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An environmental reconstruction of the sediment infill of the Bogotá basin (Colombia) during the last 3 million years from abiotic and biotic proxies

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Abstract

The lacustrine sediments of the intramontane basin of Bogotá (4°N, 2550 m altitude) were collected in a 586-m deep core Funza-2. Absolute datings show sediment infill started c. 3.2 Ma and continued almost without interruptions as a result of the balance between tectonic subsidence and sediment infill. Analysis of downcore changes in lithology, grain size, facies, loss on ignition (LOI), and hydrosere vegetation at 20-cm intervals along the core produced a 2200-sample record of basin dynamics and lake level changes with a temporal resolution from c. 800 years (during the last 1.5 Ma) to c. 2000 years (from 1.5 to 3.2 Ma). We recognized 11 discrete sedimentary facies that reflect 4 different depositional environments. Facies 1 and 2 correspond to lacustrine environment where the LOI is <20%. A swamp environment is reflected by facies 11, where the LOI is >20%. A fluvio-lacustrine environment is represented by the facies 3, 4, 5, 7 and 9. A fluvial environment is reflected by facies 6, 8 and 10.

Basin infill started with accumulation in a fluvio-lacustrine environment between 586 and 530 m below the present-day sediment surface of the basin. In the 530- to 325-m interval (c. 3–1.5 Ma), the basin contained mainly shallow water and swamps, in combination with some fluvial activity. The 325–5-m interval (1.5–0.028 Ma) shows almost uninterrupted lacustrine paleoenvironmental conditions. The uppermost 5 m reflect a fluvial paleoenvironment deposited by the Bogotá River and its tributaries. The downcore changing ratio between shallow water aquatics (*Myriophyllum, Ludwigia*, *Polygonum*, Cyperaceae) and aquatics of deeper water (*Isoëtes*) is indicative of lake level changes. *Isoëtes* as an indicator of high water levels is not consistent with fluvial and fluvio-lacustrine depositional regimes. Several lithological discontinuities, evidenced by the sharp transition from swamp deposits to fluvio-lacustrine and fluvial deposits, are present in the core, in the interval from 530 to 325 m in particular. It is plausible that swamp deposits have been eroded during episodes during which the water table quickly raised or during events of sudden coarse fluvial input into the basin.

Keywords: Bogotá basin; Basin infill; Colombia; Sediment analysis; Pollen analysis; Lacustrine depositional environments

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1. Introduction

The present-day high plain of Bogotá, located at c. 4°N and c. 74°W and 2550 m altitude, represents the floor of an ancient lake. During late Pliocene and Pleistocene time, this basin was covered by a lake. Subsidence of the bottom of the basin and inwash of sediments into this ancient lake that originated from the catchment area of the relatively small Bogotá River, kept balance. This hypothesised equilibrium allowed permanent, relatively shallow lake conditions and gradual accumulation of mainly lacustrine sediments during the last 3 million years (3 Ma) (Hooghiemstra and Sarmiento, 1991).

The mainly lacustrine sediments from the intramontane basin of Bogotá were completely sampled for the reconstruction of environmental changes. We recovered 586 m of sediments and touched the bedrock of sandstone. The basin of Bogotá belongs to the few deep intramontane basins in the world for which abiotic and biotic proxies were studied in detail. In previous drilling efforts, the bedrock of basin of Bogotá was not reached. The Funza-1 core, located at some 1 km distance, reached 357 m depth and drilling was stopped for technical reasons (Hooghiemstra, 1984). Possibly the 195 m deep core CUY reached the bedrock closely but this site is located near the eastern rim of the basin and, as a consequence, shows many gaps in the sediment record leading to frequent hiatuses of unknown length (Van der Hammen, unpublished data).

Most of the previous research on the sediments of deep boreholes in the high plain of Bogotá was focussed on pollen analysis leading to reconstructions of vegetation change, floral evolution and inferred records of climate change (Van der Hammen and González, 1963; Van der Hammen et al., 1973; Hooghiemstra, 1984; Hooghiemstra and Ran, 1994; Hooghiemstra and Cleef, 1995; Mommersteeg, 1998; Van 't Veer and Hooghiemstra, 2000). Despite our good understanding of the dynamics of vegetation and flora during the series of Pleistocene ice ages, and the evolution of high Andean biomes (Marchant et al., 2002), little is known about the geomorphological and sedimentological processes. The geological studies by Van der Hammen et al. (1973) and Helmens (1990) provided the first approach to synthesise the late Neogene history of the area of Bogotá, based on lithological information, pollen analysis, paleosol information and geomorphology.

A good understanding of the sediment record may lead to high-quality curve matching of climate records. In a first effort, Torres (1995) showed a pollen-based stratigraphical correlation of the late Pleistocene lacustrine sediments of core Ingeominas-1 with the sediments of the Funza-2 core. The present study shows for the first time, with high temporal resolution, changes in sediment characteristics along the full 586-m-long core providing a better understanding of local sediment accumulation processes and offering a basis for improved inter-core correlations. Lithological information was based on visual description of the sediments. Downcore analysis of grain size, loss on ignition (LOI) and fossil pollen content were produced at 20-cm intervals; thus, the total records consist of c. 2200 sample points. Absolute chronological control is provided by K/Ar and fission track datings of volcanic ash layers interbedded in the clayey and sandy deposits; data were presented and discussed in Andriessen et al. (1993).

This paper focuses on the downcore changes of the sedimentological characteristics and its interpretation in terms of depositional environments and energy levels. Based on this 2200-sample record that covers the last 3 Ma, we present a reconstruction of the abiotic environment in particular. The reconstruction of vegetation change and inferred climate change, and aspects of the evolution of flora and biomes will be published elsewhere.

2. Geological setting

The high plain of Bogotá (locally called 'Sabana de Bogotá') is located in the Eastern Cordillera of Colombia. It represents a tectonic-sedimentary basin, consolidated after the final upheaval of the Northern Andes, around 5 Ma (Van der Hammen et al., 1973; Wijninga, 1996) (Fig. 1). The basin is mainly formed by sandstones of Cretaceous and Palaeogene age. This sedimentary rock forms surrounding mountains up to 4000 m altitude, thus reaching to some 1500 m above the level of the high plain of Bogotá; only at