Quaternary Science Reviews 30 (2011) 3908–3924

Contents lists available at SciVerse ScienceDirect

Quaternary Science Reviews

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

First insights into mid-Holocene environmental change in central Vanuatu inferred from a terrestrial record from Emaotfer Swamp, Efaté Island

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ARTICLE INFO

Article history:
Received 17 February 2011
Received in revised form
30 September 2011
Accepted 5 October 2011
Available online 1 November 2011

Keywords:
Sedimentology
Diatom
Ostracod
Pollen
Volcanic events
Mid-Holocene
ENSO variability
Central Vanuatu

ABSTRACT

Here we present the first terrestrial record of mid-Holocene environmental changes in Vanuatu. This preliminary multi-proxy analysis of core Tfer 06 from Emaotfer Swamp (Efaté Island) indicates changes in environmental conditions are mainly related to variations in climate over the last 6500 cal yr BP. Drier periods are broadly correlated with an increase in sustained El Niño events recorded in the Pacific on a decadal timescale. The earliest change is the disappearance of mangroves adjacent to the site around 3200 cal yr BP, this could well be due to both local tectonic uplift with subsequent hydrostatic adjustment and the onset of a drier period. From c. 3250–2500 cal yr BP the prevailing drier conditions can be linked to more persistent El Niño conditions. Local volcanic events had limited ecological impact on the area. Freshwater diatoms indicate a hydroseral succession, species living on submerged plants being common in muds from c. 3250–1500 cal yr BP, but rare in fibrous peat deposited later. Palaeoecological indicators of human impact have not been identified throughout this work.

1. Introduction

The Archipelago of Vanuatu (Fig. 1) stretches between 166 and 171°E, and from Torres Group in the North (13°S) to Aneityum in the South (20° 30′S). This narrow volcanic island chain, made up of 82 islands and islets, forms an NNW-SSE-oriented area 250 km wide and 900 km long marking the convergence boundary between the Australian and Pacific plates. The convergence rate ranges from 9 to 16 cm/year beneath the west margin of the Vanuatu Arc (Pelletier, 2009). Although the environments of the islands vary with latitude, geology also contributes to their environmental differences (Ash et al., 1978, Fig. 1B).

The climate of the Archipelago, which lies along the southern edge of the West Pacific Warm Pool (WPWP), is mainly controlled by its oceanic context (Sea Surface Temperatures, SSTs) and the linkages with WPMP and atmospheric convection associated with the South Pacific Convergence Zone (SPCZ). The SPCZ (Fig. 1A) is a 200–400 km broad set of convective cloud bands (Vincent, 1994): it the most persistent extension of the Intertropical Convergence Zone (ITCZ), and is most active in austral summer. It extends from the ITCZ near the Solomon Islands to Fiji, Samoa, Tonga, and southeastwards across the tropical and subtropical South Pacific to approximately 30°S at 120°W. Spatial and intensity variabilities of SPCZ and WPWP affect strongly the climate of Vanuatu. The forcing of El Niño-Southern Oscillation (ENSO) primarily dominates the interannual variability on 2–7 years time-scales of rainfall and SSTs within the Indo-Pacific tropical climate system (Horel and Wallace, 1981; Ropelewski and Halpert, 1987). The wind-driven ocean currents redistribute heat within the ocean, during both the warm (El Niño) phase and cool (La Niña) phase in the eastern and central equatorial Pacific. Modern instrumental SSTs record from Vanuatu and the Southern Oscillation Index are positively correlated, ENSO accounting for about 64% of the interannual variance of SSTs (Corrège et al., 2000). The strength of the ocean-atmosphere coupling induces the reinforcement of El Niño-like (La Niña-like) conditions, which in turn controls the northward (southward) shifts of the ITCZ, and also the spreading of the SPCZ. During ENSO

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doi:10.1016/j.quascirev.2011.10.003

