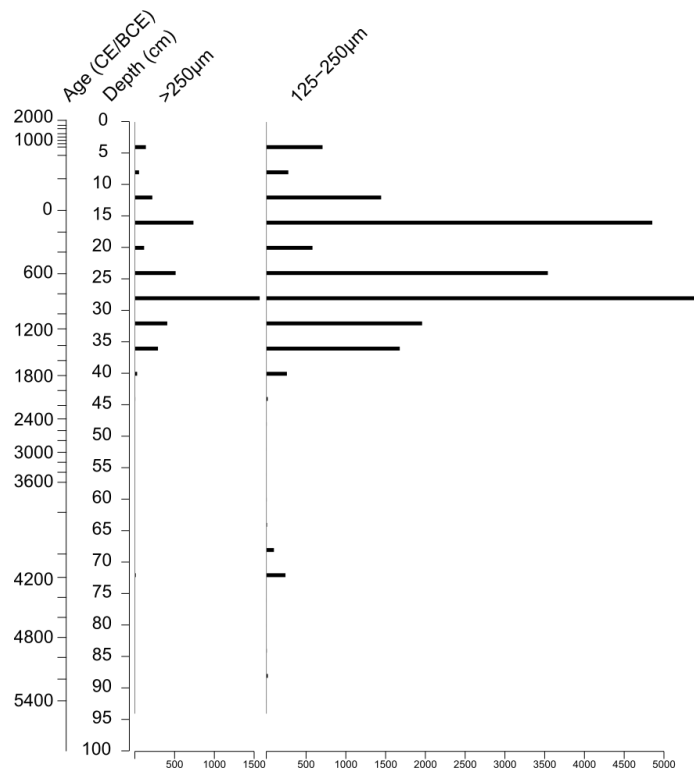
MERC18-02-01

Depth (cm)	Age	Munsell	Description
			0
365 CE		5yr 2.5/1	5 — Very dark brown humic
			10
7 CE			15
			20
		10yr 2/1	Black organic
			25
998 BCE			30
			35
		10yr 2/2	40 — Dark brown silty/clay
2241 BCE			45
		5yr 2.5/1	50 — Black silty/clay
			55
3692 BCE			60
			65
3936 BCE		10yr 3/1	70 — Dark grey silty/clay
			75
			80
4899 BCE		10yr 4/1	85 — Dark grey silty/clay black mottling
			90
5515 BCE			95
			100

