Peatlands of the Western Guayana Highlands, Venezuela: Properties and Paleogeographic Significance of Peats

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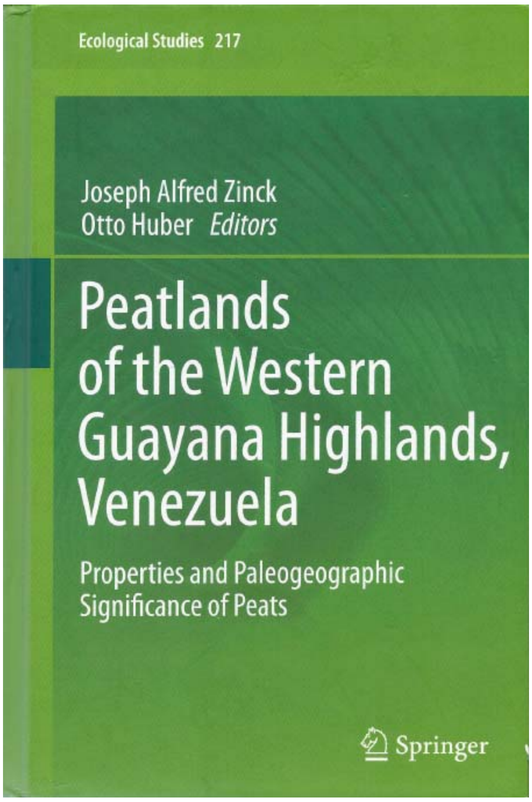

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This book presents the results of fieldwork carried out in the western section of the Guayana Highlands between 1992 and 1996. The peatlands of the tropical highlands and ‘tepuis’ in Venezuela are unique and their morphological, physical and chemical characteristics and their peculiar soils are described in detail, providing insights to an otherwise little known ecosystem.

The book has nine chapters covering geology, geomorphology, vegetation and soils of the tepui summits (table mountains) of the Guayana Highlands of southern Venezuela but with particular focus on the properties, age record and palaeogeographical significance of the peat that has accumulated during the Holocene. These tropical highland peats are much less well known than boreal and temperate peats.

Chapter 1 provides a brief introduction to the Neotropical biogeographical region of Guayana, which covers an area of around 2.5 million km^2 in the north-east of South America. Numerous landscapes are represented from sea level in the Orinoco River delta up to the summits of the Guayana Highlands, the second highest mountain massif in the neotropics after the Andes. More than 50 ‘table mountains’ (flat-top mesetas called tepuis) tower above the forested lowlands and savannah-covered uplands. These are mostly between 2000 and 2500 metres above sea level but the highest, Cerro de la Neblina, is 3014 metres a.s.l. The peatlands are found mainly on the large tepui summits.

Chapter 2 is an overview of tropical and sub-tropical peats, relating these to worldwide peatland extent and distribution. It deals also with factors controlling peat formation and development, peat characteristics and peat classification. None of the information in this chapter is new and has been garnered from a wide range of sources many of which deal with the various topics in greater detail. Whilst this information may be interesting it adds little to the core topic of the book and could have been omitted.

Chapter 3 expands upon the geo-ecological characteristics of the Venezuelan Guayana Region that were mentioned briefly in the introduction. It describes early exploration of the region in colonial British times that yielded the first plant and animal collections from this completely unknown environment. Some of the tepuis in the Venezuelan Amazonas State are part of the “Alto Orinoco-Casiquiare” biosphere reserve while others located in the south-western Bolivar State have been included in the “Canaima” World Heritage Site since 1995. The Guayana Highlands are one of the most interesting biological and geological areas in the neotropics. This chapter provides an overview of the biophysical conditions that create the environmental setting for peat initiation and evolution. There is much interesting detail of the geomorphology, climate and vegetation of the lowlands, uplands and highlands of this region together with information on the three study areas. A list of plant taxa present is provided together with notes on their distribution, habit and habitat.

Chapter 4 focuses on the physical setting of the peat deposits and the nature of the rock substratum and geomorphic landscape that control the spatial distribution, configuration and hydrology of peatland features and determine peat types and patterns. Peatland covers approximately 30 % of the tepui summits, making up about 1500 km^2 of the entire Guayanan Highlands. Owing to landscape variations peat occurs in depressions, on gentle slopes and in small valleys. Maximum peat thickness is two metres. Peat cover on tepui summits exhibits a discontinuous mosaic pattern in discrete landscape units surrounded and fragmented by rock outcrops. Bog and valley peats are elliptical while slope peats are rectangular. The extent of bogs varies from a few square metres to several hectares; average length is 150–300 m and width 50–100 m. Peat thickness varies from a few centimetres to 2 m; microtopography under the peat is very irregular.

