**Climate
of the Past
Discussions**

Interactive comment on "Climatically-controlled siliceous productivity in the eastern Gulf of Guinea during the last 40 000 yr" *by* X. Crosta et al.

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Final Author Response to two anonymous referees and Dr. Weldeab's interactive comments and on the manuscript "Climatically-controled siliceous productivity in the eastern Gulf of Guinea during the past 40.000 years" by Crosta, Romero, Ther et Schneider.

Two anonymous referees and Dr. Syee Weldeab and the congruently pointed out six flaws in the original submission, which are discussed below in order of appearance in the revised version (blue colour in the response below).

1. Attribution of source data The origin of the data previously published is now adequately referenced in the text and figure captions.

3.1 Stratigraphy Gravity core GeoB4905-4 was retrieved during the Meteor cruise

M41/1 in the eastern Gulf of Guinea (2°30'N, 9°23.4'E, 1328 m of water depth) around 115 km to the southwest of the Sanaga River mouth (Fig. 1). The age model of core GeoB4905-4 was already published in Adegbie et al. (2003) and Weldeab et al. (2005). Briefly, it is based on fourteen 14C-AMS datings of monospecific samples of the planktonic foraminifer Globigerinoides ruber pink and mixed planktonic foraminifers for the upper 9 meters of the core. Additional tuning points between the ïĄď'18O G. ruber pink record and GISP2 ïĄď'18O record allowed to extending the stratigraphy beyond the radiocarbon range. Radiocarbon ages were corrected for the mean marine reservoir age and calibrated to calendar ages using CALIB5 (Stuiver et al., 2005). The core covers the last 45.000 calendar years (cal. ka BP) in 1218 cm.

3.6 Opal analysis Opal was determined with the sequential leaching technique developed by Müller and Schneider (1993). Reproducibility of the method is below 2%. Biogenic opal accumulation rates were calculated with the following equation Opal AR = (O * WBD * SR). (2) Where Opal AR is the opal accumulation rate in g.cm-2.ka-1, O is the opal content of the sediment, WBD is the wet bulk density in g.cm-3 measured on board and SR is the sedimentation rate in cm.ka-1. Part of the biogenic opal record (0-22 cal. ka BP) that has been used here to calculate opal AR was previously published in Weldeab et al. (2007).

2. Relationships between DSi stocks and diatom production in the Gulf of Guinea The relationships between DSi stocks and diatom production in the GG are better addressed both in (1) Introduction and (2) Oceanographic and climate settings (see below). Briefly, the DSi content of surface and sub-surface waters that are reaching the GG (SACW till 500m deep) are DSi-depleted to sustain high diatom productivity. The GG is also characterized by the absence of upwelling, and windier conditions during H1 and YD may not have been strong enough to promote upwelling beyond SACW range.

1. Introduction Diatom production and burial in the Gulf of Guinea, defined as the part of the Atlantic Ocean northeast of a line running from Liberia to Gabon, are relatively

low. Abundances hardly reach 1.107 diatoms per gram in surface sediments (Romero and Armand, 2010), which is 1-2 order of magnitude lower than diatom occurrences in the Southern Ocean (Crosta et al., 1997) and coastal upwellling systems (Romero et al., 2002; Abrantes et al., 2007). Diatom abundances in surface sediments of the Gulf of Guinea additionally demonstrate a westward decreasing gradient (Pokras and Molfino, 1986) in phase with the westward increasing gradient in salinity (Weldeab et al., 2007a). Such distribution is related to low mean DSi concentrations in surface waters with values of $\sim$2.5 μM in the western part of the Gulf of Guinea where DSi stocks originate from the nutrient-poor South Atlantic Central waters transported by the South Equatorial Counter Current (Peterson and Stramma, 1991) and $\sim$8 μM in the eastern part of the Gulf of Guinea where rivers inject nutrient-rich freshwaters (Hughes et al., 2011). There is therefore a direct connection between DSi stocks and diatom production in surface waters and occurrence in sediments of the Gulf of Guinea and precipitation regimes over western Equatorial Africa. Past changes in siliceous productivity were reconstructed on glacial-interglacial timescale in the east Equatorial Atlantic and the Congo Fan from the southeast Atlantic. In the east Equatorial Atlantic, variations in siliceous productivity and marine diatom assemblages were mainly related to the intensity of the equatorial upwelling in response to changes in the intensity and direction of the trade winds (Abrantes et al., 2003). In the southeast Atlantic off the Congo river, variations in siliceous productivity and marine diatom assemblages were related to the interplay of riverine discharges, in turn controlled by changes in precipitation in western and central Equatorial Africa, and migrations of oceanic fronts, controlled by changes in wind regimes (Uliana et al., 2002; Marret et al., 2008). Because of the absence of upwelling (Stramma and England, 1999) and proximity to the ITCZ, the eastern Gulf of Guinea may provide more straightforward information on climate changes in western Equatorial Africa than the eastern Equatorial Atlantic and the Congo Fan.

