Sinnesael, M., et al., 2021, Precession-driven climate cycles and time scale prior to the Hirnantian glacial maximum: Geology, v. 49, https://doi.org/10.1130/G49083.1

SUPPLEMENTARY MATERIALS

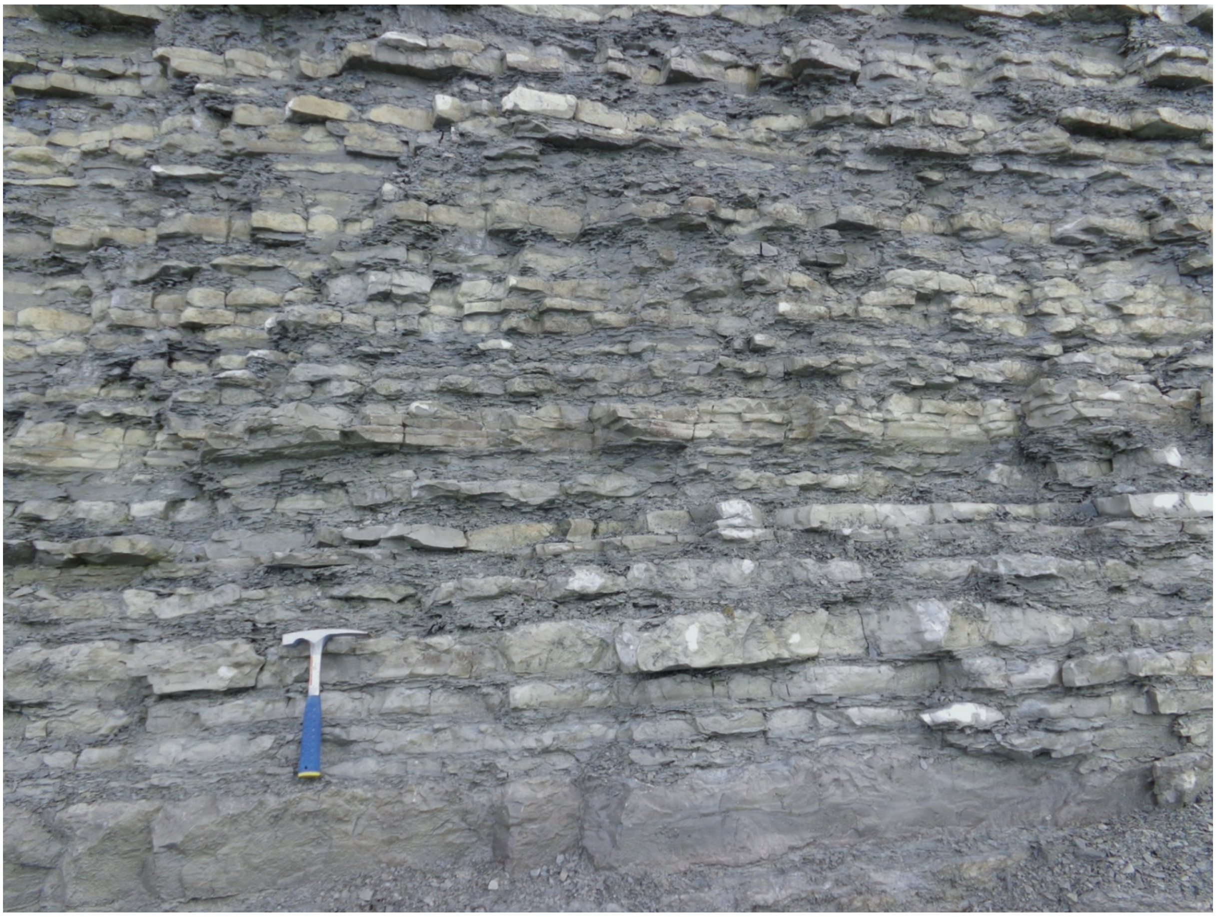

Figure S1. Picture of typical cm to dm-scale tempestites in the Vauréal Formation, Baie-de-la-Tour, Anticosti Island, Canada (hammer for scale).

