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SHORT PAPER

Absence of Last Glacial Maximum Records in Lowland Tropical Forests

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Environmental conditions of the lowland tropical forests during the last glacial maximum (LGM) between ca 20,000 and 18,000 ^{14}C yr B.P., are reevaluated in terms of dating control and lithology analyzed in seven pollen records from South America. The reevaluation shows that probably in none of the published records are LGM sediments present or abundant. This conclusion is based on the occurrence of abrupt lithologic changes coupled with changes in sedimentation rate interpolated from radiocarbon dates. These findings suggest that the LGM was represented probably by a hiatus of several thousand years, indicative of drier climates than before or after. © 1998 University of Washington.

Key Words: Last Glacial Maximum; tropical forests; lithology; sedimentology; mineralogy; palynology; ^{14}C chronology; South America.

What was the climate in the South American tropical lowlands during the Last Glacial Maximum (LGM), ca. 18,000–20,000 ^{14}C yr B.P.? Some data suggest that conditions were cooler, whereas other data are interpreted to imply drier conditions: tropical sea surface temperatures (SST) decreased during glacial times (Beck *et al.,* 1997) and climate models indicate a 5°C cooling during the LGM in these regions (Webb *et al.,* 1997). As rainfall over tropical South America mainly originates from the Atlantic by convection (Martin *et al.,* 1997), a marked decrease of SST would probably result in a lowering of moisture availability and could initiate a drier climate in tropical South America. Very few records from tropical Andes extend back far enough to include the LGM called the Fuquene Stadial in Colombia (Van der Hammen *et al.,* 1981; Markgraf, 1993). The records that do exist indicate drier climatic conditions interpreted from a lowering of lake level and a lowering of the tree line and dominance of Poaceae and Asteraceae characteristic of the Paramos and Puna. Recently a 6°C cooling during the LGM was proposed for Amazonia (Colinvaux *et al.,* 1996), and other South American tropical lowland pollen studies discuss the LGM in terms of a cool-

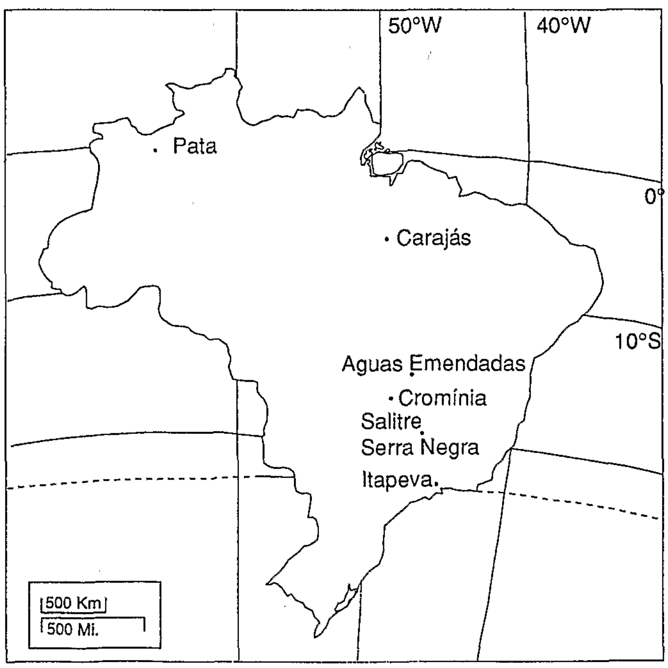

FIG. 1. Map of Brazil showing the location of the sites discussed in the text.

