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Questioning the Global Eustacy Paradigm – Evidence from Thermal History Data, West Africa

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Extended Abstract
Studies of the thermal evolution of the West African margin based on integrated AFTA and vitrinite reflectance (VR) data from the eastern Gulf of Guinea reveal four discrete paleo-thermal episodes, with cooling commencing within the time ranges recognised by AFTA of 105 to 95 Ma (mid Cretaceous), 85 to 75 Ma (late Cretaceous), 45 to 35 Ma (mid Tertiary) and 10 to 0 Ma (late Tertiary to Recent) (Figure 1).

Paleotemperature profiles defined by the AFTA and VR data from wells in Rio Muni and Cameroon indicate that the late Cretaceous and Tertiary paleo-thermal episodes were caused by kilometer-scale uplift and erosion of the continental margin under normal heat flow conditions. The late Cretaceous episode appears to be associated with localized structural inversion, whereas the Tertiary episodes are of regional extent. Conversely, the mid Cretaceous thermal episode is characterized by regionally elevated basal heat flow, requiring minimal uplift and erosion. A similar pattern of thermal history has been recognised in other studies from Gabon to Angola, emphasizing their truly regional extent (Jackson *et.al.*, this meeting).

These observations have a major impact on the understanding of the tectonic and stratigraphic development of the West African margin and in particular on the application of global eustacy and sequence stratigraphic concepts.

Prominent sequence boundaries are observed as unconformities on seismic data from the region, corresponding to stratigraphic breaks which, based on current stratigraphic understanding, occur in the late Cretaceous (Cenomanian to Santonian), in the mid Tertiary (early Eocene to late Oligocene) and in the late Tertiary (late Miocene and Pliocene). These unconformities can be correlated along the offshore margin at least from Cameroon to Gabon. The thermal history data (AFTA and VR) therefore fit well with the stratigraphic and seismic evidence and point to repeated cycles of burial and exhumation of the West African margin. Geomorphological evidence suggests that these uplift processes are continuing at the present-day.

The normal sequence stratigraphic procedure is to attribute the sequence boundaries to prominent sea-level falls as depicted by the global cycle chart (eg. that of Haq et. al. 1988). For example, the major mid Oligocene sea-level fall on the chart at around 30 Ma would constitute a candidate to explain the sequence boundary that occurs between the early Eocene and the late Oligocene. Evidence for uplift would be treated as an amplification of the relative sea-level fall, which would probably then be designated as 'tectonically-enhanced'.

The evidence for several previously unrecognized phases of uplift and erosion during the development of the West African 'passive margin' raises questions over the application of the Global Eustacy Paradigm and the sequence stratigraphic analysis approach. Miall and Miall (2001) draw attention to the circular reasoning that goes into sequence analysis procedures based on the global cycle chart and its use as a chronostratigraphic tool. They appeal to an alternative conceptual approach that they term the 'Complexity Paradigm', which asserts that stratigraphic sequences are controlled by multiple processes.

Our approach is based on using measured AFTA and VR data, combined with consideration of the sequence architecture in terms of the two main influences of subsidence and sediment supply, to reconstruct sedimentary basin histories. On the West African margin in the eastern Gulf of Guinea, the most plausible interpretation of the data implies that synchronous episodes of uplift and erosion are responsible for the prominent sequence boundaries. Importantly, these effects are not confined to single basins. In our view therefore, these sequence boundaries should be treated as

anomalies within the Global Eustacy Paradigm and add to the growing body of support for the Complexity Paradigm. With growing evidence for the broad geographic extent of the uplift, it has to considered whether a proportion (if not all) of at least Type 1 sequence boundaries are due to tectonic uplift, with sea level change being a less important control.

It is not denied that sea level fluctuation is an important process, but the global eustacy approach attributes erosion at sequence boundaries only to falls in sea level. Our results show that the key regional unconformities defining system boundaries within our Rio Muni and Cameroon study area represent periods when significant thicknesses of sediment were both deposited and then eroded. Thermal history reconstruction based on AFTA can recognise these events and distinguish them from sea level falls whereas the conventional eustatic approach cannot. Failure to recognise uplift and erosion on passive continental margins can lead to significant underestimation of source rock maturity, incorrect assessment of the time of hydrocarbon charge and can invalidate the fitting of sequence boundaries to the global cycle chart, thus impairing its use as a chronostratigraphic tool.