Correlation La Loutre #1 (49°35’18’’N, 63°38’14’’W) and NACP (49°37’20’’N, 63°37’20’’N, 63°26’18’’W) cores:

Both cores are only ~10 km apart and correlated based on the lithological units as defined in McLaughlin et al. (2016). Separation by ~10 km along the south-directed depositional dip of the Anticosti Basin is attributed to the greater thickness of the lithological units in the LLI core. Identification of the lithological units (V2,V3,V4,V5 and Ellis Bay) is based on the NACP Potassium (K) record from McLaughlin et al. (2016) and La Loutre #1 Natural Gamma Ray (NGR) K (40-K %) logging record (**Fig. S2**). The absolute values of both independently acquired logging (La Loutre) and handheld XRF (NACP) Potassium concentration values are in excellent agreement. The handheld XRF data show more scatter because those are discrete point data, while the logging data are smoothed by the continuous measurements which are saved at regular distance intervals.

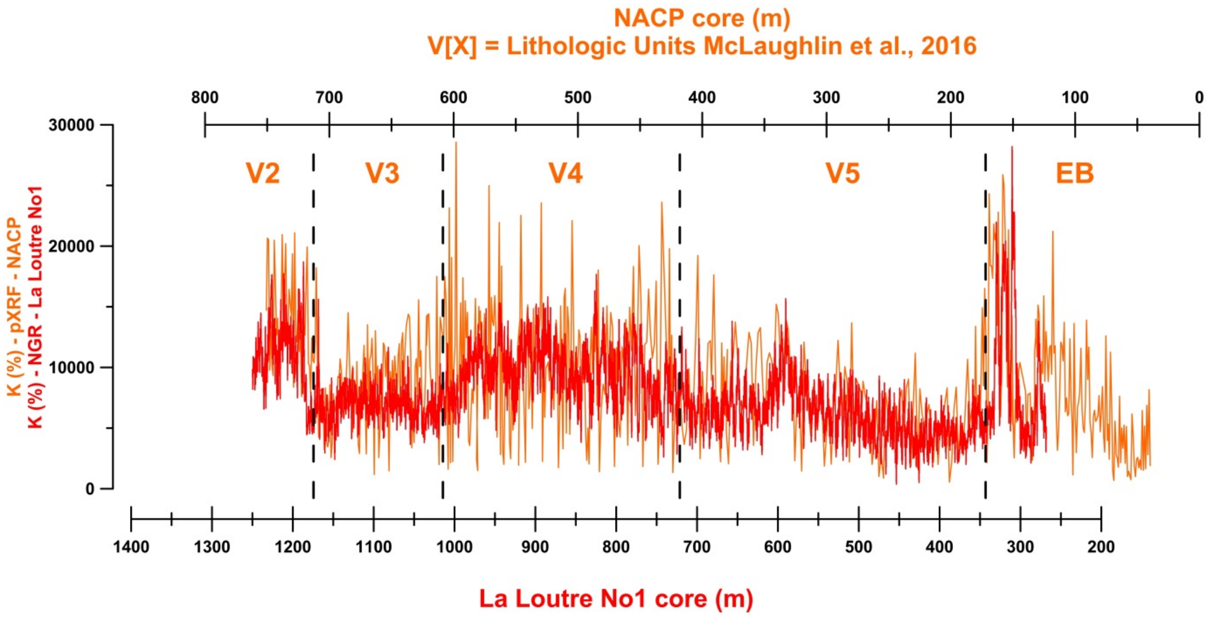

Figure S2. Lithological correlation of the NACP and La Loutre #1 cores.

$\delta^{13}C$ and $\delta^{18}O$ bulk carbonate isotope ratios NACP core:

Measurements of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope ratios of the bulk carbonate rock were carried out at the Vrije Universiteit Brussel (VUB, Belgium), using a Nu Perspective isotope ratio mass spectrometer (IRMS, Nu Instruments, UK) interfaced with a Nu Carb automated carbonate device. Acidification of the samples occurred at a temperature of 70 °C. All values are expressed relative to the Vienna Pee Dee Belemnite (‰-VPDB) standard. Calibration was carried out using an in-house Marbella limestone (MAR) standard (+3.41 ‰ $\delta^{13}C$ VPDB, -0.13 ‰ $\delta^{18}O$ VPDB) calibrated against the international NBS-19 standard. On the basis of replicated measurements of the MAR standard, reproducibility errors on $\delta^{13}C$ and $\delta^{18}O$ were determined to be <0.05 ‰ (1 σ) and <0.10 ‰ (1 σ), respectively. Corrected $\delta^{13}C$ and $\delta^{18}O$ carbonate stable isotope ratios are available in the Supplementary Materials File (“Sinnesael_etal_Anticosti_Cyclostratigraphy_SUPPLM_DATA”).