2. Oceanographic and climate settings Dissolved silica in surface waters of the southwest Atlantic Ocean are around 2.5 μM (World Ocean Atlas, 2001) and, thus, bring very little nutrient to the eastern Gulf of Guinea. Dissolved silica concentrations in surface

waters of the eastern Gulf of Guinea are slightly higher than in the open ocean with values of $\sim$6-8 μM during the boreal summer (July-October) and $\sim$2 μM during the boreal winter-spring (March-June) (World Ocean Atlas, 2001). These variations appear related to the yearly cycle of discharge of local rivers that present mean concentrations of $\sim$15 mg/l or $\sim$230 μM (Boeglin et al., 2003; Hughes et al., 2011). High dissolved silica concentrations in African rivers are related to the prevalence of warm climate conditions that favour chemical weathering of crystalline rocks abundant on this continent (Dürr et al., 2011). Monitoring of Sanaga River discharge, dissolved silica content and chlorophyll-a concentration is surface waters of the eastern Gulf of Guinea during the year 2005 evidenced a strong relationship between DSi brought to the ocean by riverine fresh water discharge and local productivity (Weldeab et al., 2007a).

3. Ecological diatom group identification The thorough review of modern diatom distribution in the phytoplankton, surface sediments and in continental waters now presented assesses the ecological preferences of main diatom species found in core GeoB4905-4. In addition, the processes and mechanisms responsible for the presence of freshwater diatoms in marine sediments are also reviewed to assess the preferential transport vector of both planktonic freshwater diatoms and raphid benthic freshwater diatoms from continental waters to the ocean. The list of diatom species encountered in core GeoB4905-4 was clearly detailed in table 1 of the submitted manuscript. Diatom species were listed in their respective ecological group. Table 1 is not pasted again below.

3. Ecological significance of diatoms Around 80 diatom species or species groups were identified in core GeoB4905-4. To simplify this large dataset, species sharing similar ecology were lumped together. Previous investigations on diatom distribution in surface water and in surface sediments from low latitude environments have demonstrated that it was indeed possible to combine diatom species in several groups, based on habitats and nutrients and SST requirements. Identification of diatom groups in previous investigations were based on simple comparison of relative abundances or statistical

approaches (Schuette and Schrader, 1981; Pokras et Molfino, 1986; Treppke et al., 1996; Schrader and Sorknes, 1997; Romero et al., 2002; Romero et Hebbeln, 2003; Jiang et al., 2004; Abrantes et al., 2007; Romero et al., 2009). We here built onto the publications cited above, summarized in Romero and Armand (2010), to identify three different marine water groups and one benthic/brackish water group. Two additional diatom groups were identified according to diatom distribution in African rivers and lakes to account for freshwater diatoms and windblown diatoms (Servant-Vildary, 1978; Gasse, 1980, 1986).

3.3.1 Marine diatoms Oligotrophe diatoms are thriving in warm, nutrient-poor surface oceanic waters where siliceous productivity is low. This group is here dominated by large and highly silicified centric diatoms such as Azpeitia spp., Planktonellia sol, Pseudosolenia calcaravis and Rhizosolenia spp., Thalassiosira spp. with lesser occurrence of pennate diatoms such as Nitzschia spp. and Thalassionema bacillare (Tab. 1). Mesotrophe diatoms are living in nutrient-rich coastal marine environments. This group tracks higher dissolved silica levels, higher siliceous productivity but low turbulence (no upwelling conditions). This group is here dominated by large and highly silicified centric diatoms such as Actinocyclus spp., Actinoptychus spp., Coscinodiscus spp., Paralia sulcata and the pennate species Fragilariopsis doliolus (Tab. 1). Cyclotella species, dominated here by C. stylorum/litoralis and C. striata occur both in coastal marine and coastal brackish environments (Lange and Syversten, 1989). The record of Cyclotella spp. in core GeoB4905-4 resembles the record of mesotrophe diatoms (Fig. 3), indicating that the two groups may share similar ecological preferences in the study area. Cyclotella spp. were subsequently added into the mesotrophe group (Fig. 4). Eutrophe diatoms are thriving in surface waters with high DSi concentrations and/or high rate of nutrient replenishment to sustain blooming conditions. This group is here dominated by resting spores Chaetoceros Hyalochaete spp. (CRS) and Thalassionema nitzschioides var. nitzschioides with accompanying occurrences of Thalassionema nitzschioides var. claviformis (Tab. 1). Such species are very abundant in upwelling systems, though they can reach high occurrences in any eutrophe environment where DSi and iron concen-