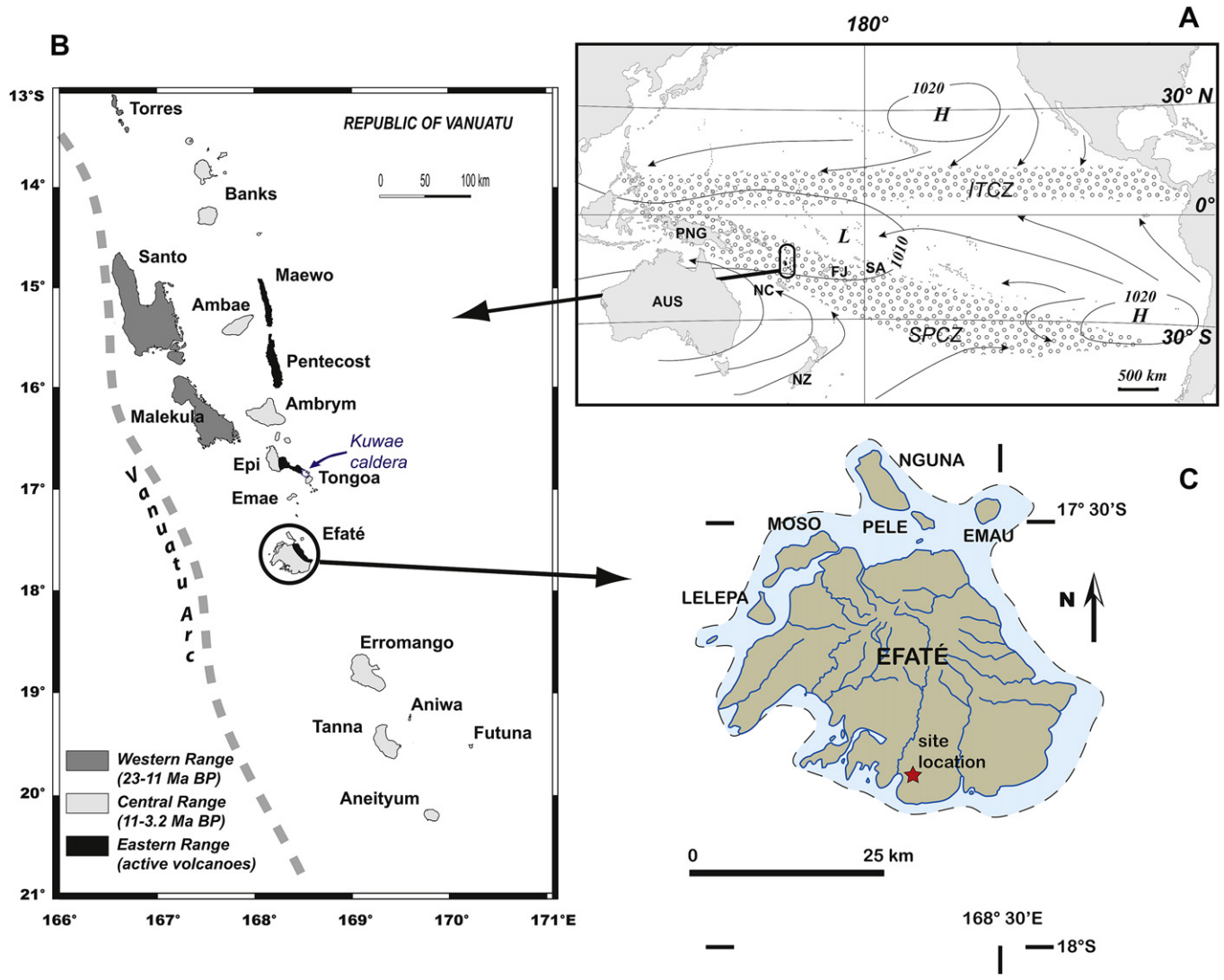

Fig. 1. A) The Archipelago of Vanuatu in the Australasian region [AUS: Australia; PNG: Papua New Guinea; S: NC: New Caledonia; FJ: Fiji; SA: Samoa; NZ: New Zealand] and schematic view of the ITCZ and SPCZ along with the annual mean sea level pressure contours and surface wind streamlines adapted from Trenberth (1991). B) The three geological ridges of the Vanuatu Archipelago, their ages of formation and the location of the Kuwae caldera (adapted from Ash et al., 1978; Witter and Self, 2007). C) Location of Emaotfer Swamp (red star) on the left bank of Teouma River, south coast of Efaté Island. The dashed line on map corresponds to the 100 m isobath.

warm phase (cool phase) years, the SPCZ weakens (strengthens) due to its northeastward migration, and Vanuatu is dry (wet).

An easterly trade wind regime prevails throughout most of the year in southern and central Vanuatu. It promotes the western movement of oceanic water, so the lowest annual oceanic temperatures and highest salinity levels occur in austral winter. During the austral summer the oceanic waters are warm and desalinated because of heavy rainfall linked to the presence of the SPCZ. Thus, northern and central Vanuatu islands are characterized by greater precipitation, higher minimum temperatures, and lower mean variation in daily temperature than are the islands of southern Vanuatu.

Models and paleoclimate data suggest that the tropical Pacific climate system plays a key part in the mechanisms underlying orbital-scale and abrupt climate change (Clement et al., 2001). Few studies have produced paleoenvironmental data from Pacific islands locality, these mostly lack high-resolution data for the Quaternary. Most research in the Vanuatu region has been into submarine geology and paleosea levels (Neef and Veeh, 1977; Lecolle and Bernat, 1985; Taylor et al., 1987; Pineda and Galipaud, 1998; Cabioch and Ayliffe, 2001; Neef et al., 2003) and also volcanology (Ash et al., 1978; Eissen et al., 1991, 1994; Robin et al., 1993; Monzier et al., 1994; Robin et al., 1994). Paleoenvironmental Quaternary studies remain cursory (Warden and Mitchell, 1974; Quantin, 1992; Hope et al., 1999), there are more studies dedicated to archaeology (Garanger, 1972; Galipaud, 1998; 2004; Spriggs, 2003; Valentin et al., 2005; Bedford et al., 2006; Galipaud and Swete Kelly, 2007). This paper presents the first set of data obtained from vibracores retrieved in Emaotfer Swamp (Efaté Island). Our aims were to characterise the environmental variability to understand better the relationship between paleoenvironment changes and climate variability. We also intended to disentangle localized from regional variability. The final and further aim was to provide tighter dates to work out with high-resolution the mechanisms of climate change and the timing of connections between climate and humans.

2. Site settings

The Efaté Island Group is centred at 17°40′S and 168°20′E between the central and eastern ridges of the active Vanuatu Arc (Fig.1). It comprises both subaerial and submarine volcanoes (Ash et al., 1978), some of which are still active. The main island