Key integrated stratigraphic constraints on the Vauréal Formation:

<u>Biostratigraphy</u> (Fig. 2 in McLaughlin et al., 2016): The *D. complanatus* and *P. prominens* graptolite zonations can be identified in the lower and upper Vauréal Fm. respectively. Further biostratigraphic constraints are provided by the identification of the following chitinozoan zonations: lower Vauréal Formation to the *Belonechitina senta* Zone, while the

middle and upper Vauréal spans the *Cyathochitina vaurealensis*, *Tanuchitina anticostiensis*, and *Hercochitina crickmayi* zones. No conodonts from the lower and middle Vauréal are known, while *Amorphognatus ordovicicus* Zone species are identified from upper Vauréal outcrops.

Chemostratigraphy (Fig. 3 in McLaughlin et al., 2016): (A) The latest Katian is characterized by the lowest $^{87}Sr/^{86}Sr$ values of the entire Ordovician. The Vauréal values between the narrow 0.7079-0.8082 range are in close agreement with the Ordovician $^{87}Sr/^{86}Sr$ reference curves based on measurements on well-preserved conodonts and brachiopods. (B) The lower temporal resolution provided by $^{87}Sr/^{86}Sr$ isotope stratigraphy can chemostratigraphically be refined by the potential identification of the Waynesville and Whitewater positive carbon isotope ($\delta^{13}C$) excursions.

Cyclostratigraphic analyses:

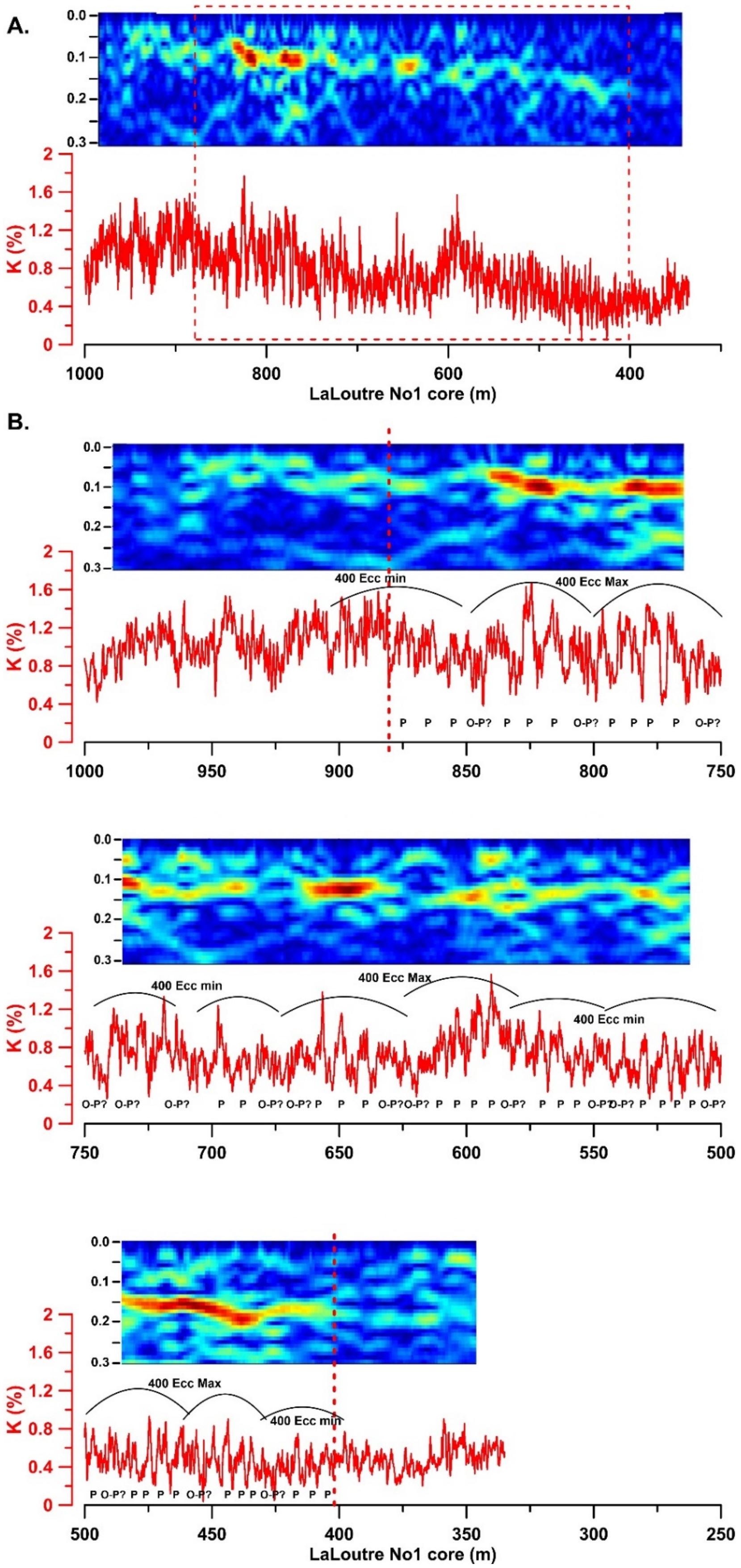
A.
B.
K (%)
LaLoutre No1 core (m)
400 Ecc min
400 Ecc Max
P
O-P?

