A contribution of diatom analysis to Lateglacial and Holocene environmental reconstructions of Colombian lowland and montane ecosystems

Velez, M.A.

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Abstract

This thesis presents an environmental and climatic reconstruction for Colombia (South America) since the Holocene, based on the integrated analysis of diatoms, pollen and sediments. We examined five sites in Colombia selected along a longitudinal and altitudinal gradient in order to cover the widest limnological and ecological ranges.

From lowland ecosystems we studied three sites, one located in the humid rain forest of the Pacific Coast (chapter 2) and the other two located in the savannas from the Llanos Orientales of Colombia (chapters 5 and 6). From the Andes two sites were analysed. One located in an internadean valley near the Patía River at 750 m altitude where the the dry forest is abundant (chapter 3) and the second one from the high Andes, at 2580 m altitude where the main vegetation is composed of wet and dry montane forest (chapter 4). In the following paragraphs we present the main results of each chapter.

Site 1 shows a reconstruction of lake El Caimito at 50 m elevation in the Pacific rainforest of Colombia. The regional vegetation seems related to the tectonic activity in this unstable coastal area. The record shows that from 3850-2700 cal BP the site was under the influence of the fluvial system; erosive event(s) removed part of the sediment record and we observed a hiatus representing 700 years. After that, the basin became more isolated from the river drainage system. From 2010-1430 cal BP mainly clay was deposited and repeatedly interrupted by river pulses that left sandy and silty horizons in the record. Benthic and littoral-benthic diatom species indicate a shallow water body and stable water chemistry. Mangrove forest was close to the lake, apparently growing along the close-by inlets. Regionally, the main vegetation elements were palms, and taxa in the families of Moraceae-Urticaceae, Melastomataceae, Leguminosae and from a number of other families and genera, characteristic of tropical lowland rain forest. From 1430-810 cal BP the river impact gradually diminished. Each fluvial event that affected the local forest is shown in the pollen record by an expansion of *Cecropia* dominated pioneer forest. Decreasing intensity of forest disturbance coincides with an increase in the diversity of fossil pollen taxa, possibly
reflecting an increasing plant diversity of the forest. Mangrove pollen declined, indicating that the coastline moved seaward and suggesting tectonic uplift of the coastal area. Between 810 and 580 cal BP mangrove forest was closer to the lake again, reflecting an inland migration of the coastline, suggesting tectonic subsidence. From 580-300 cal BP the last fluvial events was recorded, water chemistry was oligotrophic and acidic. The mangrove belt moved seaward again, suggesting tectonic uplift. Palms and *Cecropia* became more abundant, suggesting increased human impact in the near shore lowland forest. During the last 300 years, stable lacustrine conditions and lowland rain forest with the highest floral diversity is registered.

Site 2 presents a climatic and environmental reconstruction of the dry forest ecosystem in the Patia Valley from cores Patia at 760 m elevation. Five different periods were recognised. From 7830-7670 BP, a small lake was formed following partial isolation from the main river system. The catchment area was covered by herb vegetation, indicating humid climatic conditions. From 7670-6860 BP the small lake was totally isolated from the river, and possibly reached its maximum extension. Dry forest dominated the surroundings, indicating that the climate was more humid than that of the preceeding period. From 6860-3570 BP there was paludification as the small lake turned into a marsh. Though overall moist conditions prevailed, precipitation in this period seems to have been more seasonal than previously. From 3570 to the present day there has been human intervention in the area; this makes inferences concerning climatic conditions unsure, since increases in lake level may reflect a greater flow of runoff water into the lake due to human clearance of the forest, rather than greater humidity.

Site 3 presents the late Pleistocene-Holocene ecological and limnological history of Lake Fuquene, located at 2550 m altitude in the Eastern Cordillera. The record shows that from 19,000-14,200 BP the climate was cold and dry, lake levels were low and the area was surrounded by paramo and subparamo vegetation. From 14,200 to c. 13,500 BP climates turned warm and humid. The El Abra Stadial, a Younger Dryas equivalent, is reflected by a gap in the sedimentary record present between c. 13,500 and 8700 BP, probably a consequence of the cessation of deposition due to a drop in lake level. From 8700-7070 BP,
the lake reached its maximum extension and was surrounded by Andean forest, climates were warm and humid. After 7070 BP, the onset of the drier climates prevailing today took place. Human activity occurred after 1600 BP and caused a reduction of the forest and transformation of the landscape.