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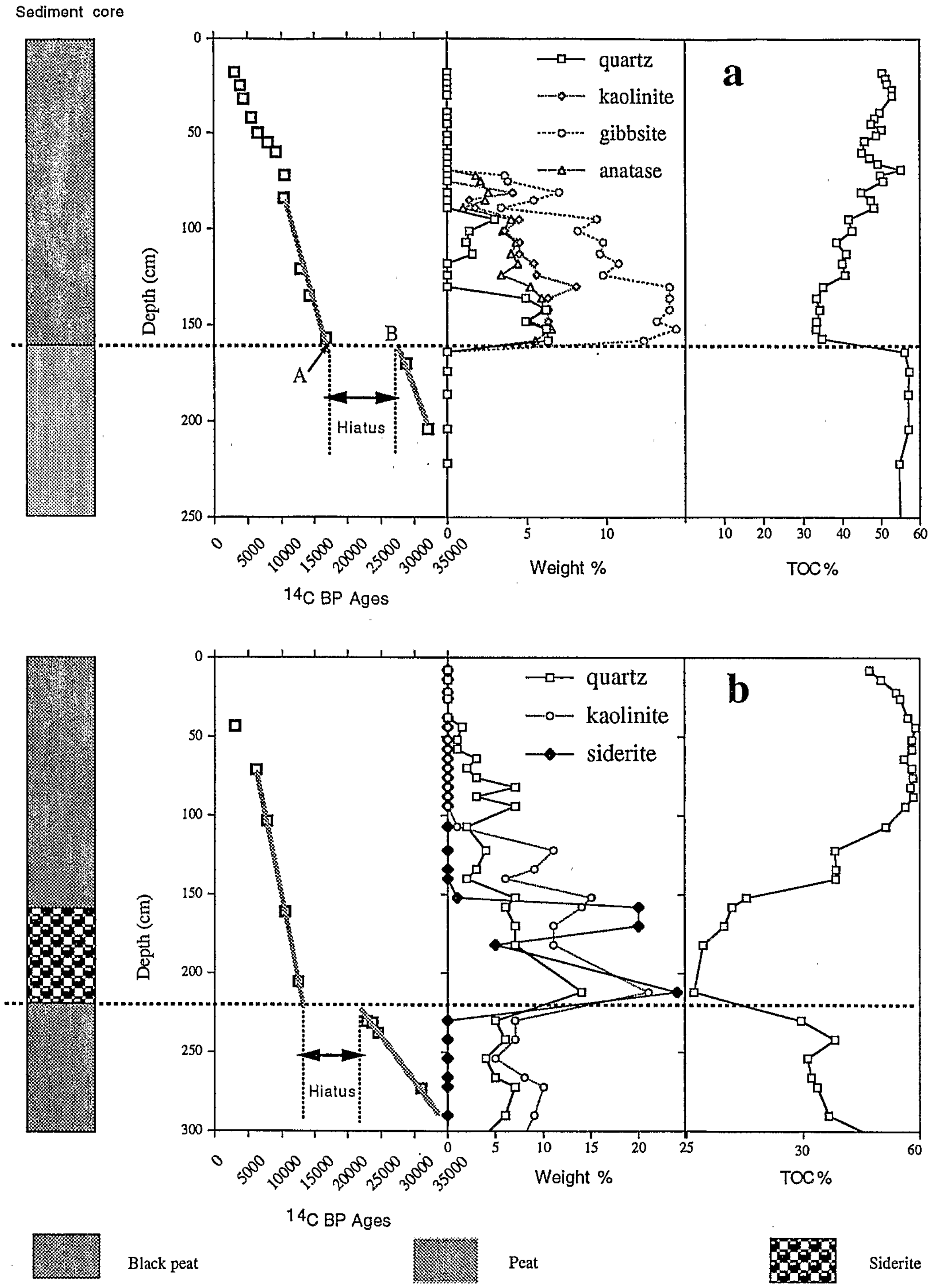

FIG. 2. Chronology, mineralogical and total organic carbon (TOC) evolutions of (a) LC3 core in Salitre (46°46′W, 19°S) and (b) CSS2 core in Carajas (50°W. 6°S).

ing and/or a dry interval. However, doubts remain that the LGM is actually represented in these sections. Most of the interpretations suggesting the presence of LGM are based on linear interpolation between radiocarbon dates, even though sediment composition in most cases changes between these dates. Therefore changes in sedimentation rate or even a hiatus cannot be excluded.