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trations are sufficient (Armand et al., 2008). As modern oceanography argues against upwelling of deep waters in the eastern Gulf of Guinea (Stramma and England, 1999), we here associate these species to eutrophe surface waters whose DSi and iron content depend on the Sanaga River discharge.

3.3.2 Benthic and freshwater diatoms Diatoms of the benthic group are living attached to a substratum (rocks, sand, mudflats, macrophytes, etc...) present in shallow, marine to brackish waters of coastal zones and river mouths. This group is here dominated by pennate diatoms and, more particularly, by marine species of the genus Cocconeis (Tab. 1). This group tracks transport from the coast and/or river mouth to the core site (Pokras, 1991). Freshwater diatoms are living in rivers and lakes beyond the marine influence. Their presence in the marine environments can be due to river discharge and/or wind transport, the importance of each transport agent been variable between regions. This issue had to be assessed before any paleo-interpretation based on the downcore records of freshwater diatom assemblages in core GeoB4905-4. Investigation of sediment traps and surface sediments in the western and eastern Equatorial Atlantic indicated that Aulacoseira granulata and A. islandica (planktonic diatoms) are the most abundant freshwater diatoms transported by winds while small pennate diatoms (benthic diatoms) are only present as trace (Romero et al., 1999). Similarly, investigation of diatom assemblages in a dust collector located at Mbour, Senegal, indicated that A. granulata and Hantzschia amphioxys are the two dominant diatoms in eolian dust coming from central and northern Sahara, respectively (Skonieczny et al., 2011). It is worth noting that H. amphioxys is absent from the diatom assemblages in core GeoB4905-4, which agrees well with an origin from the central Sahara of the eolian dust reaching the eastern Gulf of Guinea (Stuut et al., 2005). On the other hand, high abundances of freshwater diatoms were observed off the mouth of the Congo River (Jansen et al., 1989) due to high occurrence of Aulacoseira spp. (Uliana et al., 2002). In core GeoB4905-4, we observed a strong anti-correlation between Aulacoseira spp. AR and pennate diatom AR (R = 0,77; n = 158), therefore suggesting different transport agents for these two groups. Additionally, Aulacoseira spp. relative abundances are

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much lower than that of pennate diatom (1-2% and 5-7% respectively, except during H1 and the YD when relative abundances were not significant due to very few diatom valves present), which is opposite to findings off the Congo Riven where Aulacoseira spp. is the main freshwater diatom. These results argue against a riverine transport agent for the presence of Aulacoseira in core GeoB4905-4, especially as this genus is highly silicified and should better survive dissolution and mechanical break up during wet transport. Raphid pennate diatoms Fragilaria spp. and Navicula spp., dominate here the benthic community of freshwater diatoms (Tab. 1). It has been proposed that this group generally tracks river input to the marine environment (Gasse et al., 1989; Romero and Hebbeln, 2003). In the present study, it tracks the Sanaga River discharge in the eastern Gulf of Guinea and, ultimately, represents a record of the continental climate. In opposition, Aulacoseira spp., and in lesser occurrence Stephanodiscus spp. (Tab. 1), has been proposed to record wind deflation and transport intensity to the eastern Gulf of Guinea (Romero et al., 1999; Gasse, 2000). It is worth noting that Aulacoseira spp. are extremely abundant in emerged sediments of the dessicated paleolake Tchad (Servant-Vildary, 1982), which is the main source of aeolian dust to the eastern Equatorial Atlantic (Gasse et al., 1989; Stuut et al., 2005). The rather good agreement between Aulacoseira spp. AR and phytoliths AR records (R = 0.33; n = 158), the latter ones been mainly transported in the eastern Equatorial Atlantic by winds (Jansen et al., 1989; Romero et al., 1999; Abrantes et al., 2003; and references therein), further argue for an atmospheric transport agent for Aulacoseira spp.