Supplementary Figure 2b Sediment description for the MERC18-02-01 core (ME). Red arrows indicate the location of radiocarbon dated material and the modelled mean calibrated age. Munsell colour chart codes provided at notable changes in sediment type.
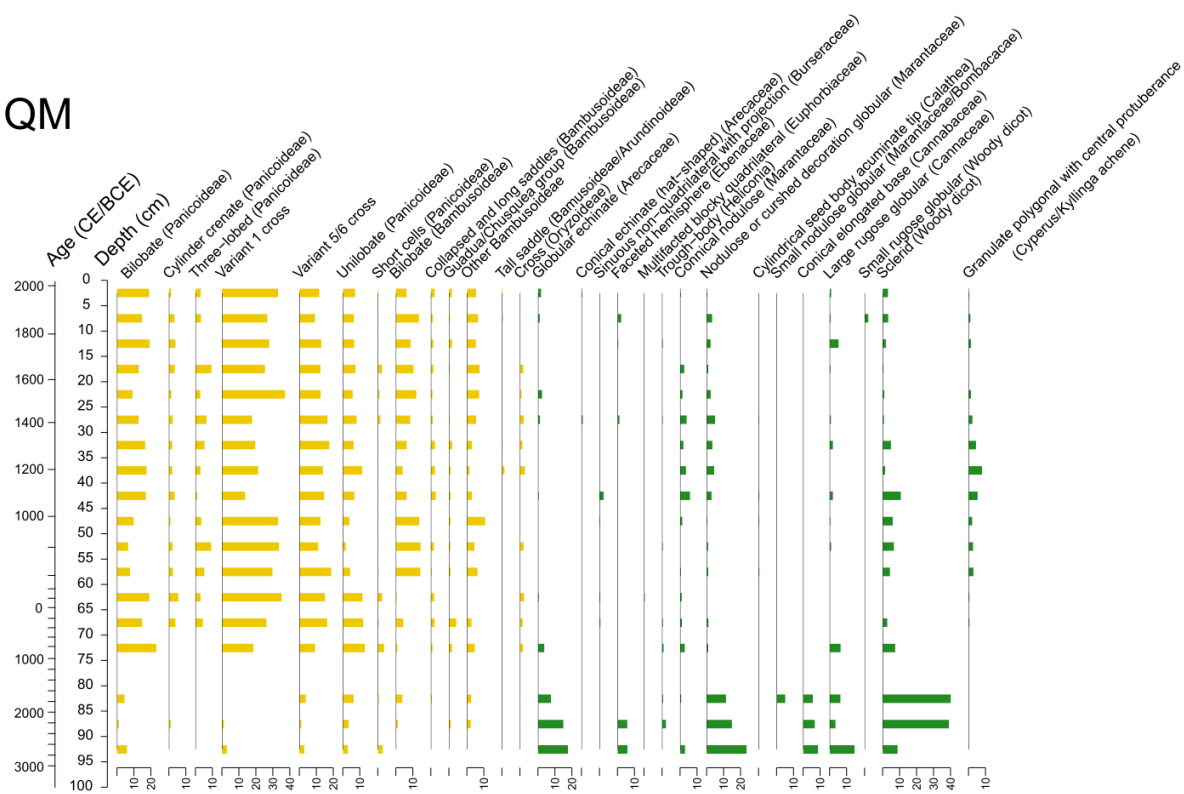
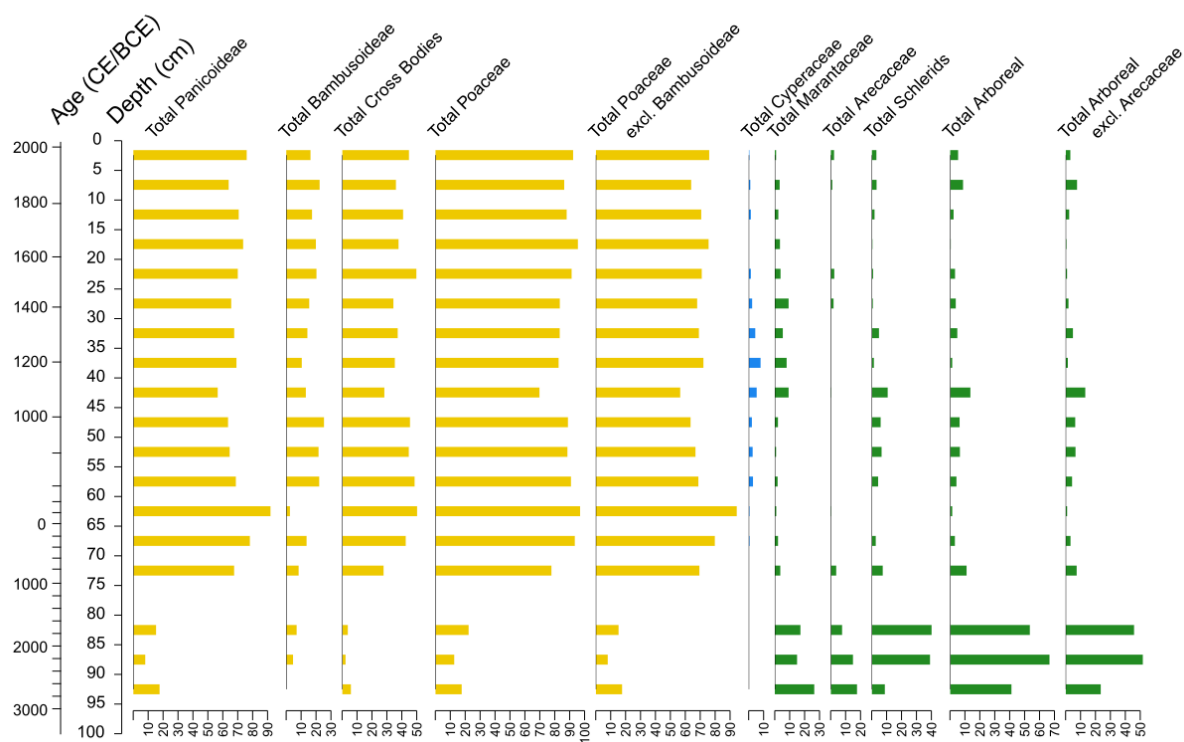**Supplementary Figure 3a** Number of charcoal fragments per cm^3 for the QM18-02 core (QM).