Seven sites cored in lacustrine sediments have been se-

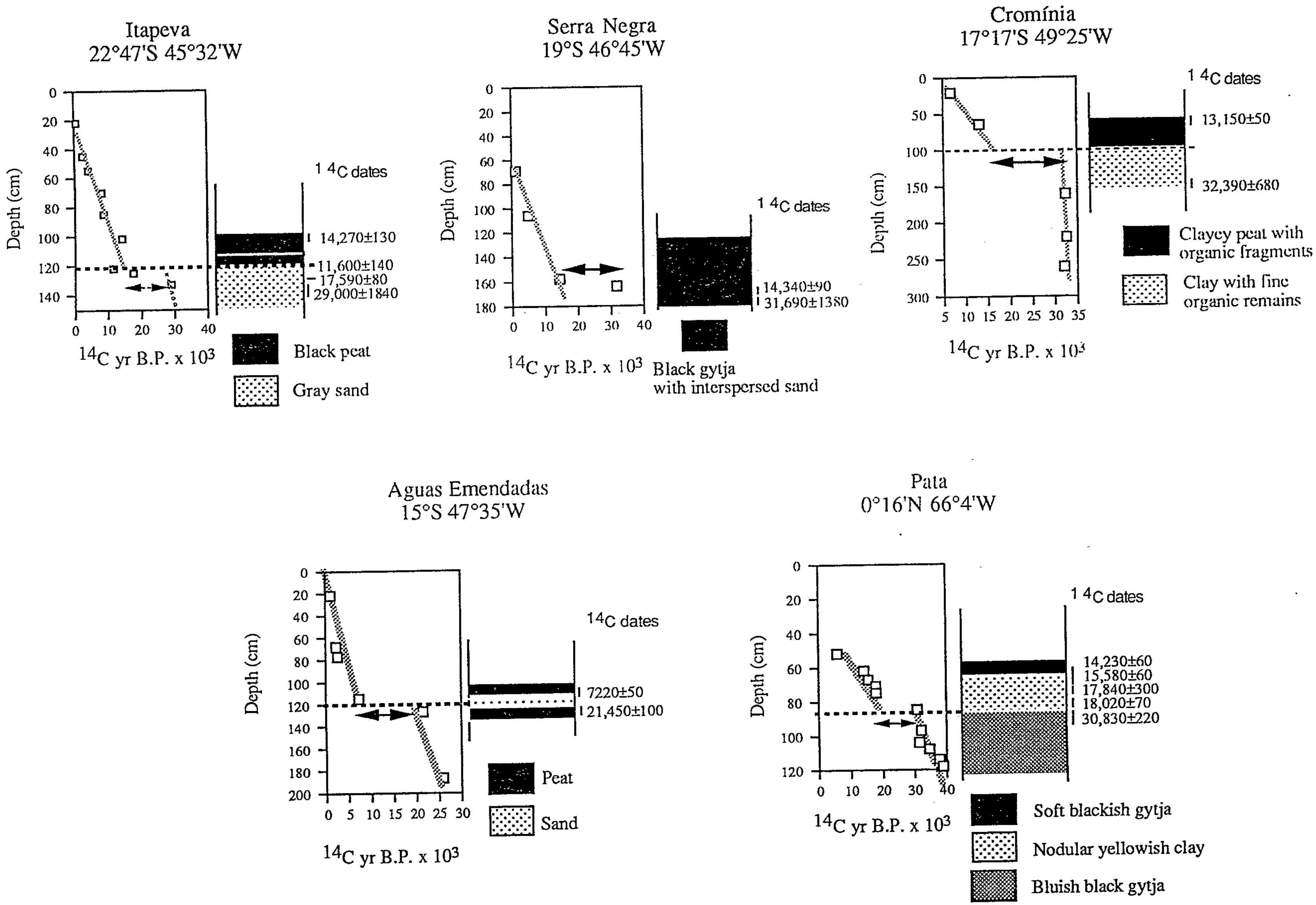

FIG. 3. Sediment descriptions, ^{14}C age control, and depth/age curves for the remaining five sites: (a) Itapeva (after Behling, 1997), (b) Serra Negra (after Oliveira, 1992), (c) Cromínia (after Ferraz-Vicentini and Salgado Labouriau, 1996), (d) Aguas Emendadas (after Barberi, 1994), (e) Pata (after Colinvaux *et al.*, 1996). Uncertainties with the ^{14}C dates are one standard deviation.