4. Addition of new data and references Comparison of diatom records from core GeoB4905-4 has been extended to SST data from nearby core MD03-2707 (Weldeab et al., 2007) and precipitation index from core GeoB9508-5, taken off Senegal River (Mulitza et al., 2008). The data have been added to figure 5. Throughout the revised manuscript, comparisons and references to various studies (marine, continental and models) has been added to better interpret our records in term of the spatio-temporal evolution of monsoon precipitation and of the expression of millennial-scale events: Adkins et al., 2006; Alley et al., 2005; Bond et al., 1997; deMenocal et al., 2000; Kim

et al., 2008; Mulitza et al., 2008; Peck et al., 2004; Salzmann et al., 2002; Shanahan et al., 2006; Timm et al., 2010; Weldeab et al., 2011.

5. Over-estimation of precipitation during the LGM This point has been modified to tame the possible over-interpretation of the diatom data. The possibility of a stronger upwelling during the LGM to account for higher DAR and eutrophe diatom relative abundances is now also thoroughly commented. Thorough information confirming rather wet conditions in western equatorial Africa is now included.

5.1 Diatom productivity 5.1.1 The Last Glacial Maximum Diatom productivity was relatively high during the LGM, about half of the maximum siliceous productivity recorded during the AHP (Fig. 3). Diatom preservation was also good during the LGM. Mesotrophe and eutrophe diatoms dominated (Fig. 3C, orange line; Fig. 3D) while freshwater and benthic diatoms were half as abundant as during the AHP (Fig. 3E). Taken together, these results suggest that Sanaga River discharge was greater during the LGM than the rest of the last glacial and the deglaciation. The extra pool of DSi was used by mesotrophe and eutrophe coastal diatoms. The cool SST (Fig. 5B) probably limited the development of oligotrophe subtropical diatoms despite large availability of DSi. The large peak in eutrophe diatoms, CRS and T. nitzschioides var. nitzschioides, generally dominant in coastal upwelling systems (Romero and Armand, 2011), may argue for the resurgence of subsurface waters during the LGM when the ITCZ migrated southwards therefore strengthening trade winds (Gasse et al., 2008). However, other windy but arid periods of the last 40 cal. ka BP, such as H1 and the YD (Multiza et al., 2008), conversely demonstrated lowest DAR in core GeoB4905-4 (Fig. 3). Subsurface waters transported into the eastern Gulf of Guinea are DSi-depleted (World Ocean Atlas, 2001) and resurgence of these waters could not support high diatom productivity during the LGM. This information supports our interpretation of a riverine origin of the DSi along the coast of Guinea and, therefore, of wetter conditions above the Sanaga River drainage area during the LGM.

5.2 Precipitation changes in western equatorial Africa 5.2.1 The Last Glacial Maximum

The LGM is generally understood as a very dry period in western Equatorial Africa due to cold SST and atmospheric temperatures. The diatom records in core GeoB4905-4 however indicated that the LGM was indeed drier than the AHP but wetter than MIS3 and H1 (Fig. 5A). This is reflected in other marine and terrestrial records from the Equatorial band. SST records from GeoB4905-4 core (Weldeab et al., 2007a) and the twin core MD03-2707 (Weldeab et al., 2007c) showed a ~1°C surface water warming during the LGM compared to conditions prevailing just before and after (Fig. 5B). Reconstructed sea-surface salinities in core GeoB4905-4 (Weldeab et al., 2005) were ~2‰ lower during the LGM than during H1. However, reconstructed sea-surface salinities in the twin core (Welddeab et al., 2007c) do not show any significant variations between 40 cal. ka BP and 17 cal. ka BP (Fig. 5C). Record of fluvial delivery in core GeoB6518-1 (Weijers et al., 2009), located at the mouth of the Congo River, showed a small rebound during the LGM (Fig. 5D). Similarly, the Fe/K record in core GeoB9508-5 off Senegal (Mulitza et al., 2008) indicated moderate fluvial delivery during the LGM (Fig. 5F). Conversely, low resolution pollen records from two cores situated at the mouth of the Congo River (Marret et al., 2008) did not evidence any precipitation change during the 30-16 cal. ka BP period (Fig. 5E). Records from Lake Bosumtwi in Ghana evidenced lower dust load and higher organic content during the LGM than during H1 and the YD (Peck et al., 2004) arguing for wetter and less windy conditions during the LGM. Lake Abhé from Ethiopia depicted a drop in lake level during the middle part of the LGM (Gasse et al., 2008; Fig. 5G black line) while Lake Tila from northern Nigeria suggested an increase in lake level at around 17.800 14C years BP, i.e. 20.5 cal. ka BP (Salzmann et al., 2002), though radiocarbon date inversions preclude a precise age assignment. Finally, a high-resolution climate simulation (precipitation minus evaporation) at the LGM compared to the present showed a patch of increased effective moisture above the Sanaga drainage basin (Kim et al., 2008). Overall, our diatom data combined to existing paleo-records from the Equatorial Africa suggest that land precipitations during the LGM were sufficient to promote moderate diatom production in the eastern Gulf of Guinea. Discrepancies between paleo-records from the

