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Passive margin stratigraphy for source to sink numerical models calibration: diffusion coefficient measurements in the Ogooué and Zambezi deltas

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One major and under-appreciated aspect of stratigraphic modeling based on diffusion is the wide range of diffusion coefficients used in the literature to simulate natural examples without considering their meaning in term of transport and deposition processes. Most of the time, stratigraphic simulation tools are indeed used as a semi-inversion tool based on a “best-fit” approach to reproduce well-constrained sedimentary architectures.
The aim of this work is to consolidate inputs of stratigraphic numerical modeling such as slopes of sedimentary systems, grain-size distributions and diffusion coefficients calibrated on natural examples of passive margin deltas: the Plio-Pleistocene Ogooué Delta in Gabon and the Mio- to Pleistocene Zambezi Delta in Mozambique.

We calculated diffusion coefficients from high resolution seismic stratigraphy and well log analyses in three-steps: (1) calibration of sand/shale ratio variations (from wells) along the depositional profile; (2) restoration of the slope of sedimentary systems at time of deposition (including differential compaction corrections); (3) calculation of accumulation rates using a high resolution age model and quantification of uncompacted volumes for each time step in various stratigraphic context.

Most of diffusion coefficients calculated on the two natural examples range over two orders of magnitude (x0,01 to 10 km2/ka), in agreement with most of the published diffusion process-based stratigraphic modeling (x0,0001 to x10 km2/ka). Our results suggest that: (1) neither the stratigraphic context nor the sand/clay ratio impact the diffusion coefficients but, (2) they strongly depend on the slopes along the depositional profiles. We also observe (3) a high variability of coefficients on the shelf and the basin floor that could reflect the occurrence of sedimentary processes that cannot be simplified to a simple diffusion (e.g. waves or flood on the shelf; oceanic currents, turbiditic channels or hemipelagites in the most distal domain). Finally, investigations of the influence of the temporal and spatial resolution on coefficient values show that diffusion process is optimal at a scale of several kilometers and million years for which the lesser coefficient variability suggests that the diffusion approach allows averaging numerous sedimentary processes.

We use the diffusion coefficient values and geometrical parameters of observed stratigraphic architectures to calibrate the marine deposition of a new coupled erosion-deposition numerical model developed by Yuan et al. (COLORS project, funded by Total) that accounts for both erosion onshore and sediment deposition in the marine domain. Highly efficient, this model allows for inverse simulations to be run and to address a large variety of questions in various setups.