Geomorphology 206 (2014) 307–317

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

The role of airborne dust in the growth of tree islands in the Okavango Delta, Botswana

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ARTICLE INFO

Article history:
Received 4 June 2013
Received in revised form 12 September 2013
Accepted 16 September 2013
Available online 18 October 2013

Keywords:
Tree islands
Okavango Delta
Dust accumulation
Kalahari
Makgadikgadi pans

ABSTRACT

The Okavango Delta, situated in the Kalahari Desert (Botswana), is host to extensive areas of seasonal swamp that are characterised by the presence of numerous tree-covered islands. Islands have been shown to play an important role in the landscape through the creation of habitat diversity, focusing of nutrients, and sequestration of salts. Islands are thought to grow through the subsurface precipitation of carbonate and silica, although recent work has suggested that other factors may be involved, notably airborne dust accumulation. In this study, we investigate the role of airborne dust in the maintenance and growth of tree islands in the seasonal swamps of the Okavango Delta. Chemical and grain size analyses indicate that whilst the channels and floodplains in the Okavango are dominated by well-sorted Kalahari sand that covers the entire region, material on the surface of islands is distinctly different. Island soils are enriched in Al_2O_3 and are characterised by higher proportions of poorly sorted, fine-grained material that we attribute to the addition of airborne dust. Large quantities of material that circulate in anticyclonic systems over southern Africa represent a potentially significant source of particulate sediment to the Okavango, whilst peat fires and the desiccation of the surrounding floodplains during the dry season are also considered to be important sources of local dust. The data suggest that varying proportions of Kalahari sand, dust, and chemical precipitate give rise to the range of compositions found on and within the islands of the Delta. Dust typically accounts for between 20 and 60% of material found on the surface of islands, whilst dust and chemical precipitate dominate the subsurface material. Islands thus appear to grow through a combination of ongoing surface and subsurface processes that result in considerable heterogeneity in soil composition. In both instances vegetation, especially trees, is the main driving force behind island development, not only causing the subsurface accumulation of $CaCO_3$ and SiO_2 in island soils, but also trapping airborne dust on the surface of islands. Our study suggests that dust fallout is an equally or possibly even more important contributor to the local topographic irregularities and thus habitat diversity in the Okavango Delta. Despite the potential importance of airborne material to the biogeochemistry and development of tree islands in wetland systems, our knowledge regarding these processes remains poor.

1. Introduction

Tree islands form an important component of many wetlands because they increase habitat diversity in the landscape. They have been described from many parts of the world including the Okavango Delta in Botswana (Ellery et al., 1993; Ramberg and Wolski, 2008), the Everglades in Florida (Sklar and Van der Valk, 2002; Wetzel et al., 2011), the Pantanal of South America (Ponce and da Cunha, 1993), and the Nylsvlei wetland of South Africa (Tooth et al., 2002). Islands exhibit unique characteristics that differentiate them from the surrounding landscape and have been recognised as biogeochemical hot spots, serving as important sites for nutrient and chemical accumulation (McCarthy et al., 1993; Ellery et al., 1998; Troxler Gann et al., 2005). Although the mechanisms are still not fully understood, islands are thought to develop autogenously as a result of landscape processes and feedback between hydrological, biological, and climatic factors (Ellery et al., 1993; Sullivan et al., 2010; Wetzel et al., 2011).

The origin of islands on the Okavango alluvial fan (Fig. 1) has been the focus of detailed study for a number of years (McCarthy et al., 1993; McCarthy, 2006; McCarthy et al., 2012). Morphological examination has revealed that some islands originate through fluvial activity on the fan surface and represent scroll bars or abandoned channels. However, the majority of islands appear to be unrelated to fluvial processes. These islands owe their origin to mound-building termite colonies. Once established, such elevated areas can support shrubs and trees, which are unable to survive on the seasonally flooded floodplains. Islands are

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http://dx.doi.org/10.1016/j.geomorph.2013.09.035