Climate patterns from the Late Glacial and throughout the Holocene are similar to other records from Colombia and northern South America (the Caribbean, Venezuela and Panama) and suggest that the changes in lake level were due to precipitation variations driven by latitudinal shifts of the Intertropical Convergence Zone.

Site 4 presents the environmental and climatic reconstruction of lake Las Margaritas at 290 m elevation in the savannas of the Llanos Orientales. Dry conditions, a landscape covered by savanna and an incipient lake still influenced by the river system, characterised the period from 11,150-9100 cal BP. More humid conditions prevailed from 9100-7330 cal BP, during which time the forest advanced over the savanna and a swampy, isolated lake formed. From 7330-1870 cal BP, humid conditions prevailed, except for two dry periods that caused a decrease in lake level; these periods occurred between 5430-5200 cal BP and 2750-2500 cal BP. A period of unstable climatic conditions, i.e. frequent alternations between drier and wetter periods, causing alternation between the savanna and the forest and oscillations of lake level, occurred from 4180-2750 cal BP. During dry conditions the lake level dropped, the water featured richer nutrient contents and higher conductivity, and swamps with Arecaceae were formed. During the humid periods, the lake had high water levels, the water was acidic, poor in nutrients and with low conductivity, swamps with *Mauritia* surrounded the lake. Modern climates and limnological conditions have prevailed since 1870 cal BP. Comparisons with other environmental and climatic reconstructions from the Llanos Orientales and the Colombian Amazon allowed us to conclude that the humidity of this zone is highly dependent on moisture coming from the Amazon region.

Site 5 presents information for the site El Piñal located at 180 m elevation in the savannas of the Llanos Orientales. From 18,290-9020 BP sediment accumulation was intermittent with periods of fluvial sediment accumulation being interrupted by episodes of sediment erosion. The
pollen record shows dry savanna conditions from the LGM and a change towards wetter conditions during the Lateglacial, around 10,690 BP. From 9020 BP onward a diatom record is also available. The period from 9020-c. 1260 BP show aquatic pollen taxa (Cabomba, Eichhornia and Utricularia and a decrease in Isoetes) and planktonic diatoms (Aulacoseira spp.) indicative of open, shallow and acidic waters with low in nutrient concentrations. The coexistence of Aulacoseira and Botryococcus indicate eutrophic to mesotrophic conditions, and probably some degree of mixing, which may be indicative of the temporary influence of the river on the lake. There is a change from a high energy, riverine environment to a quieter and more stable lacustrine sedimentary environment; occasionally the river still had some influence on the lake. From c. 1260 to 1065 BP there was a decrease in Aulacoseira spp. and an increase in ephiphytic and littoral diatoms (Cymbella cesatii, C. aff spicula, Frustulia rhomboides and Eunotia minor). The lake became totally isolated from the river and conditions similar to those of today were reached during this period. Diatom assemblages show an Amazonian affinity.

We observed a good correspondence between pollen and diatom proxies and environmental reconstructions improved on the basis of multi proxy records. Diatoms provide strong evidence in reconstructions of water body and changes in the local basin, but reflect poorly changes occurring beyond the immediate surroundings of the lake. Of the pollen signal only the records of aquatic taxa, algae and other microfossils provide information on changes in the local basin, whereas the majority of the pollen taxa are informative of changes in the regional vegetation.

This study shows that diatom analysis is a powerful tool for climatic and environmental reconstructions. In general terms, pollen and diatoms record synchronously changes in the environment; however, a salient advantage of diatoms as a tool is their sensitivity to water changes, which in turn reflect the evaporation-precipitation balance in a closed lake. This advantage was manifest in two cases: the diatoms reflected the specific nature of temporary changes in water level, while the aquatic plants did so ambiguously.