southern part of the Gulf of Guinea, tracking precipitation changes in the Congo River drainage basin, and records from the northern part of the Gulf of Guinea and western north Africa, tracing precipitation changes in the Sanaga and Niger drainage basins, suggest different precipitation dynamics over the basins drained by the Congo and the Sanaga during the LGM or different impacts of Sanaga and Congo rivers discharges onto the marine environment. First, the Congo drainage basin is influenced by both the WAM and the East African Monsoon (Gasse, 2000; Tierney et al., 2011) while the Sanaga drainage basin is essentially influenced by the WAM. Second, southeastern trade winds promote a seasonal upwelling off the Congo River (Uliana et al., 2002; Marret et al., 2008) that does not occur in the eastern Gulf of Guinea. Enhanced upwelling during times of stronger trade winds generally intensified marine paleoproductivity in the Congo fan area during cold stages, but strongest river discharges also yield to upwelling of nutrient rich sub-surface waters during warm stages (Kim et al., 2010).

6. Millennial scale events Better consideration is now given to abrupt climate events present during the last glacial and the Holocene both in terms of expression, impact and forcing.

5.1 Diatom productivity 5.1.4 Millennial-scale events Short lived drops in siliceous productivity, superimposed to the long trend, occurred during H1 and the YD, at ~20 cal. ka BP during the LGM, ~10 cal. ka BP, ~8.5 cal. ka BP and ~6 cal. ka BP during the AHP (Fig. 3). These drops probably represented short-term events of reduced DSi availability and, thus, sub-millennial periods of more arid conditions over western Equatorial Africa. Events of reduced diatom productivity were accompanied by large drops in oligotrophe diatoms (Fig. 3B), again indicating that most of the DSi may have been used by marine coastal diatoms. Diatom productivity was lowest during H1 and the YD. Diatom valves were greatly fragmented and dissolved, and diatom counts are not statistically significant. The bad preservation of diatom valves during these two periods further supports very low siliceous productivity during known windy and arid

periods (Mulitza et al., 2008).

5.2 Precipitation changes in western equatorial Africa 5.2.3 Millennial-scale events The diatom records from core GeoB4905-4 and other marine and terrestrial records from the Equatorial band demonstrate that H1 was the driest period in western Africa during the last 40 cal. ka BP (Fig. 5). Increase in AR of windblown diatoms and opal phytoliths between 17 cal. ka BP and 15 ka BP (Fig. 3F) indicated concomitant windy conditions in agreement with the high dust loads recorded in Lake Tila during H2, H1 and the YD (Peck et al., 2004). The YD was the second driest period of the last 40 cal. ka BP (Fig. 5A). Dry conditions and low Sanaga River discharge are also reflected by the 4‰ increase in sea-surface salinity records from cores GeoB4905-4 (Weldeab et al., 2005) and MD03-2707 (Weldeab et al., 2007c) (Fig. 5C) and the decrease in Congo River delivery (Weijers et al., 2009; Fig. 5D). A phase lag of ∼500 years is present between records from core GeoB4905-4 and records from cores located at the mouth of the Congo River. Disregarding dating uncertainties, ∼200 years in each core during the deglaciation, this phase lag may again indicate different precipitation dynamics over the two drainage basins during southward and northward migrations of the WAM and associated rainfall belt (Weldeab et al., 2011). Age model constrains do not allow, however, presenting a more accurate comparison and a further discussion on this issue. The diatom records indicate that the AHP was interrupted by three prominent dessication events centered at ∼10 cal. ka BP, ∼8.5 cal. ka BP and 6.5 cal. ka BP (Fig. 5A). These millennial scale events are not well expressed in the SST and SSS records from the eastern Gulf of Guinea (Fig. 3C and 3D) but are evident in records of African lake levels (Fig. 3G). Low AR of windblown diatoms and phytoliths during these events (fig. 3F) suggest that trade winds intensity did not change congruently. Within dating accuracy, the 8.5 cal. ka BP event evidenced in the diatom records of core Geob4905-4 may represent the well known 8.2 cal. ka BP event recognized worldwide (Alley and Agústsdóttir, 2005).

