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Phytolith analysis from the archaeological site of Kota Cina (North Sumatra, Indonesia)

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ABSTRACT

In archaeological sites where plant remains (charcoal, seeds, pollens…) are not preserved, phytoliths constitute a major proxy to provide information about resources and human practices. Because of their siliceous structure, they offer new perspectives to reconstruct environmental changes and human development. This paper presents the first phytolith analysis in Sumatra (western Indonesia) from the historical archaeological site of Kota Cina. This site was an ancient trade harbour of the Strait of Malacca between the XI–XIVth centuries AD. Nowadays, it is located at 7 km from the coast.

This study aims to assess the potential of phytoliths in a coastal tropical wetland. The objectives of this paper are (1) to document the vegetation evolution in a coastal environment changing in Kota Cina during the last 1000 years and (2) the human activities impact (e.g. land clearings, cultivations) on the environment. The phytolith assemblages of seventeen modern soil samples collected in various habitats and twenty-six fossil samples were analysed. The results underline the potential of the phytolith signature and the difficulties of interpretation of the assemblages of certain environments, especially because of a complex taphonomy. However, in combination with geomorphological and archaeological data, the study of phytoliths provides four stages of vegetation changes over the last 1000 years: (1) before the first human settlements, the volcano-sedimentary sequence of the site is devoid of phytoliths; (2) in the XIth century AD, the estuarine environment of Kota Cina is covered with a dense forest to the south and a palm mangrove to the north; (3) between the XIIth and the XIIIth centuries AD, the vegetation changes with the first human settlements and siltation of the estuarine land. Poaceae morphotypes increase and the first cultivated plants are identified as Musaceae. In the north, the vegetation is similar to that of the XIth century AD; (4) After the XIIIth century AD and the abandonment of the site, a widespread opening of the vegetation occurs as attested by the increase of Poaceae GSCP. This is probably the result of the human land clearings due to the development of colonial plantations from the XIXth century onwards in a more terrestrial geomorphological context.

1. Introduction

Phytoliths constitute a major tool to provide information about past vegetation, resources and human practices (Piperno, 1988, 2006; Kealhofer and Piperno, 1998; Pearsall, 2000). Because of their mineral body produced in and among living plant organ cells, phytoliths are well preserved in all sediments unlike other plant remains such as pollen which is mainly restricted to anoxic waterlogged deposits (Piperno, 2006).

In archaeological studies, phytoliths were first used in the early 1970s (Kealhofer and Piperno, 1998). They were widely used for palaeoenvironmental reconstruction and to identify past human activities and their interactions on vegetation (Rosen, 2005). However, in South-East Asia, phytolith analysis in archaeological and historical studies is still relatively limited. More generally, late Pleistocene and Holocene environmental history and human-plant relations are relatively under-documented (White et al., 2004). Two regions, New Guinea and Thailand, were particularly studied and provide data on the human impact on prehistoric landscapes, their land use patterns (e.g. land clearing, rice, banana cultivation) and vegetation changes (Maloney and Rovner, 1990; Kealhofer and Piperno, 1994; Kealhofer, 1996, 2002, 2003; Boyd et al., 1998; Kealhofer and Penny, 1998; Lentfer et al., 2001; Denham et al., 2003; Lentfer, 2003; Lentfer and Green, 2004).

In Sumatra, the phytolith potential has never been tested. Despite

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the wealth of the archaeological sites, this island is still unknown with regard to human settlements, human-plant relations and palaeoenvironmental changes.

Some prehistoric sites were studied in the north and south of Sumatra. Archaeological excavations have revealed that the island was an important migration route between the mainland Asia and the Indonesian islands from the ancient Pleistocene to the Holocene (Forestier, 2005, 2007). Sumatra was occupied to the lower Paleolithic (Pandang Bindu, South Sumatra) (Forestier et al., 2005a; Forestier, 2007); then to the early Holocene on the northeast coast, by hunter-gatherers (Van Heekeren, 1972; Bronson and Asmar, 1975; Glover, 1977, 1979; Bronson and Glover, 1984; Edwards McKinnon, 1991; Forestier et al., 2005b; Bellwood, 2007; Forestier, 2007); and finally during the pre-Neolithic and Neolithic period in the south, probably by hunters (Simanjuntak and Forestier, 2004; Simanjuntak et al., 2005; Forestier et al., 2006). This last period also provides the first significant data on vegetation changes in Sumatra related to human activities. Palaeobotanical studies conducted mainly in the western highlands, with pollen analyses, revealed clearings of 4.5–4 ka BP (Morley, 1980, 1982), becoming major from 1 ka BP (Maloney, 1980; Flenley, 1988; Stuijts, 1993). Evidence of rice cultivation (around 2 ka BP) in the Toba region during the recent Holocene was also recorded (Maloney, 1990).

During the last two millennia, Sumatra was characterised by an Indian, then Chinese influence. The island was a major place of international trade since the beginning of the first millennium AD, because of its natural resources (e.g. camphor, benzoin) (Wolters, 1967). Archaeological excavations of several ancient settlements in northern Sumatra (Kota Cina, Barus and Padang Lawas) and in the south (Palembang area) since the 1970s have highlighted these features and documented the history of the island from the IXth century AD to the XIVth century AD (e.g. Miksic, 1979; Edwards McKinnon, 1984; Guillot et al., 1996; Guillot, 1998, 2003; Perret and Surachman, 2009, 2014; Perret, 2014). As early as the XIXth century AD, the Dutch colonisation of Sumatra led to a new foreign influence and confirmed its commercial function through the development of tobacco, rubber and oil palm plantations, particularly in the north (Perret, 1994). Today, the environmental history of these ancient human settlements and their activities remains unknown due to a lack of studies.

