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Climate of the Past Discussions

Interactive comment on "Vegetation response to the African Humid Period termination in central Cameroon (7 N) – new pollen insight from Lake Mbalang" *by* A. Vincens et al.

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Comment by Jean MALEY on "Vegetation response to the African Humid Period termination in central Cameroon (7° N) – new pollen insight from Lake Mbalang" by A. Vincens and co-authors. Climate of the Past Discussions, 5, 2577-2606, 2009.

The possible role of stratiform clouds and seasonality.

The paper of Vincens & al. is very welcome providing precise informations on the vegetation and palaeoclimates during middle and late Holocene from the modern belt of Sudanian savannas in Adamaoua. Considered within the context of other notable sites from the region, an approximate meridional transect can be now outlined between the

northern part of the rain forest in south Cameroon, with the sites of Ossa and Barombi-Mbo, and the present day Sudanian belt, with Mbalang and Tilla. In the discussion of the results by the authors Vincens et al., and also by the reviewers Lézine and Dupont, I would like to intervene about the variations of the two main montane taxa, Olea and Podocarpus, and also on the question of climatic seasonality.

The data presented by Vincens & al. indicates a significant development of the montane taxa Olea and Podocarpus between ca. 7000 – 2800 cal. yr BP. Should we interpret these results as indicating the mixing of these two taxa with those of the dense semi-deciduous forest, as suggested by Vincens & al., or rather as being associated with distinct environments near the lake ? For this second possibility, an altitudinal distribution of these taxa needs to be considered through the presence of Mt. Nganha in the vicinity of Mbalang. A similar question was considered to interpret these taxa in the fossil pollen record of Lake Barombi-Mbo, situated in western Cameroon at an altitude of ca. 300 m a.s.l. (Maley and Brenac, 1998; hereafter abbreviated as M-B, 98). Considering the two phases before and after the Last Glacial Maximum (LGM)(calendar chronology in fig. 4, M-B, 98), Olea and Podocarpus expressed opposing behaviours (fig.6 and fig.7 in M-B, 98; see joint Figure extracted from Elenga & al. 2004). Olea is evident at relatively high levels (34 – 28%) before the LGM, but declines to 18 – 6% during the LGM. Then it exists only at low levels during the Holocene (2 – 1%) before disappearing just after ca. 3000 cal. yr BP, similar to the Mbalang record. Podocarpus, on the other hand, appears to exhibit an evolution close to that of Olea at Mbalang, which compares well with the pollen data from Lake Ossa (Reynaud-Farrera & al.,1996) as noted by Lezine in her review. At Barombi-Mbo, however, Podocarpus is only present at very low levels (< 1%) from the base at ca. 32,000 cal. yr BP to the beginning of the Holocene. Then during the early Holocene it increases to ca. 2% and to a maximum of 3.8% between ca. 4000 – 3000 cal. yr BP, before dropping sharply between ca. 3000 and 2500 cal. yr BP, as in Mbalang. It is important to recognise that the marked decrease in these two taxa occurs in a broadly synchronous manner at Mbalang, Barombi-Mbo and Ossa. In a effort to understand the climatic mechanisms responsible for the variations observed at Barombi-Mbo, an examination of the opposing behaviours of these two taxa may be helpful. Considering the elevated percentages of Olea before and during the LGM, M-B, 98 estimated that this taxon could have grown then at short distances from the lake, probably on the nearby hills culminating between 400 and 600 m (similar extension was observed around the Bosumtwi lake in Ghana : Maley & Livingstone, 1983; Maley, 1991). However the very low frequency of Podocarpus during the same period and then the relative increase during early and middle Holocene until a peak between ca. 4000 and 3000 cal. BP, cannot be explained by its growing close to the lake but very probably on distant mountains, the closest being Mount Koupé. And so this large growing intervened in "cloud forests" developped on these mountains with formation of stratiform clouds and fogs – this point is explained in M-B, 98 (p.182-183) and Maley & Elenga (1993). If this explanation is correct, then the very low Podocarpus percentages during and before the LGM would be related to a very low stratiform cloud development – probably because strong increase of dry winds coming from the Sahara and blowing until these low latitudes. Moreover, the fact that at Barombi-Mbo variations in Olea and Podocarpus pollen are very different, particularly before and during the LGM, could be explained by the fact that dry winds from the Sahara only have a significant influence at altitude, inhibiting the development of stratiform clouds, such as near the summit of Mt. Kupé where Podocarpus could have existed. However under these conditions, these clouds would have been able to develop at lower altitude, such as on the hills near Barombi-Mbo, favouring the spread of Olea. The action aloft of the Saharan winds could have thus reduced the thickness of the monsoon that follows the seasonal meridional shifts of the Intertropical Convergence Zone (ITCZ). Considering this, it should also be noted that the very low levels of Podocarpus pollen at Barombi-Mbo during the terminal Pleistocene stand in contrast to the results from many other tropical African sites, in particular those studied by Dupont & al. (2000) from the Gulf of Guinea. This apparent contradiction could be accounted for by the relatively weak Saharan winds, and their limited influence on the source regions for this taxon, probably restricted to regions closer to the equator and

