The Pliocene-Pleistocene transition and Quaternary ice ages in the tropical Andes: a record of 2100 pollen samples from a lacustrine 586-m core from the Bogotá basin in Colombia

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Introduction
The high plain of Bogotá (4° N; 2550 m a.l.) represents the floor of an ancient lake in the Eastern Cordillera of Colombia. The lake existed since 3.2 million years ago (late Pliocene). Subsidence of the basin floor was in equilibrium with sediment influx.
In 1988 we collected the Funza-2 core. At 586 m depth the core touched the bedrock. Sediments were collected in increments of 150 cm. The diameter of the core was 3 inches (0-369 m), 2 inches (369-512 m), and 1.5 inches (512-586 m).
Samples for pollen analysis were taken at 20 cm distance along the core. Volcanic ash was collected for absolute dating. Pollen analysis took over 10 years. We analysed 2100 samples, making Funza-2 the longest pollen record of the world.

Diagrams
Characteristic taxa of modern zonal vegetation belts:
- Subandean forest (1000-2300 m): Acalypha, Alchornea, Cecropia
- Andean forest (2300-3200 m): Bocconia, Deiphopsis, Dodonaea, Dirinda, Eugenia, Galadendron, Hedyspermum, Jujube, Malvaceae, Micora, Myrica, Myrsine, Myrtaceae, Pilea, Podocarpus, Quercus, Stylitæra, Symphoricarpos, Urticaceae, Vellera, Weinmannia.
- Subparamo (3200-3500 m): Asteraceae, Ericaceae, Hypericum, Polylepis.
- Grassparamo (3500-4200 m): Poaceae
Azonal vegetation: The following taxa reflect a gradient from shallow (shore) conditions to deeper water: Myriophyllum, Ludwigia, Hydrocotyle, Hypericum, and Isoetaceae.

Results
1. Zircon fission-track ages provided time control: ± 0.2 Ma at 67 m, ± 1 Ma at 300 to 320 m, and 2.7 Ma at 506 m.
2. Alnus is the most important tree in the swamp forest around the lake. This northern-hemisphere tree had passed the Panamanian Isthmus and arrived in Colombia around 1 Ma (267 m core depth); an important biogeographic horizon.
3. Oak (Quercus) arrived much later in Colombia: around 450 kyr BP. Oak needed 200 kyr to establish "zonal oak forest".
4. High arboreal percentages during late Pliocene time (566 to 470 m) reflect a high altitude position of the upper forest line (UFL), thus warm climatic conditions. This "proto-Andean" forest floristically differed from the modern forest: Hedyspermum, Podocarpus, Weinmannia, Jujube, Eugenia and Myrsine reached much higher proportions as today.
5. During 3-2.5 Ma (470 to 410 m) glacial intervals became progressively colder and reflect climatic cooling of 5°C across the Pliocene-Pleistocene boundary.
6. At 402 m the first cold episode is registered: possibly Marine Oxygen Stage (MIS) 100.
7. Decreasing marsh and swamp vegetation reflects a consolidation of the basin: more abundant fossilaceae reflects higher water levels.
8. Abundant Borrichia, from savanna origin, suggests presence of dry mountain savannas.
9. At 560 to 480 m Myrica represents mainly azonal swamp vegetation. Around 1 Ma (250 m) the new immigrant Alnus replaced Myrica on wet soils. Since that time Myrica mainly contributed to the zonal forests.
10. In 'early-Andean forest' Weinmannia adapted to higher altitudes and became more abundant. Polylepis became an important tree at the UFL.
11. MIS 11 (the best Holocene equivalent) is recorded from 95 to 90 m.
12. MIS 5 (the 'Eemian' period in Europe) is recorded from 52 to 41 m.

References