# 1 DATASET

Location of the complete studied subsurface database is shown in Fig. S1. Interpreted stratigraphic horizons are shown in Fig. S2. Additional sections are shown in Figures S3 and S4.

# 2. ESTIMATION OF ACCUMULATION HISTORIES AND ASSOCIATED UNCERTAINTIES

We estimated offshore accumulation volumes and rates were estimating from the isopach maps shown in Figure 6 using the methods of Rouby et al. (2009) and Guillocheau et al. (2011) following the steps below.

## 2.1 Stratigraphic horizons and isochore maps

From the subsurface dataset (Fig. S1), we interpreted 9 stratigraphic horizons across the studied area (Fig. 4) using the method of seismic stratigraphy (Van Wagoner et al., 1988; Homewood et al., 1992) and 33 wells located in the shelf and bathyal domains for lithological and biostratigraphic calibration (Fig. S1).

To do this, we deduced the migration of the depositional profile through time from the stratigraphic architecture (Homewood et al., 1992; 1999), in particular the location of the offlap break (upper slope break of the depositional profile) and its associated truncations (onlap, toplap, downlap; Vail et al., 1991). If the offlap break corresponds to the shoreline, its seaward migration is interpreted as a progradation and its landward migration as a retrogradation. Maximum flooding surfaces (MFS) are defined as the inversion from progradation to retrogradation whereas flooding surfaces (FS; or transgressive surfaces, TS, for Posamentier et al., 1988a, 1988b; Maximum regressive surfaces, MRS, for Embry, 1993) are defined as the inversion from retrogradation to progradation (Figs. S5 and S6). A progradational succession includes a highstand system tract (HST) and lowstand system tract (LST), separated by an unconformity (UN; Posamentier et al., 1988a, 1988b; Figs. S5 and S6). A retrogradational succession includes a transgressive system tract (TST; Fig. S5).

We defined sedimentary environments from well-log signatures, calibrated the seismic geometries in terms of sedimentary facies and obtained geometries of the sedimentary bodies (Fig. S6). Coastal and deltaic plain were mapped as continental environments, shoreface and delta front as transitional, upper offshore as shallow marine (<200m) and lower offshore as deep marine (>200m). From the 9 horizons, we constructed 8 isochores maps in two-way time (TWT; Fig. 5).

## 2.2 Depth conversion of isopach maps

We depth converted the isochores maps using a 6 layers law constrained at well locations. For each layer, we defined either a polynomial law, the velocity map of the top and bottom layers or a mean velocity map of the interval depending on the variability of velocities in space and data available (Table S1).

We also estimated the spatial variability of velocities within each layer used to estimate uncertainties in accumulated volumes and rates (see §2.6; Table S2).

## 2.3 Correction of *in situ* production

Following the method of Rouby et al. (2009), we corrected the deposited volumes from the *in-situ* production content (i.e., carbonates) to estimate the terrigenous portion. To do this, we compiled the mean carbonate contents of each time interval (Fig. S7) using 12 wells in the GS basin, 6 wells on the Demerara plateau, and 12 wells in FOZ basin (mostly located on the shelf; Fig. S1).

From this, we evaluated the spatial variability of carbonate content within each layer from well data that we used then to estimate uncertainties in accumulated volumes and rates (see §2.6; Table S3).

## 2.4 Correction of remaining porosity

Following the method of Rouby et al. (2009) and Guillocheau et al. (2011), we corrected the terrigeneous volumes from remaining porosity using an exponential law (1) to reach solid volumes of terrigenous sediments:

$∅\left(z\right)=∅\_{0}e^{-cz}$ (1)

where $∅$(z) is the porosity at depth z, $∅\_{0}$ the porosity at the surface and c the compaction factor depending on the lithology. We used, $∅\_{0}$ equal to 0.4 for sand and 0.6 for clay, and c equal to 0.4 km-1 for sand and 0.5 km-1 for clay (Jones et al., 2001).

Averaged porosity ($∅$|) between the depth z1 and z2 was then obtained by:

$∅|=(\frac{∅0}{c})\frac{e^{-cz1}-e^{-cz2}}{z1-z2}$ (2)

The solid volume was estimated by the equation (6):

V𝑠 = (1 − $∅$|) Vt (3)

where Vs is the solid volume, Vt is the total volume.