References

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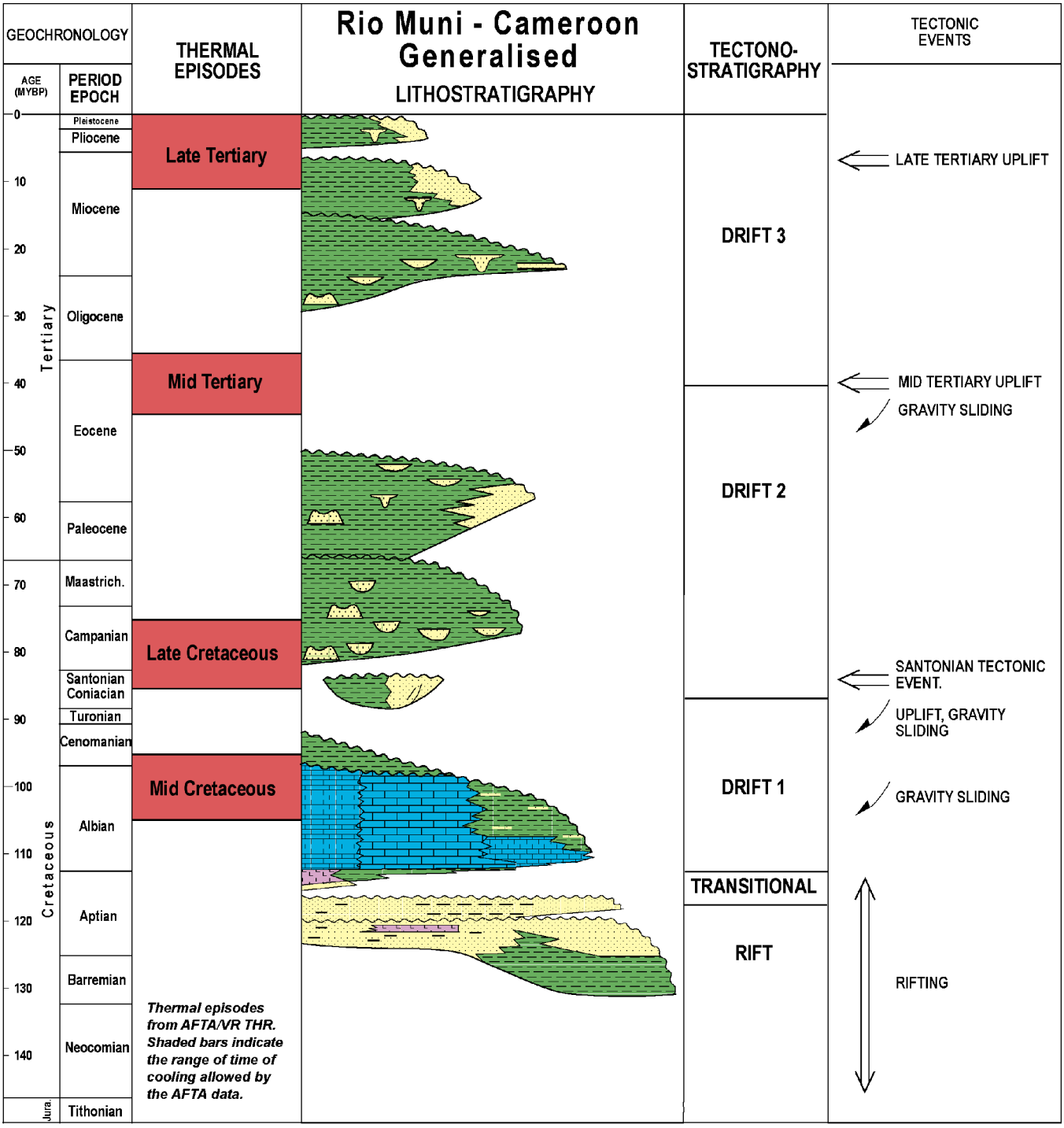

Rio Muni - Cameroon Tectono Stratigraphy and Thermal Episodes

Figure 1