Supplementary Figure 3b Number of charcoal fragments per cm^3 for the MERC18-02-01 core (ME).
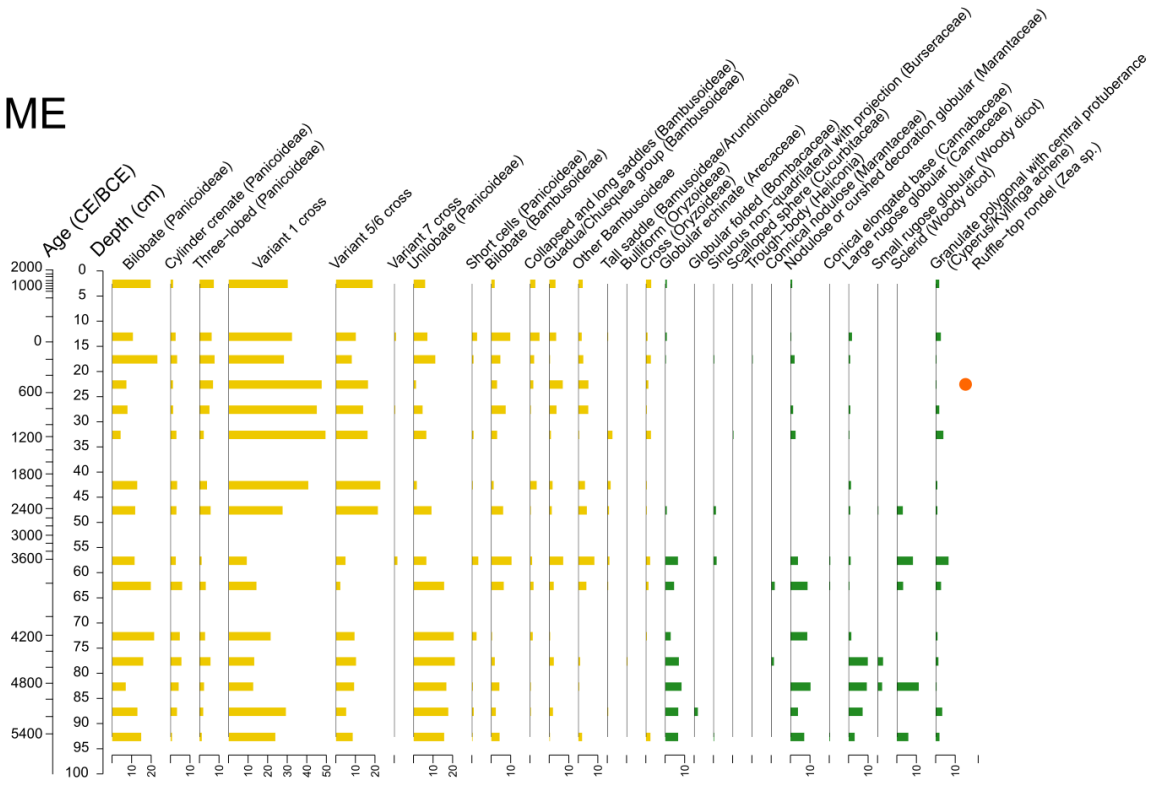
Supplementary Figure 4a QM18-02 phytolith percentage.
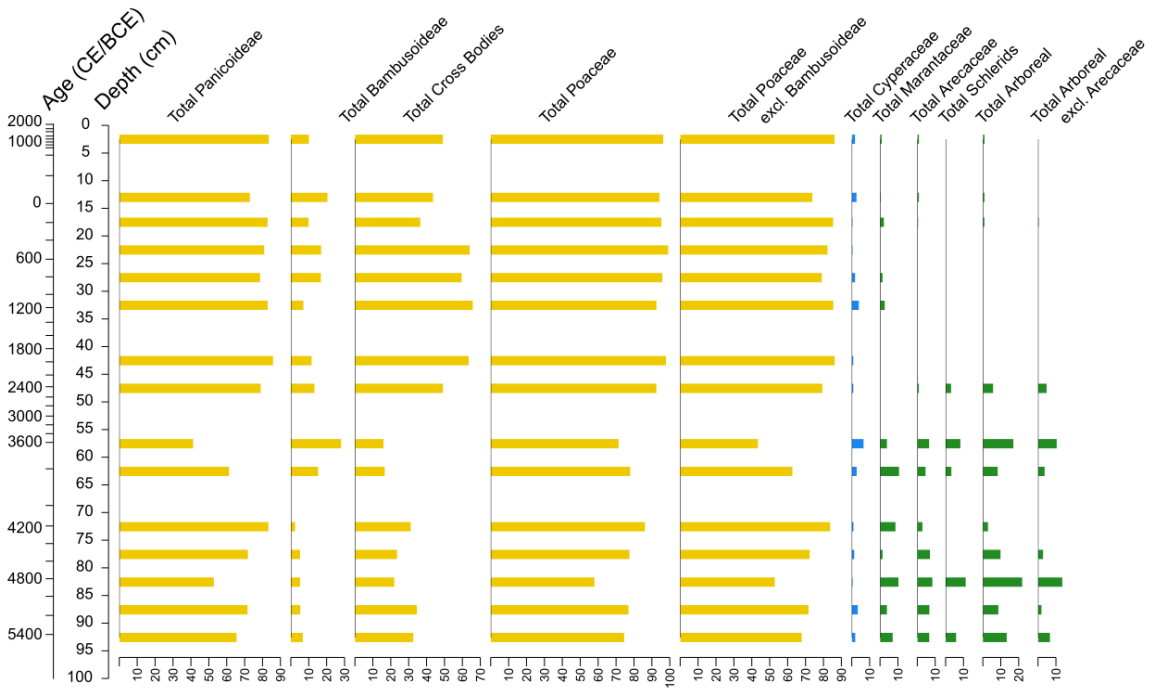