To assess the uncertainties related to the porosity correction, for each layer, we calculated multiple corrections using the whole range of sand content from 0 to 100% (see Guillocheau et al., 2011 for details).

## 2.5 Calibration of horizons in absolute ages

We calibrated the stratigraphic horizon in absolute ages using available well data and the International Chronostratigraphic Chart (Cohen et al., 2013; updated). To account for uncertainties associated with this calibration, we defined age ranges for each stratigraphic horizon that we used to estimate uncertainties in accumulated volumes and rates (see §2.6; Table S3).

## 2.6 Estimation of uncertainties

Following the method Guillocheau et al. (2011), we estimated uncertainties in the calculation solid volumes and rates using a Monte Carlo simulation assessing the variability of the accumulated volumes and rates resulting from: (i) uncertainties in the calibration of horizon in absolute ages (Table S4); (ii) uncertainties in the depth conversion of horizons (Table S2); (iii) uncertainties in the correction for carbonate content of each time intervals (Fig. S4; Table S3) and the uncertainties related to the porosity correction (§2.5). These uncertainties are shown in Table S5 along with accumulation volumes and rates and by the error bars on Figure 4.

Uncertainties associated with the accumulation calculation vary from ± 0.1 to ± 5.0 103 km3/Myr (Table S5). They are highest for short duration accumulation maxima (e.g., c. 6-0 Ma in the FOZ basin; Fig. 4G). Accumulation rates tend to be higher for short time intervals (Figs. 4E, 4F, and 4H) and this could partly result from more frequent and longer hiatuses likely to be incorporated during longer time intervals (Sadler, 1999). To test for this effect, we resampled accumulation rates for five intervals in both the GS and FOZ basins and showed that the Cretaceous trends are preserved in the resampled rates (Figs. 4E and 4F).

# 3. PALEO-ENVIRONMENTS AND PALEO-LITHOLOGIES MAPS

To map the depositional environments at the scale of the study area, we used the framework of the continent scale paleo-geologic maps of Ye et al. (2017) and Bajolet et al. (submitted; Fig. 6). These includes sedimentary paleoenvironments, active faults, magmatic occurrences, paleocurrents, heating or cooling from low-temperature thermochronology, source areas of sediments (provenance analyses by means of detrital geochronology heavy minerals associations studies) or reported bauxite/laterite occurrences (see Bajolet et al. submitted and references therein). Sedimentary paleoenvironments are represented by the area of preserved deposits and the minimal areal extent beyond that preserved area at the period of deposition (light colored; Fig. 6). The minimal extent is estimated following the method of Ye et al. (2017) from the mean regional slopes of cratonic and marginal basins and the mean denudation rates given by thermochronology (c. 10m/Ma). Plate boundary configurations and kinematics is compiled for the end of the considered time interval in a fixed South America reference frame (see Bajolet et al. submitted and references therein). The African and offshore Atlantic margin paleogeography and kinematics are after Ye et al. (2017 and references therein).

From seismic facies, we mapped fluvial, coastal and deltaic plain facies as continental environments, continental platform facies as transitional, bathyal (continental slope) as shallow marine (<200m) and abyssal as deep marine (>200m; Fig. 6). We mapped the shelf-break at its most distal location during each considered interval.

We also mapped domains of 6 dominant lithologies: sand (sand content > 90%, usually the fluvial, coastal and deltaic plain), sand/clay (sand content > 60%), clay/sand (sand content < 40%), clay (sand content < 10%, usually the abyssal domain), carbonates (usually the platform domain), shale (usually deposits in bathyal environment at the toe of carbonate platforms; Fig. 7). For example, we mapped sand dominated deposits for chaotic and non-rectilinear facies and shale dominated for are less chaotic and better stratified facies while for carbonates, facies are highly reflective, rectilinear and stratifies. We mapped Mass Transport Deposits (MTD) for bodies bounded by unconformities, located at the base of the slopes, with folded stratifications in the upper part and extension structures in the lower part. Turbiditic systems show channel/level, lobes at the distal end of channel and canyon at the proximal end with strong reflectance and erosive bases.

