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ABSTRACTS

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COMPARISON OF 20,000 yr B.P. PALAEOCLIMATIC RECORDS FROM AMAZONIAN RAIN FOREST (CARAJAS PLATEAUX, BRAZIL) AND PUNA ENVIRONMENT (LAKE TITICACA, BOLIVIA)

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Comparison of different types of palaeoclimatic records from several types of environments provides a mosaic of local to regional responses to global climatic change. The aim of our presentation is to compare palaeoclimatic proxies from 2 lacustrine deposits, the first in the Carajás plateaux at an elevation around 750 m and rising ca. 100 m above the surrounding Amazonian forest, the second in the Bolivian Altiplano, Lake Titicaca, at an elevation of 3809 m in the puna ("steppe") vegetational belt of the Central Andes.

The Carajás region comprises a prominent series of plateaux, 500 km south-west of Belém exhibiting in the central depressions numerous small lakes. This region, situated in a dry corridor, presents annual precipitation 1500-2000 mm. The data, a 6.5 m core, were obtained from infrared analysis technic and palynology.

Lake Titicaca is the largest water body of Peru and Bolivia. It is located in the semihumid northern part of the Altiplano (800 mm. yr^{-1}). The data presented here (sedimentological, micropalaeontological and palynological) concern a core collected in the center of a depression situated in the southern part of the lake.

Correlations between the two sites show generally a good correspondance. The two environments have evolved through the following pattern:

- the period 20 - ~14/13 kyr B.P. corresponds to a dry climate; presence of a hiatus in Carajás core and low lake-levels and hiatuses in Lake Titicaca;
- the period 13/14-10 kyr B.P. corresponds to a wet climate forest development in Carajás surroundings, high lake-levels (phase Tauca) in the Bolivian Altiplano;
- the period 10-8 kyr B.P. is characterized by the extension of forest cover in the Carajas plateaux region and decreasing Lake Titicaca levels;
- the period 8-0 kyr B.P. corresponds to a highly fluctuating climate in the two tropical environments, consequence of a reinforcement of El-Niño phenomenon.

LATE QUATERNARY PALEOCLIMATES IN BRAZIL

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Several recent studies have considerably enhanced our knowledge of paleoclimate changes in Brazil during the last 60,000 years and allow us to outline a chronology of topical climate evolution. The longest record is from Carajás (Eastern Amazonia). Its base revels the existence of a dry stage prior to 60 ka. This stage seems also to be present at the undated base of the Salitre record (Central Brazil) where it demonstrates characteristics of cold climate.

Following this stage a humid period is registered between 60-55 ka and 31-28 ka in Eastern (Carajás) and Western Amazonia (Rondonia, Acre), in Central Brazil (Salitre, Serra Negra, Crominia) and southeastern Brazil (São Paulo). This period appears to be cool in Serra Negra record where the development of an Araucaria Forest indicates a strong influence of cold frontal systems. In Amazonia at least one dry phase, represented by savanna development, interrupted the rainforest phase between 50 and 40 ka. Fluctuations toward a drier climate are also present in Serra Negra, and colluvium dated around 42 ka in São Paulo and Acre may also relate to this dry interval.

At 31-28 ka the climate became drier again, the forest regressed in Carajás, Crominia and São Paulo, and sedimentation was interrupted by a complete drying of the lakes in Salitre and Serra Negra. The decrease of water discharge provoked the sedimentation of peat deposits in the valley floors of Southeastern and Central Brazil.

The Last Glacial Maximum is associated with an intense generalized dryness which began around 20 ka and is marked in almost all the sites by a sedimentary hiatus. In Crominia and Serra Negra this interval is associated with the development of savannas and a cold climate.

The change toward Holocene conditions occurred progressively from 16 ka in Salitre and 13 ka in Carajás. During this period strong slope erosion occurred which was responsible for numerous landform features observed in Brazil. In Crominia the cold and dry conditions seem to have persisted until 11.3 ka, which is also the date of the last cold event in the Salitre record. The forests reached their full development between 10 and 9 ka in all regions. The presence of an Araucaria forest in Salitre at that time indicates the reinforced influence of cold frontal systems.

Middle Holocene dryness, marked by forest regression and fires, is a typical feature of Brazil, although its timing differs from one region to another. A new episode of slope erosion is well marked in Southeastern Brazil after 9 ka and, depending on the local conditions, may have been active until 4 ka. Between 4 and 1 ka the climate rapidly reached its present-day wet characteristics.