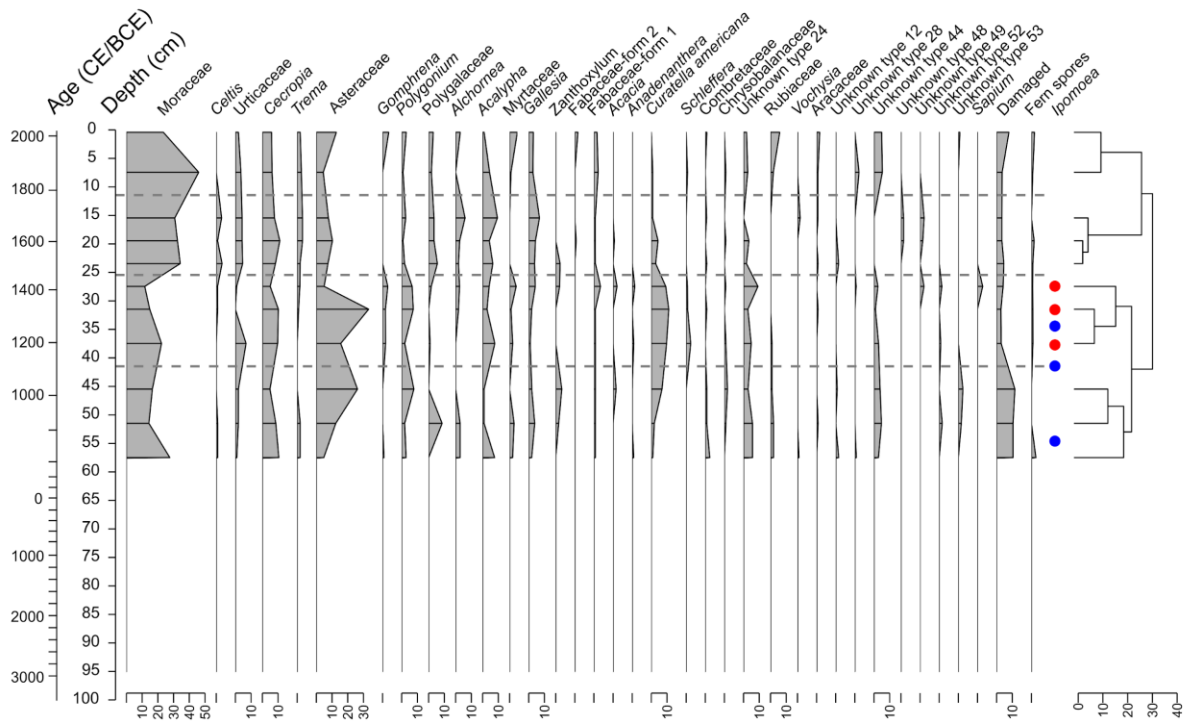**Supplementary Figure 4b** QM18-02 phytolith summary.