Chapter 5 highlights the specific nature of organic soils and the different criteria and methods used to characterise and classify them compared to mineral soils. Field sampling faced several limitations that could affect laboratory analysis. For example, it was difficult to collect undisturbed samples because of high water tables, contamination of deeper layers by material from upper ones and the collapse of sample pit walls.

Chapter 6 presents the morphological, physical and chemical properties of the peat soils in the western Guayanan Highlands and their spatial variations. Taxonomic classification of the soils is presented and issues related to the classification are discussed. The summary conclusions are:

1. Morphological features

a. Peatlands are generally small and thickness usually varies from 40 to 150 cm.
b. There is a thick surface root mat but root content decreases with depth.
c. Peats are soft and unconsolidated deposits that are water-saturated for most of the year.
d. The water table is usually near or above the ground surface owing to high rainfall, low evapotranspiration, low hydraulic conductivity and high water retention.

2. Physical properties

a. Dry matter content increases with depth.
b. Unrubbed and rubbed fibres increase with depth.
c. Mineral content varies considerably from 0–80 %.
d. Wet bulk density has lowest variability ranging from 0.54 to 0.78 Mg m^{-3}. Dry BD varies with depth from 0.11 to 0.16 Mg m^{-3}.

3. Chemical properties

a. Average organic matter content is 74 % and decreases with peat depth.
b. pH varies from ultra-acidic (pH 3.1–3.5) to strongly acidic (pH 5.2–5.3). Acidity decreases with depth.
c. Cation exchange is very variable (20–187 cmol(+) kg^{-1}) both between different peat profiles and the various peat layers.
d. Levels of exchangeable bases are low but highly variable between and within profiles. The relative amounts of exchangeable bases is Ca>Na>K>Mg with average levels of 0.71, 0.52. 0.42 and 0.38 cmol(+) kg^{-1}, respectively.

4. Soil classification

a. Soils were classified according to the US Soil Taxonomy (USST) and the World Reference Base for Soil Resources (WRD).
b. All soil profiles are Histosols of the suborders Saprists (50%), followed by Hemists (25%) and Fibrists (25%).
c. The organomineral soils classify as Endoaquents and Humaquepts according to the USST and as Fluviosols according to the WRB.

Chapter 7 discusses the ^{14}C dating of selected peat layers and interprets the peat age record with respect to peat formation and environmental changes within the Holocene. In summary:

a. Peat formation commenced around 7500 YBP in the Lower Holocene; maximum age found is 8400 calYBP.
b. Peat accumulated during the major part of the Holocene but the rate was not constant.
c. Peat formation started at different times in the various sites depending on local conditions.
d. There are often major time gaps between consecutively dated peat layers, as large as 2000-4000 ^{14}C years.
e. There are no significant differences in peat age and depth between the study areas or individual tepui.
f. Peat depositional rates range from 0.065 mm a^{-1} to 0.333 mm a^{-1} with an overall average of 0.164 mm a^{-1}.

g. It is likely that there were two major periods of peat formation from 7500–5200 YBP and from 3600 YBP to the Present.
h. The period around 4000 YBP seems to be a time threshold in peat formation of broader significance in the regional context as well as in the continental context (South America, Africa and SE Asia).

Chapter 8 evaluates the relationship between peat $\delta^{13}C$ and peat age as estimated by ^{14}C dating in order to relate the variability of $\delta^{13}C$ values to vegetation composition, changes in atmospheric CO_2 concentration and chemical changes occurring during peat ageing. In general, $\delta^{13}C$ decreased with peat age and it is suggested that this is the result of differential decomposition of organic matter constituents (e.g. cellulose, hemicellulose and proteins compared to lignin and waxes).

Chapter 9 presents a synthesis of the major findings of the field and laboratory research based on the conclusions presented at the end of each of the previous chapters. Tepui peatland is a unique ecosystem in which peat has formed from specialised, largely endemic plant communities on (pseudo-)karstic landforms that have developed from non-calcareous rocks in a high-altitude tropical humid environment. The formation of karstic depressions allows water and organic matter to accumulate leading to rock weathering and the formation of depressions. Joints and fractures in rocks, especially in sandstones, favour the export of clastic products and humus to the lowlands. Peat formation was discontinuous in time and space, often suspended for some time and then resuming again, and proceeded at variable decomposition rates. Deconstructing and deciphering the complex palaeogeographical fabric archived in these peats are challenges that need to be addressed as is understanding the formation and functioning of the tepui peatlands, especially in terms of environmental services and vulnerability to climate change and human-induced impacts.

Overall, this book is a fascinating read and is recommended as a major source of information on a little known and hardly understood peatland ecosystem. It will appeal to a broad range of scientists interested in tropical peatlands and peat including quaternarists, soil scientists, and land use planners and others although the price may be a disincentive.

Jack Rieley, November 2012