5.3 Forcing of precipitation changes 5.3.2 Millennial-scale events Millennial-scale

events identified in the diatom records from core GeoB4905-4 and other records from Equatorial Atlantic and Equatorial Africa occurred under different mean climate states but may have rather similar origin. The dry events identified during the LGM, H1 and the YD (Fig. 5A) were concomitant to pronounced sea-surface cooling in the eastern Gulf of Guinea (Fig. 5B; Weldeab et al., 2007a), which ones limited moisture availability to the WAM. High AR of windblown diatoms during these periods argues for more intense atmospheric circulation that could allow for the spreading of the ACT. Climate modeling suggested that such temperature cooling, enhanced atmospheric circulation and precipitation reduction was induced by a southward shift of the ITCZ in conjunction with an intensification and southward expansion of the midtropospheric African Easterly Jet in response to a weakening of the Atlantic Meridional Overturning Circulation (AMOC) (Mulitza et al., 2008). Millennial-scale events of reduced precipitation interrupting the AHP (Fig. 5A) are concomitant to small drops in eastern Equatorial Atlantic SST (Fig. 5B; Weldeab et al., 2005). Low windblown diatom AR (Fig. 3F) indicates no congruent intensification of the atmospheric circulation and therefore no significant extension of the ACT. These millennial-scale events are also synchronous to Bond's event 4, 5 and 7 (Bond et al., 1997), suggesting a possible relationship between Holocene AMOC reduction and dry AHP events through the atmospheric and oceanic teleconnections identified for the last glacial (Mulitza et al., 2008). Millennial-scale events interrupting the Holocene warm mean state appear less intense than the ones scattering the glacial mean state suggesting that both the initial mean state and the amplitude of AMOC reduction are important to dictate precipitation changes in western Equatorial Africa at this time scale.
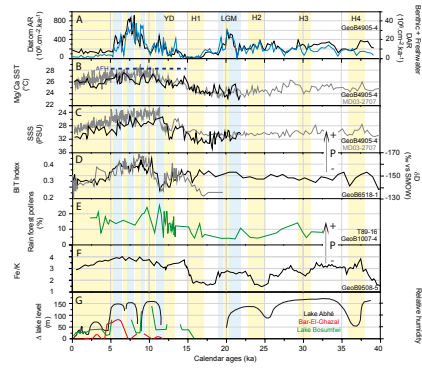

Figure 5. Comparison of diatom and biogenic silica accumulation rates recorded in core GeoB4905-4 with climate proxies from Equatorial Africa. A – Total diatom accumulation rates (black curve) and freshwater+benthic diatom accumulation rates (blue curve), B – eastern Equatorial Atlantic sea-surface temperatures in core GeoB4905-4 (black line, Weldeab et al., 2007a) and in core MD03-2707 (grey line, Weldeab et al., 2007c), C - eastern Gulf of Guinea sea-surface salinities in core GeoB4905-4 (black line, Weldeab et al., 2005) and in core MD03-2707 (grey line, Weldeab et al., 2007c), D – BIT index tracing the input of continental organic carbon to the eastern equatorial Atlantic (black line, Weijers et al., 2009) and relative changes in central African humidity based on δD values of plant wax n-C$_{29}$ alkanes (grey line, Schefuss et al., 2005), , E – proportion of lowland rainforest pollens in cores T89-16 and GeoB1007-4 (Marret et al., 2008), F – elemental Fe/K ratio in core GeoB9508-5 off Senegal River (Mulitza et al., 2008), G – lake level height above present level in Lake Abhé (11°05'N – 41°50'E, black curve) and Bar-El-Ghazal (18°N – 17°E, red curve) (Gasse, 2000) and relative humidity inferred from Lake Bosumtwi (green curve; Peck et al., 2004). Locations of cores are quoted in Figure 1. P: inferred precipitations over western Equatorial Africa.

Fig. 1.

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