ME

Supplementary Figure 4c MERC18-02-01 phytolith percentage. Red dot indicates the presence of a single ruffle-top rondel (*Zea* sp.).
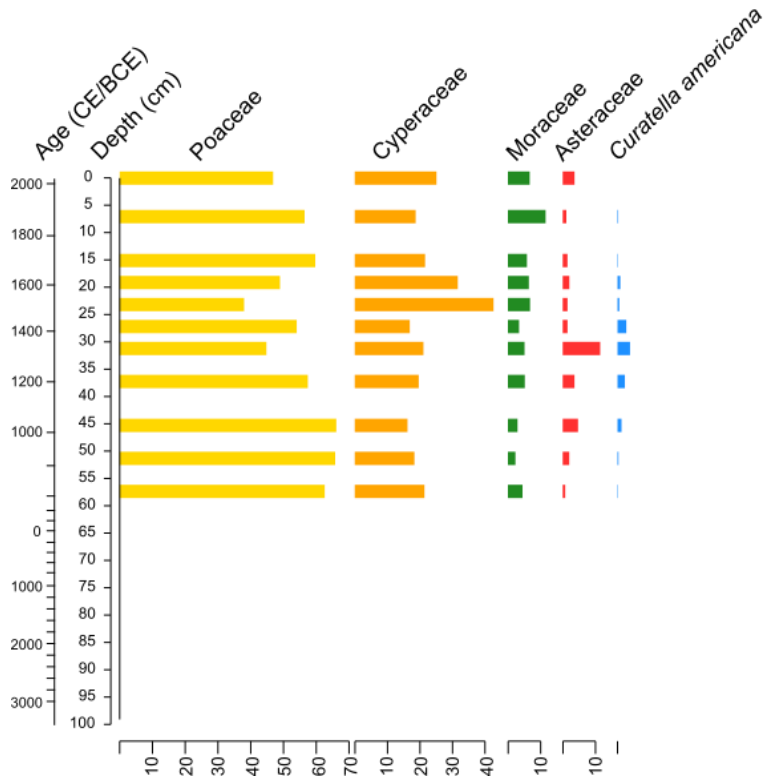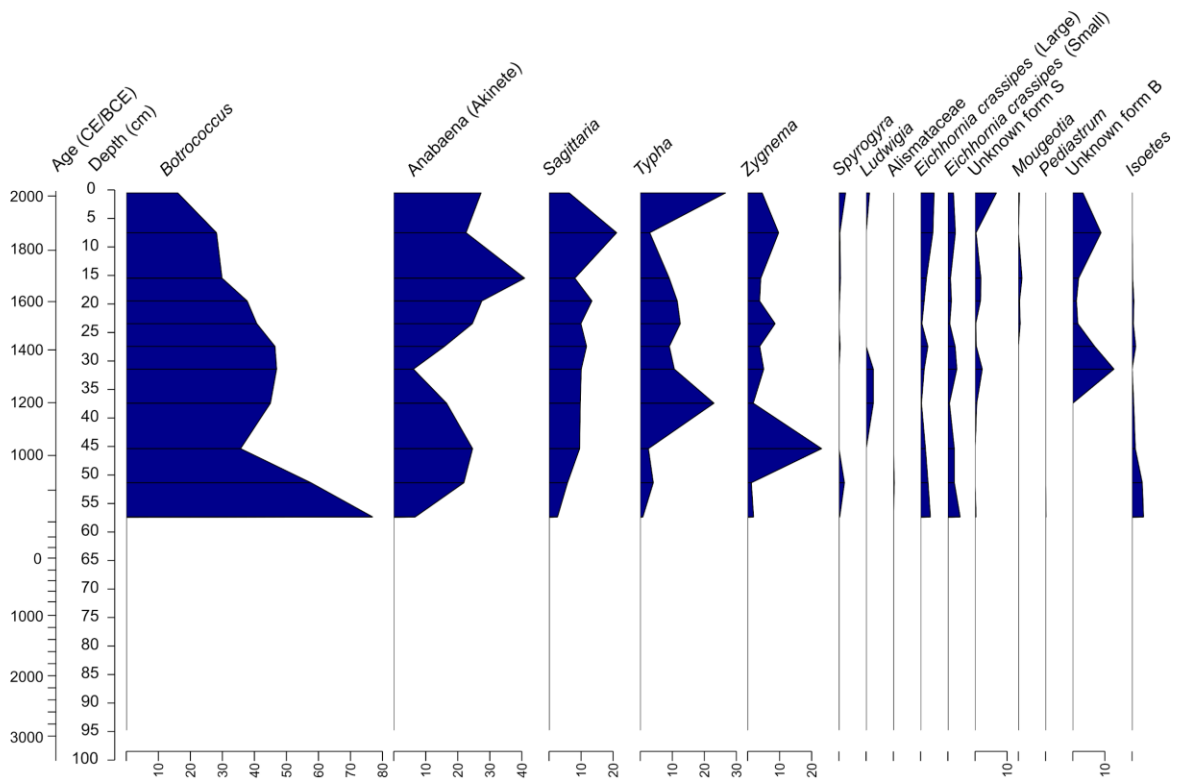
ME