lected in South America (Fig. 1) according to their location in a lowland tropical forest (deciduous, semideciduous, *Araucaria*) or in the rain forest, and to their chronological control with ^{14}C dates right before and after the LGM. Among these sites, only in two of them, Salitre LC3 (Ledru, 1993; Bertaux *et al.*, 1996) and Carajás CSS2 (Absy *et al.*, 1991; Sifeddine *et al.*, 1994a,b), the evidence of a gap in sedimentation during the LGM is discussed (Fig. 2). Nevertheless the gap can be recognized in the five other records as well (Fig. 3). In Salitre (Fig. 2a) (Ledru, 1993; Bertaux *et al.*, 1996) an 11,000 ^{14}C yr hiatus was detected between 28,740 and 16,800 ^{14}C yr B.P., based on a change in sediment composition at 164 cm depth. Mineralogical studies supported the evidence for an abrupt change in sediment composition during this interval. Below 164 cm the sediment is purely organic as indicated by the high carbon content; above 164 cm depth detrital minerals originating from surrounding soils abruptly appear (kaolinite, gibbsite, quartz, and anatase). The duration of the hiatus can be determined by extrapolating from the radiocarbon dates above and below the sediment change (Fig. 2a). The hiatus defines an interruption in the observed sediment record which can result from either absence of sedimentation or erosion of previously deposited sediment, or both. In both lacustrine systems, represented by small catchment area with low relief, runoff energy is very low and erosion is unlikely. Because a hiatus is generally the result of drier climates, particularly in the cases where the catchment area is small, the duration of a hiatus presents relevant paleoclimatic information. Locally moist climate was attested by the presence of a Myrtaceae floodplain forest before 28,000 ^{14}C yr B.P.; drier conditions set in after 16,800 ^{14}C yr B.P. with Poaceae–Asteraceae dominance. The hiatus includes the LGM. Also in the Carájas record (Fig. 2b) (Absy *et al.*, 1991; Sifeddine *et al.*, 1994a,b) changes in lithology and vegetation are documented. Before 28,000 ^{14}C yr B.P. the sedimentation is mainly organic and characterizes a moist period with tropical forest. Between 28,000 and 23,000 ^{14}C years B.P. the sedimentation is more minerogenic and vegetation becomes more open, indicating a drying trend. Between 23,000 and 13,000 ^{14}C yr B.P. a hiatus is recorded: at 220 cm depth, a sharp lithologic boundary separates black organic clay from the overlying siderite layer. Radiocarbon dates on both sides of this boundary are 22,870 ^{14}C yr B.P. at 230 cm and 12,520 ^{14}C yr B.P. at 206 cm depth, showing that the hiatus lasted about 9000 ^{14}C yr and included the LGM. In Itapeva (Fig. 3a) (Behling, 1997), a sharp break in lithology from sand to peat and changes in pollen content, with the presence of *Araucaria, Podocarpus,* and *Drimys* suggesting higher moisture conditions, and in sedimentation rate are observed at 121 cm depth. The length of the hiatus, according to ^{14}C dates is 9000 ^{14}C yr, between ca. 26,000 and 17,000 ^{14}C yr B.P. Therefore we suggest that 121 cm represents the transition from a dry to a moist climate and corresponds to the transition from glacial to the Late Glacial. In Serra Negra (Fig. 3b) (Oliveira, 1992) no change has been recorded in either lithology or vegetation, which is described as a cool and moist forest. ^{14}C dates indicate that the 6-cm interval, between 31,690 and 14,340 ^{14}C yr B.P., represents 17,000 ^{14}C yr including the LGM. This reduction in sediment thickness suggests that sedimentation ceased during the LGM. In Cromínia (Fig. 3c) (Ferraz-Vicentini and Salgado-Labouriau *et al.*, 1997) a change in lithology, from clay to peat, occurred at 100 cm depth; Poaceae–Asteraceae are dominant taxa and Cyperaceae increased between 140 and 80 cm. Extrapolating between the sedimentation rates below and above the 100-cm depth suggests that there is a hiatus at that level. Sedimentation restarted after LGM at ca 14,000 ^{14}C yr B.P. with peat deposition. In the Aguas Emendadas record (Fig. 3d) (Barberi, 1994) a lithological change is recorded between 123 and 118 cm depth, as represented by a sand layer intercalated in peat. This sand layer contains no pollen and probably represents dry climatic conditions. ^{14}C dates below and above this 9-cm-thick sand layer provide an age of 21,450 ± 100 ^{14}C yr B.P. at 125 cm and 7220 ± 50 ^{14}C yr B.P. at 116 cm and extrapolation of sedimentation rates show a gap. We interpret all these data to represent a hiatus lasting 14,000 ^{14}C yr, including the LGM. In Pata (Fig. 3e) (Colinvaux *et al.*, 1996) a change in lithology from clay to peat occurred at 83 cm depth but no vegetation change was detected. The climate is described as cool and moist primarily based on the presence of *Podocarpus.* ^{14}C dates of 32,010 ± 630 ^{14}C yr B.P. at 86 cm depth and of 18,020 ± 70 ^{14}C yr B.P. at 75 cm suggest a sudden change in sedimentation rate, resulting in a hiatus of 12,000 ^{14}C yr. That sedimentation restarted at 18,000 ^{14}C yr B.P. is questionable, given that the nodules deposited in the clay layer attest to sediment reworking.

Sediments from seven cores in South America show either detritic material with little or no organic matter right before or after the LGM or a gap in sedimentation corresponding to LGM. Depth/age diagrams (Figs. 2 and 3) show that it is misleading to interpolate between radiocarbon dates when sediment composition changes. Apparently in the South American tropical lowlands, the LGM is not recorded but sediment changes attest to drier climates between ca. 24,000 and 17,000 ^{14}C yr B.P. The present findings support the assumption underlying Webb's model in tropical ocean (Webb *et al.*, 1997).

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