Figure S3. La Loutre #1 core NGR K record and Evolutive Harmonic Analysis (EHA) in the spatial domain. (A) For the whole V4-V5 [1000-335m] interval. (B) Detailed analysis with indicated individual precessions (P), potential obliquity (O-P?), short eccentricity (Ɛ) and 405-kyr eccentricity extrema positions (400 Ecc Max & 400 Ecc min). Notice how the 405-kyr eccentricity maxima are characterized by higher power in the precession band and the intervals with potential obliquity cycles mainly correspond with low precession power- as shown by the EHA analysis.

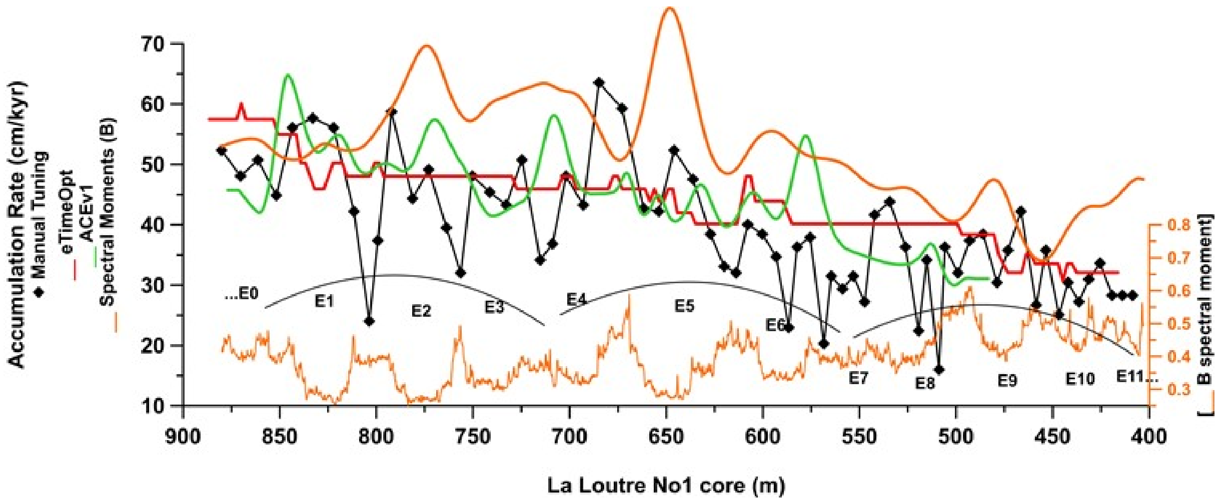

Figure S4. Comparison of reconstructed accumulation rates by the use of different methods (Manual tuning [black line], eTimeOpt [red line], ACEv1 [green line] and spectral moments [orange line]). All methods show roughly the same absolute numbers and a similar decrease for the reconstructed accumulation rates towards the top of the core. The spectral moment bandwidth varies stronger in 405-kyr eccentricity maxima and shows a short eccentricity period [thin orange line]. Higher bandwidth (B) spectral moment values correspond with short eccentricity minima and with lower reconstructed accumulation rates by manual tuning (e.g. clear example at 800 m). This pattern is suggestive of an astronomical control on the accumulation rates, with lower accumulation rates in eccentricity minima (e.g. less clay input because of reduced seasonal contrasts).