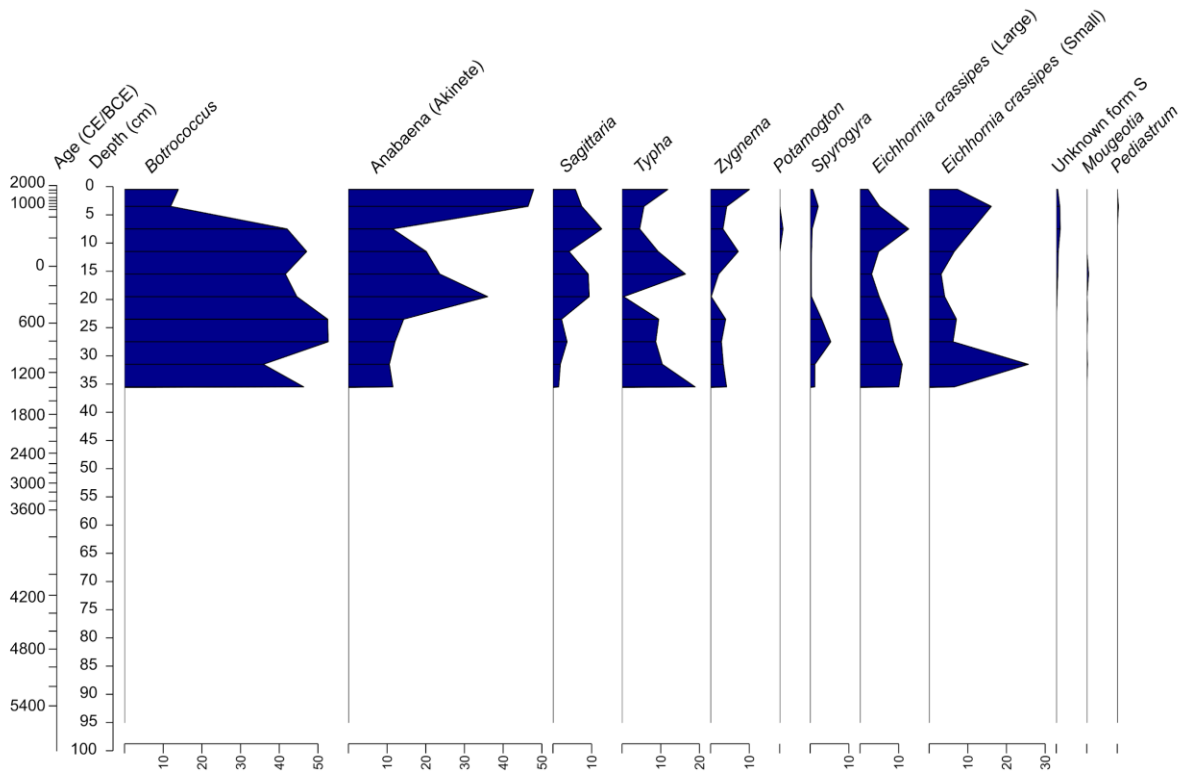**Supplementary Figure 4d** MERC18-02-01 phytolith summary.