further to the south (Congo, Angola). So it appears that the variable development of stratiform clouds could explain, at least in part, the variations of the montane taxa Olea and Podocarpus during the periods considered. In this context, it is also remarkable that at the Olea and Podocarpus maximum phases, the most abundant forest taxa are Caesalpiniaceae (see Fig. 7 in M-B, 98). This feature could be related to the fact that certain evergreen lowland forests are also favoured by stratiform clouds and mist developments. Indeed today near the climatic boundary of such a formation, certain forests rich in Caesalpiniaceae, with for examples Bikinia (syn. Monopetalanthus) are most likely to be found on hill tops, as instances in south Cameroon (Letouzey, 1985; Achoundong, 1985) or in Congo and Gabon (Maley & al. 1990). These considerations could help to understand the particular ecology that allowed for the persistence of specific forest refugia during arid periods, like the LGM (Elenga & al., 2004).

My second comment concerns the question of seasonality. Indeed a shortening of the yearly rainfall season, possibly without reduction of the total yearly rainfall, can explain properly in the Mbalang area the phases of savanna extension until its full development at ca. 2500 cal. yr BP. However, at Barombi-Mbo such an explanation was presented in 1998 concerning the Younger Dryas and the 2500 BP event, based on the evidence of variations in lake level, using percentages of Cyperaceae as a proxy. Indeed, M-B, 98 (p.182) indicated that "the lacustrine regression at the time of Younger Dryas could be due to an increase of the evaporation but primarily to a reduction in precipitation linked to an increase in seasonality with a particular lenghtening of the annual dry period. Moreover the fact that the frequency of Cyperaceae was less than 1% in the samples situated in the dry period between ca. 2800 and 2000 yr BP indicates that no lacustrine regression was registered. This important point indicates that this period, characterized by a savanna extension in this area presently forested, was a response to a reduction in the lenght of the rainy season, i.e. an increase in the seasonality, rather than a lower total of precipitation." In conclusion it appears that this abrupt seasonality increase, leading to a phase of savanna extension, was linked to the prevalence of cumuliform clouds (cf. Maley, 1982).

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Interactive comment on Clim. Past Discuss., 5, 2577, 2009.

186 ELENGA, MALEY, VINCENS AND FARRERA

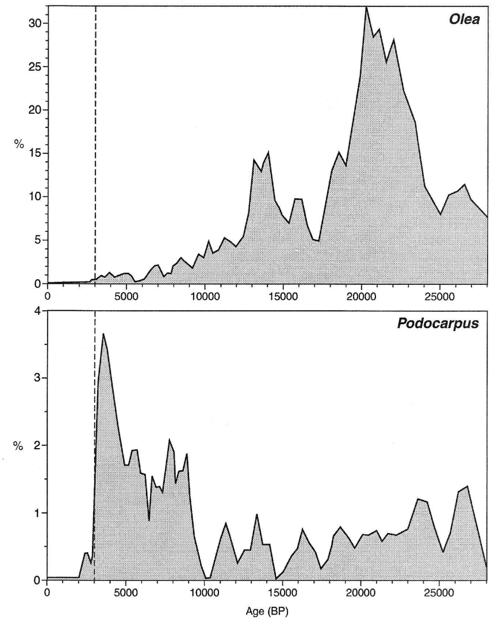

Figure 4. Lake Barombi Mbo, Cameroon (core BM-6): Pollen variations (%) of 2 typical afromontane forest trees, *Podocarpus cf. latifolius* and *Olea capensis* (the pollen sum includes all taxa, excluding spores and damaged grains) (adapted from Maley and Brenac (1998a)).

Fig. 1. Figure -Podocarpus and Olea; Barombi-Mbo