We organized our results for visualizing the spatial and temporal evolution of accumulation history (Fig. 4), isopach / depocenters (Fig. 5), depositional environments (Fig. 6), main lithologies (Fig. 8) and denudation history of the cratonic domain (Fig. 8). The paleomaps of figures 5 to 8 are arranged by time intervals from (A) to (H) on a same layout for comparison. We also provide in Supplemental File 1an alternative presentation of the maps, with depocenters, depositional environments and lithologies shown together on a same figure for a given time interval.

# 4. DENUDATION HISTORY

Location of the LTT samples of Dereycke et al., (2021) is shown in Fig. 2. The method to evaluate the denudation rates shown in Fig. 8 is described in the “Method” section of the main text. Denudation rate values are given in Table S6.

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**TABLE CAPTIONS**

Table S1: Polynomial laws used for the depth conversion of the isopachs shown in Figure 5. CABU: Central Atlantic Break-up Unconformity. EABU: Equatorial Atlantic Break-up Unconformity. T1 and T2 are the maps in TWT (two-way travel time) of the top and bottom horizons of the considered interval. V1 and V2 are the velocity maps of the top and bottom horizons of the considered interval. These maps are proprietary and cannot be published.

Table S2: Variability in the seismic velocities for each time interval used to estimate uncertainties in accumulated volumes and accumulation rates shown in Figure 4.

Table S3: CaC03 and volcanic contents used for the in-situ correction of the raw accumulated volumes and accumulation rates shown in Figure 4.

Table S4: Calibration of horizons in absolute ages and associated uncertainties used for the calculation accumulation rates and associated uncertainties shown in Figure 4.

Table S5: Accumulated volumes, accumulation rates and associated uncertainties for the GS basin, the FOZ and DEM basins and total. The values high-lighted in gray are minimal values for which the volcanic/clastic ratio is unknown.

Table S6: Denudation and denudation rates for the LTT samples of Deryck et al. (2021) assuming the thermal history is primarily driven by denudation/burial and a geothermal gradient of 25°/km (Fig. 8).

**FIGURE CAPTIONS**

Figure S1. Location of the complete studied subsurface database (2D seismic in brown lines and well data in yellow cercles). After Loparev et al. (2021).

Figure S2: Stratigraphic chart showing the horizons interpreted on the seismic data, the main geodynamic stages for the Guiana-Suriname (GS) and Foz do Amazonas (FOZ) basins and the main mechanisms assumed to drive the subsidence. EA: Equatorial Atlantic; CA: Central Atlantic; BU: Break-up Unconformity. After Loparev et al. (2021).

Figure S3. Additional geological cross-sections. (A) GS1 and (B) GS2 sections through the transform segments of GS basin (CA). (C) DEM1 and (D) DEM2 sections through the transform segment of North Demerara basin (EA). (E) FOZ1 section through the oblique segment of FOZ basin (EA). (F) FOZ3 strike section along the FOZ basin and the Amazon Delta. (CA: Central Atlantic; EA: Equatorial Atlantic; ND: Necking Domain; BU: Break-up Unconformity; DM. Distal margin; ICC: Intruded Continental Crust; FZ: Fracture Zone; GS: Guiana-Suriname; FOZ: Foz do Amazonas). Modified after Loparev et al. (2021).

Figure S4. Line drawing of additional studied 2D seismic sections. (CA: Central Atlantic; EA: Equatorial Atlantic; ND: Necking Domain; BU: Break-up Unconformity; DM. Distal margin; ICC: Intruded Continental Crust; OC: Oceanic crust; FZ: Fracture Zone). Modified after Loparev et al. (2021).

Figure S5. Method of seismic stratigraphy for a theoretical example. Modified after Jermannaud et al. (2010).

Figure S6. Method of calibration of sedimentary environments on seismic data. (A) Definition of the sedimentary environments from the well-log data. (B) Calibration of seismic facies at ell location. (C) Interpretation of depositional environments on seismic data. Modified after Jermannaud et al. (2010).

Figure S7: Averaged carbonate content estimated for each time interval from the calibration wells of the GS (blue curve) and FOZ, northern and eastern Demerara basins (green curve). Associated uncertainties correspond to the spatial variability of the CaCO3 content in each basin (see Table S3).