Supplementary Figure 5a QM18-02 pollen percentage plot. Grasses and sedges are excluded from the count. Red dots are *Ipomoea batatas* (sweet potato) and blue dots are *Ipomoea* undiff.

Supplementary Figure 5b QM18-02 total pollen percentage plot of key taxa.

Supplementary Figure 5c MERC18-02-01 pollen percentage plot. Grasses and sedges are excluded from the count.

Supplementary Figure 5d MERC18-02-01 total pollen percentage plot of key taxa.
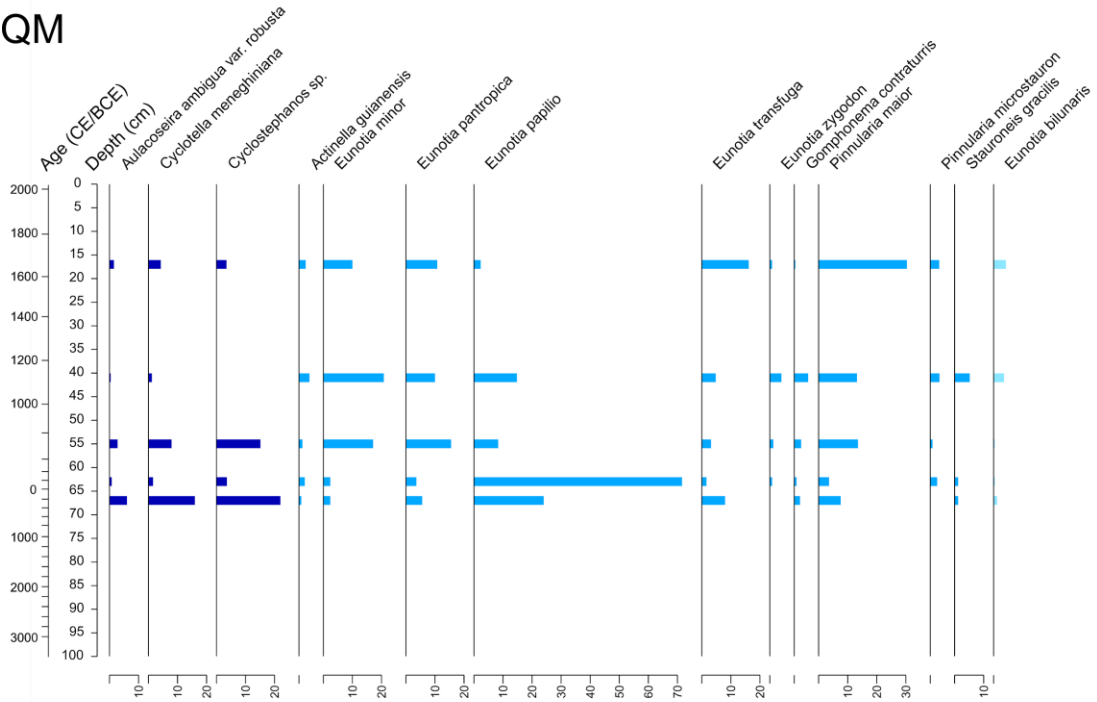
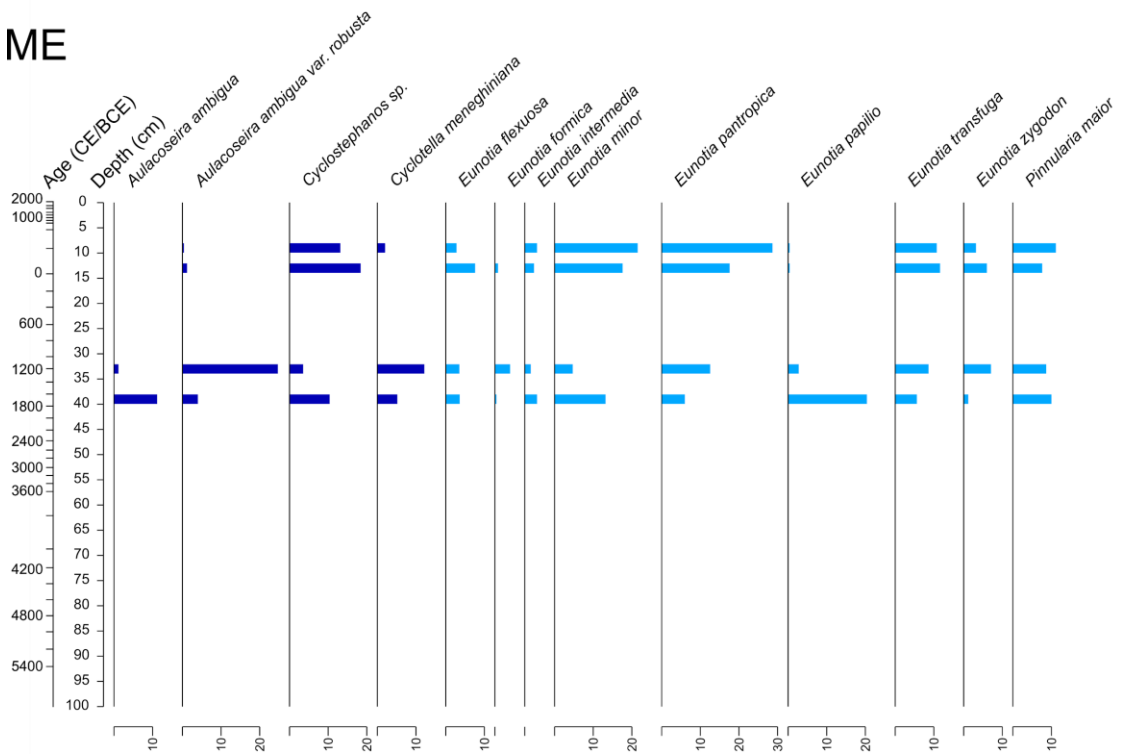**Supplementary Figure 6a** Aquatic remains for the QM18-02 core (QM).