This paper applies the first phytolith analysis from a historical period site in western Indonesia, located in Kota Cina (North Sumatra region). Archaeological excavations at Kota Cina revealed that the site was probably an ancient trading harbour in the Strait of Malacca from the first half of the second millennium AD. The sequence of occupation dates from the end of the XIth century AD until the beginning of the XIVth century AD (Perret et al., 2013, 2016). It records the first human settlements in the XIth century AD in an estuarine swampy area, then the development of the site between the XIIth and XIIIth centuries AD and finally its abandonment at the beginning of the XIVth century AD due to its gradual silting (Chabot et al., 2017).

The aim of this paper is to document (1) the evolution of the vegetation in a coastal environment that changed at Kota Cina during the last 1000 years AD and (2) the influence of human activities (e.g. land clearings, cultivations) on the site environment during its occupation. The study is based on the analysis of seventeen modern samples and twenty-six fossil samples from the Kota Cina site and the Deli catchment. The modern approach makes it possible to appreciate the value of phytoliths for the reconstruction of landscapes in cultivated and uncultivated environments. It is particularly useful for interpreting fossil assemblages of sedimentary records from the Kota Cina site.

1.1. Study context

The present village of Kota Cina is located in the northeast of Sumatra, in a densely populated area of the lower Deli Valley. It is 7 km from the harbour of Belawan, located along the Strait of Malacca, and 20 km from Medan, a city of two million inhabitants (Fig. 1A). Kota Cina lies on the edge of a Holocene deltaic alluvial plain crossed by channels and characterised by swampy lands and islands covered with a mangrove of *Nypa fruticans* and shrimp farming ponds (Fig. 1B). Upstream of this area, back mangrove species (e.g. *Pandanus furcatus*, *Acrostichum aureum*, *Imperata Cylindrica*, *Cyperus* sp., Bambusoideae) grow in the northern part of the site. To the south and east, Kota Cina is surrounded by the suburbs of the city of Medan. On the present site, the development of a suburban environment since the 1970s has led to the disappearance of natural and cultivated vegetation in favour of increasing urbanisation (Perret et al., 2013). Today, some cultivated fields (e.g. rice, cassava, sugar cane, maize) and many palm trees (e.g. coconut, betel nut, oil palm) are still present (Fig. 1B).

The archaeological site of Kota Cina was first mentioned in 1823 by Anderson (1826) and excavated only from the 1970s by Edwards McKinnon (1984). The initial surveys revealed brick structures, stone sculptures (Buddhist and Hindu statues), inscriptions (especially Chinese), remains of wooden posts, Chinese coins, earthenware and ceramic shards, as well as a large amount of organic remains (shell middens and wood fragments) (Edwards McKinnon, 1977, 1984). In the 1980s, remains of shipwrecks, harbour equipment (e.g. part of keels, part of wooden anchor, a paddle) as well as large quantities of Chinese ceramics were discovered. At the same time, a first brief geomorphological study was conducted and revealed that Kota Cina was located in an estuary open on the sea during its occupation (Miksic, 1979).

Based on the dating of the imported ceramics as well as several radiocarbon analyses, the first dating hypothesis suggested an ancient settlement of Kota Cina from the end of the XIth century AD until the beginning of the XIVth century AD (Milner et al., 1978; Miksic, 1979; Manning et al., 1980; Edwards McKinnon, 1977, 1984, 2009). Moreover, the variety and quantity of finds suggest that Kota Cina was an important place for long-distance trade with China or the Indian Ocean (Milner et al., 1978; Miksic, 1979; Manning et al., 1980; Edwards McKinnon, 1984). This is mainly due to its location in the Strait of Malacca (Miksic, 1979) and access to natural resources in the hinterland (Wolters, 1967; Perret, 1994).

After this first period of discovery, Kota Cina was neglected for about thirty years. However, initial knowledge and assumptions about the history of the site in the 1970s prompted archaeologists to conduct new excavations starting in 2011. Since 2013, these excavations have led to the archaeological program: “The ancient settlement site of Kota Cina (North Sumatra, Indonesia)” including for the first time in Sumatra for a historical site, a palaeoenvironmental research based on a multidisciplinary approach (Perret et al., 2013; Chabot et al., 2013).

2. Methods

2.1. Sampling

Modern soil sampling was carried out in the main plant formations typical of the Sumatran phytogeographical context (Van Steenis, 1958; Whitten et al., 1984; Laumonier, 1997). Seventeen surface soil samples were collected from the Deli catchment. Our data are divided into two categories: (1) uncultivated environments and (2) cultivated environments (Table 1).

The first category is composed of two classes. The first class (A) concerns plant formations in lowland swamp areas that include mangrove forest and fresh water swamp formations (Table 1).

The mangroves of Sumatra occupy large areas (about 300,000 to 350,000 ha), especially on the east coast, as in the Medan region (60,000 ha), despite significant anthropogenic pressure (Laumonier, 1997). In this area, the mangrove forest is mainly composed of Arecaceae (*Nypa fruticans*) and back mangrove formations that grow on alluvium deposits and correspond to the upper limit of tidal influence (Wyatt-Smith, 1963). These forest formations announce the end of the mangrove and the beginning of the fresh water swamp forest. The back mangrove forest includes specific species such as (e.g.) *Xylocarpus* sp.