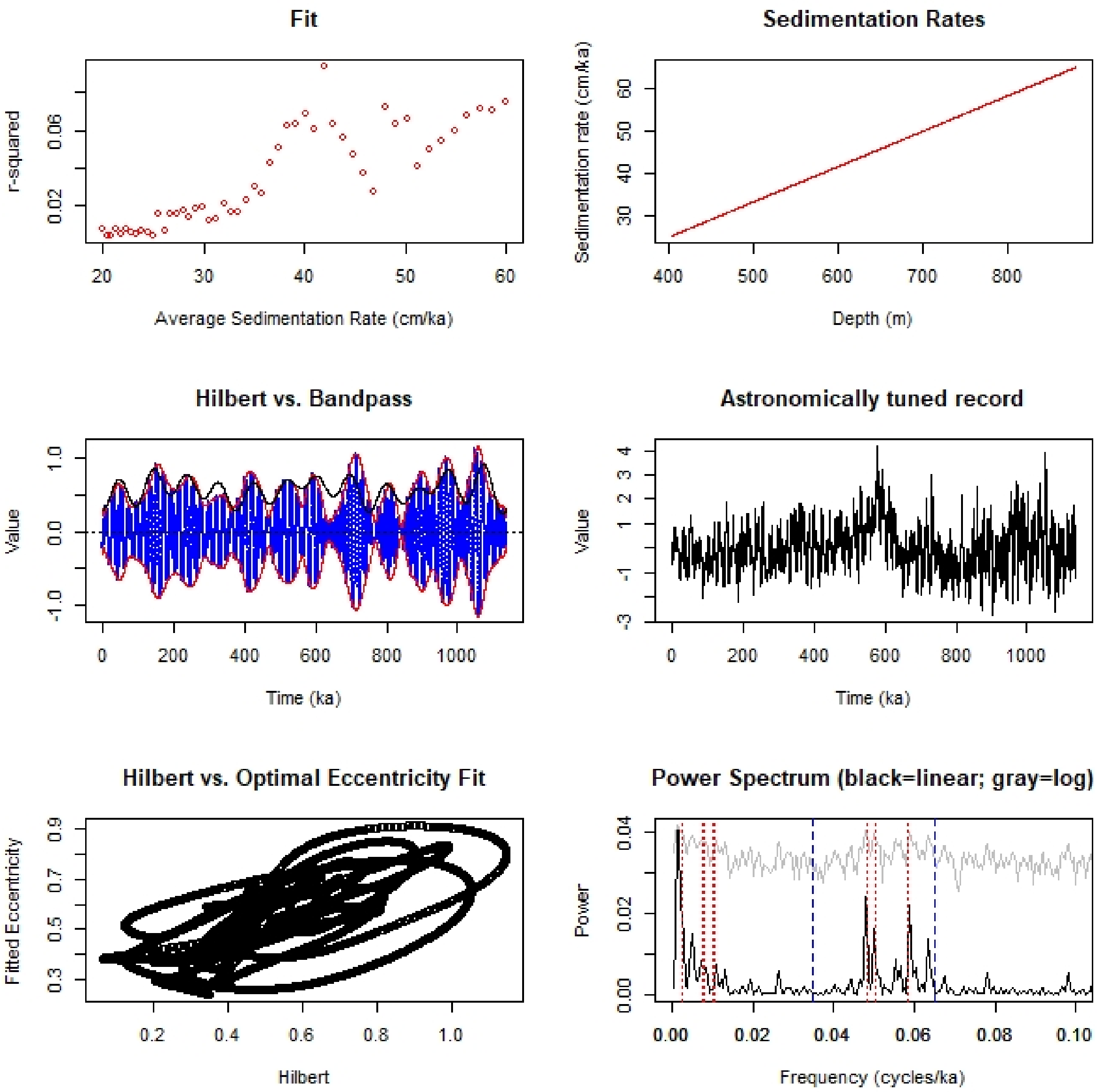

Figure S5. TemplateTimeOpt_precession outcome.