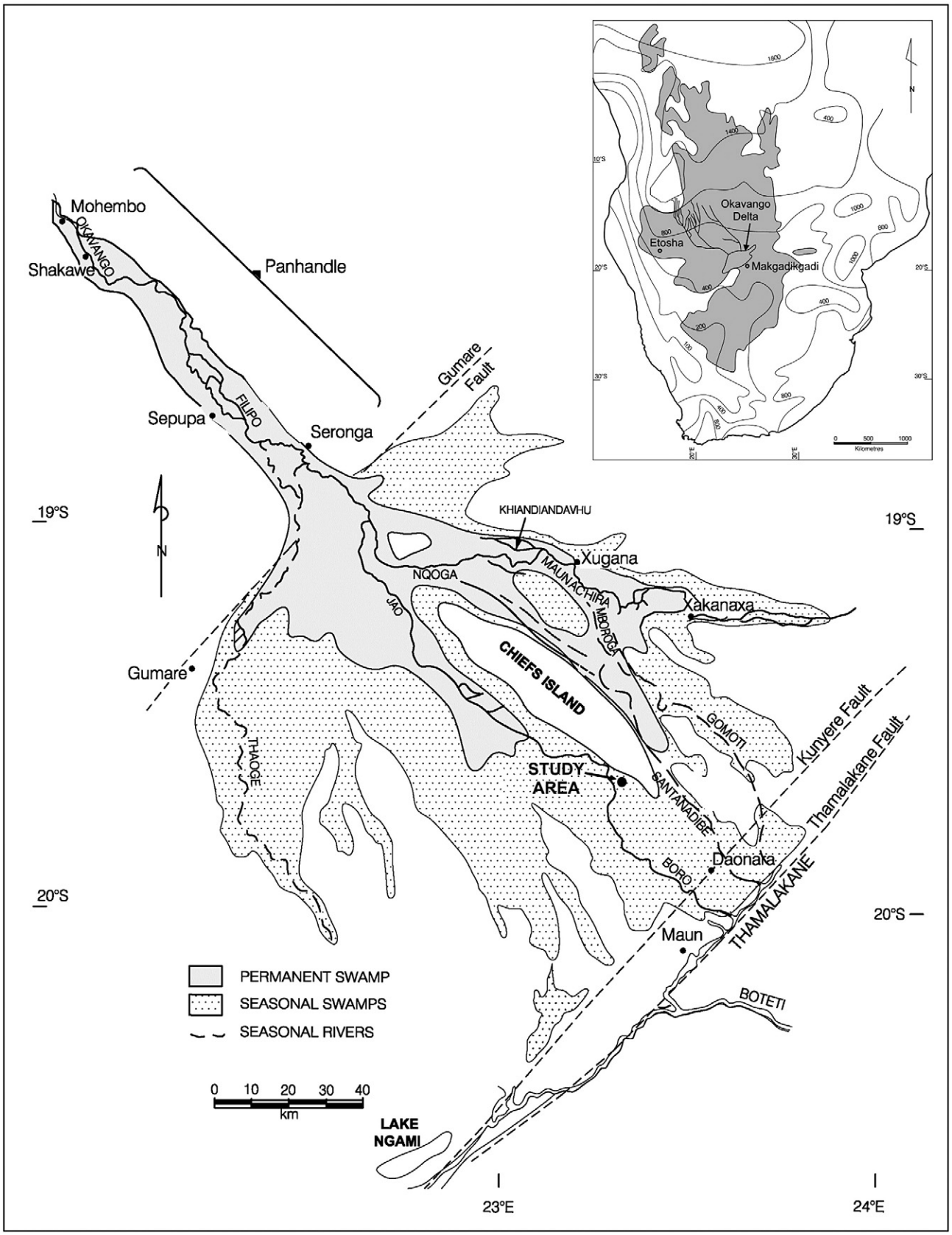

Fig. 1. The Okavango Delta in northern Botswana showing the location of the study area. The inset shows the extent of the Kalahari sands and mean annual rainfall distribution (in mm) over southern Africa.