Supplementary Figure 6b Aquatic remains for the MERC18-02-01 core (ME).

Supplementary Figure 7a Diatoms <3% for the QM18-02 core (QM). Sample at 83cm only returned fragments. Plantic taxa (dark blue), benthic taxa (blue) and aerophilous taxa (light blue).

Supplementary Figure 7b Diatoms <3% for the MERC18-02-01 core (ME). Samples at 59cm and 81cm only returned fragments. Plantic taxa (dark blue) and benthic taxa (blue).

Supplementary Figure 8a Principle component analysis of phytolith data from QM18-02 (QM - red squares) and MERC18-02-01 (ME - pink squares) cores compared to modern phytolith assemblages (6).

Supplementary Figure 8b Principle component analysis of phytolith data from QM18-02 (QM - red) and MERC18-02-01 (ME - pink) cores compared to modern phytolith assemblages (6).

References

1. D. M. Pearsall, *Phytoliths in the Flora of Ecuador* (The University of Missouri, 2000).
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3. A. G. Hogg, *et al.*, SHCal20 southern hemisphere calabration , 0–55,000 years cal BP. *Radiocarbon*, 1–20 (2020).
4. M. Blaauw, J. A. Christen, M. A. Aquino L., *rbacon: Age-Depth Modelling using Bayesian Statistics* (2020).
5. R Core Team, *R: A language and environment for statistical computing* (R Foundation for Statistical Computing, 2020).
6. R. Dickau, *et al.*, Differentiation of neotropical ecosystems by modern soil phytolith assemblages and its implications for palaeoenvironmental and archaeological reconstructions. *Rev. Palaeobot. Palynol.* **193**, 15–37 (2013).