** Maximum r-squared = 0.09355524 at an average sedimentation rate of 41.91375 cm/ka*

Total duration = 1137.813 ka

srMin (min. sedrate) = 25.0865 and srMax (max. sedrate) = 64.97409

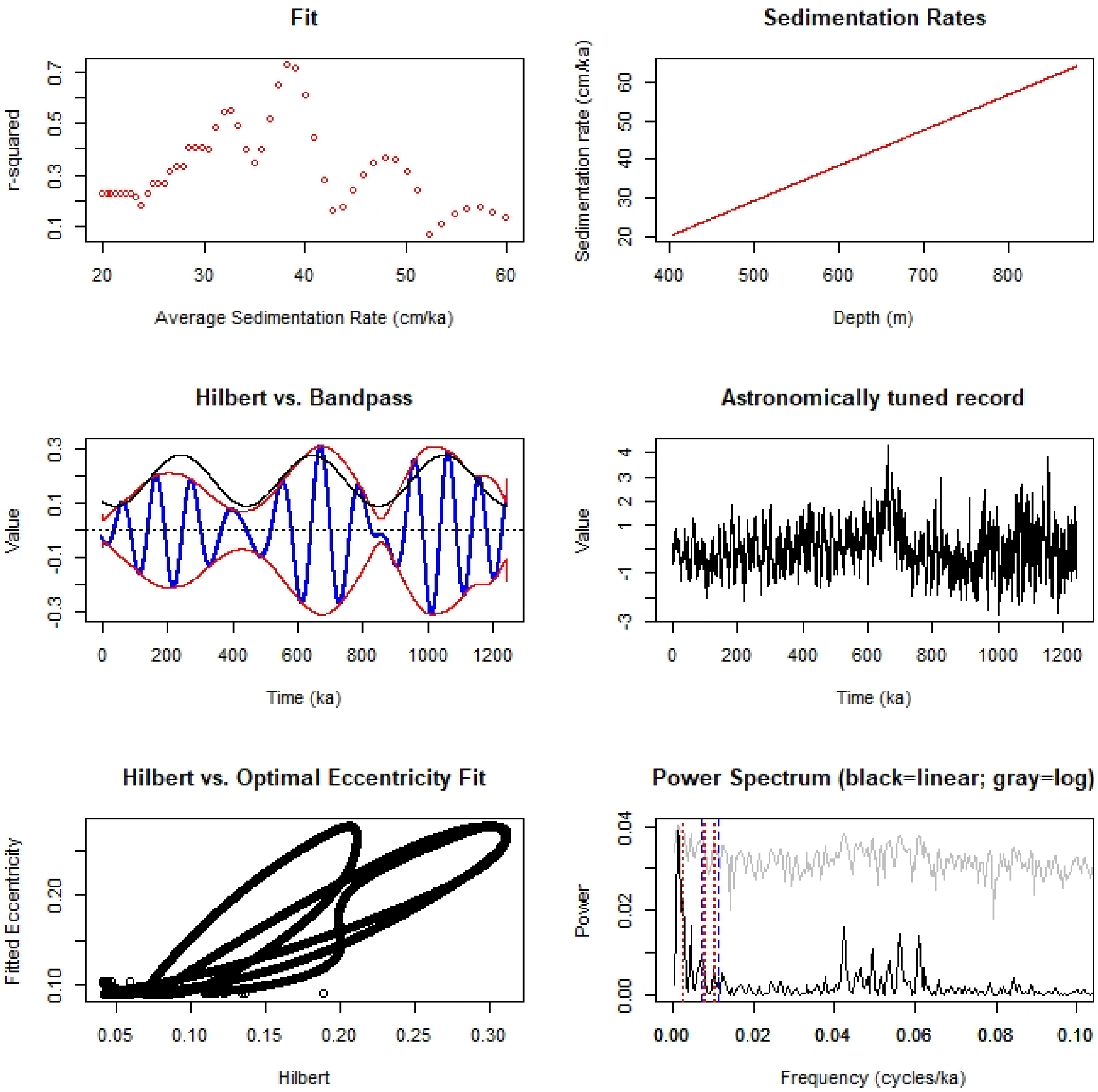

Figure S6. TemplateTimeOpt_eccentricity outcome.

** Maximum r-squared = 0.7227406 at an average sedimentation rate of 38.31845 cm/ka*

Total duration = 1244.57 ka

srMin (min. sedrate) = 20.63455 and srMax (max. sedrate) = 64.01948

Sub-Milankovitch

MTM and EHA analyses of the 550-325 k.y. interval shown in Fig. 3E showing strong spectral power in the precession and 1.5-1.0 k.y. frequency range.