QUATERNARY DRY PERIODS IN AMAZONIA

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The main arguments in favor of the existence of dry periods in Amazonia came from (1) biogeographical observations upon which was based the Refuge Theory, which implies substitution of the forest by savannas during dry Pleistocene climate, and (2) geomorphologic evidence such as erosion features, stone lines and sand dunes under the present-day dense forest. Several arguments against the Refuge Theory have been outlined during the last decade and some geomorphologic data were also be criticized. The refuge locations as well as the time duration of both biological and geomorphologic processes have been questioned. Even the pollen records from Amazonian region do not give incontestable proof of dry climate phases since they may have been a strong influence of atmospheric CO_2 decrease. It therefore seems to us interesting to reviewed the geological data, with a chronological support, pointing toward the existence of dry climate phase in Amazon during the Quaternary. Two time intervals will be under study : the late glacial and the Holocene.

Two kinds of data are available for the late glacial : (1) lake development and (2) slope erosion. The Carajás record in Eastern Amazonia shows three periods of complete dryness of a small lake: before 60ka, between 40 and 50 ka and between 22 and 13ka. These periods correspond to the lowest temperatures and the lowest atmospheric CO_2 concentrations in Vostok ice core record in Antarctic. The last period corresponds to an interruption of several lacustrine deposits due to the dryness. The lakes in Bolivian Altiplano, whose rainfalls provide from Amazon basin, also demonstrate the same behavior.

The Carajas record also indicates that the clastic deposition supplied by slope erosion is greater during transition periods, mainly from dry to humid stages when the lake-level was going up. Colluvial deposition is also observed at 43 ka and after 42 ka in Western Amazonia (States of Acre and Rondonia). Strong alluvial deposition is dated since 13 ka in Peruvian and Columbian rivers.

All these data seem to confirm a marked reduction of the precipitation during some periods of the Pleistocene. However the parameters described are no completely independent from changes in rain-forest because the vegetation is an important factor of slope erosion and because rainfall is partly related to local evapotranspiration.

The middle Holocene is characterized by occurrence of dryness under the form of repeated dry climate events. This dryness is marked by the presence of charcoals in soils and sediments. During the 8000-4000 BP period Carajás lake turned ephemeral and the dryness was also well marked in Titicaca lake (Bolivian Altiplano). The present-day humid conditions were reached after 4000 years BP but sedimentological, paleonthological and anthropological data indicate the occurrence of some dry events similar to the Middle Holocene ones. These events last some decades and are marked in several regions of Tropical South America. Their regional effects were identical to those of present-day El-Niño phenomenon and, for that reason, they were denominated "El Niño-like situations".

MAJOR PROBLEM AREAS WITHIN THE EUROPEAN QUATERNARY SEQUENCE

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Ever since the development of the deep-ocean record of Quaternary oxygen-isotope stages, it has been clear that the continental stratigraphic record must be more complex than previously recognized. Two intervals which have been poorly understood, the early Middle Pleistocene – equivalent to the 'Cromerian Complex' of the Netherlands, and the span of time between the Holsteinian (Hoxnian or Lichvinian) Interglacial Stage and the last (Eemian) Interglacial Stage – what could best for the time being be described as the 'Saalian Complex' perhaps.

Both these intervals have been the subject of discussion and field meetings of the INQUA Subcommission on European Quaternary Stratigraphy (SEQS) in recent years.

It is now evident that during the early Middle Pleistocene there was a complex sequence of temperate and cold climatic fluctuations, but, in fact, recorded early Middle Pleistocene stratigraphy in the two classic and stratotypic areas, East Anglia (eastern England) and the Netherlands, is based on very fragmentary fluvial sequences. Actual stratigraphical relationships between sites in these areas is often obscure, and correlation based on an amalgam of different lines of biostratigraphical evidence, as increasingly detailed palaeontological studies are carried out. In Eastern Europe, where many more sequences of this general age occur, the Don glacial event, initiating the most extensive glaciation of Central Russia, unquestionably falls within the early Middle Pleistocene, as perhaps do smaller glacial events. How can this be reconciled with the Western European sequence? Hitherto reports of early Pleistocene glaciation there have generally been disbelieved or ignored, but reconsideration is necessary.

Recently, fresh attempts to re-evaluate and elaborate the stratigraphy of the 'Saalian Complex', recognizing new interglacial or interstadial events, have raised much discussion and often heated debate, particularly in Germany, in England and in Poland. The implications of these schemes in some cases appear to be contradictory, particularly those based primarily on amino acid racemization studies, rather than on litho- or biostratigraphy. Discussions of this problem have to take into account the continental rather than just a regional scenario.