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Sediments or soils? Multi-scale geoarchaeological investigations of stratigraphy and early cultivation practices at Kuk Swamp, highlands of Papua New Guinea

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ABSTRACT

Kuk Swamp is a globally significant archaeological site of early agriculture in the highlands of Papua New Guinea. Mixed-method and multi-scalar investigations of the stratigraphy and selected feature fills at Kuk were instrumental in determining the character of plant exploitation and agricultural practices there during the early and mid Holocene. In this paper, macro-scale (field recording), meso-scale (X-radiography) and micro-scale (thin section micromorphology) analyses are presented in summary form for a stratigraphic column, as well as for a palaeochannel and palaeosurfaces associated with plant exploitation at c.10,000 cal BP and cultivation at 7000–6400 cal BP. Major and minor stratigraphic units have been characterised, primary and secondary formation processes differentiated, and the anthropic associations of specific stratigraphic units determined, especially in regards to cultivation. The Kuk research highlights several methodological problems with the investigation of early cultivation on allophane-rich soils in tropical environments.

1. Introduction

Kuk Swamp in the Upper Wahgi Valley in the highlands of Papua New Guinea is the type-site for the investigation of early agriculture on the island of New Guinea (Golson, 1977, 1991; Golson and Hughes, 1980; Denham et al., 2003, 2004a, 2004b; Denham, 2011; see Golson et al., 2016). Archaeological excavations at Kuk have identified multiple periods of human manipulation of the wetland margin: plant exploitation, potentially including nascent forms of cultivation, from c. 10,000 cal BP (Denham, 2005a); the earliest unequivocal evidence for cultivation using mounds from 7000 to 6400 cal BP (Denham et al., 2003; Denham, 2007); and, successive drainage using ditches from c. 4000 cal BP to the recent past (Denham, 2005b; Bayliss-Smith, 2007). Multi-disciplinary investigations at Kuk have confirmed New Guinea as a place of early agriculture and plant domestication. The global significance of Kuk has been recognised through its inscription on UNESCO's World Heritage List in 2008 (Muke et al., 2007).

A geoarchaeological perspective has been central to the reconstruction of plant exploitation and cultivation practices at Kuk. The seemingly straightforward and relatively shallow (often less than 1.5 m) stratigraphy at Kuk masks extremely complex site formation processes that have occurred over the last 10,000 years. Consequently, multi-scalar investigations were designed to disentangle the complex sedimentary, pedogenic and human contributions to the deceptively simple stratigraphy.

Multi-scale and mixed-method geoarchaeological investigations at Kuk comprise macro-scale (field recording), meso-scale (X-radiography) and micro-scale (thin section micromorphology), among others (Denham, 2003, 2008; Denham et al., 2003, 2009a, 2009b). The analyses were designed to differentiate three stages in the development of each stratigraphic unit and archaeologically significant context (based on Barham, 1995:161):

1. Original deposition represented by inherited stratification;
2. Pedogenic alteration of the sediment and the formation of archaeologically significant palaeosols and cultivation pedofeatures; and,
3. Pedogenic transformations of contexts prior to and after burial.

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Foremost, analyses sought to identify and characterise palaeosols associated with prehistoric agriculture. Most palaeosols include a palimpsest of pedogenic attributes superimposed on relict properties, i.e., those properties acquired under previous sedimentological or pedogenic conditions (Stoops, 1989:98). Feature fills are often the best-preserved, as they have been partially removed from the zone of most intensive pedogenesis. These contexts contain crucial archaeobotanical and palaeoecological evidence, as well as evidence for artificial admixture and plot preparation.

Here, the multi-scalar results are presented in summary form for a stratigraphic column, as well as for palaeochannel and palaeosurfaces associated with plant exploitation at c.10,000 cal BP and with cultivation at 6400–6000 cal BP. The multi-scale analyses have enabled the characterisation of major and minor stratigraphic units, the differentiation of primary and secondary formation processes, and the determination of anthropic associations for specific stratigraphic units, principally in regards to cultivation. They have also enabled assessments of the taphonomic integrity (and hence reliability) of different stratigraphic units for radiocarbon dating and microfossil (diatoms, microcharcoal, pollen and phytolith) analyses (Denham et al., 2009a; Haberle et al., 2012).

1.1. KUK within the upper WAHGI landscape

Kuk Swamp (5° 47′ S, 144° 20′ E) is located at c.1560 m altitude on the floor of the Upper Wahgi Valley (Fig. 1), one of the largest inter-montane valleys along the highland spine of New Guinea. The Upper Wahgi Valley has a lower montane humid climate, an average annual temperature of 19 °C, and annual rainfall of c. 2700 mm (Hughes et al., 1991). The climate is moderately aseasonal and dominated by local orographic effects (Powell et al., 1975). Seasonal variations in mean monthly rainfall, temperature and humidity are moderate, slight and slight, respectively, with very low variability in annual rainfall (McAlpine et al., 1983). A slight dry season occurs between May and June, although soil water content does not usually limit plant growth (McAlpine et al., 1983).

The stratigraphy in the Kuk wetland reflects the deposition of late Pleistocene and early Holocene, largely allogenic or detrital, inorganic sediments over Pleistocene, largely autogenic, organic sediments. Pleistocene peats infill an incised basin cut into underlying tephra and debris-avalanche deposits (Blong, 1986). Some of these tephra-mantled lahar deposits form low rises at Kuk and neighbouring wetlands.

The stratigraphy in the southeast corner of the station, where archaeological investigations have focussed, is situated in a catena extending down to the swamp edge from low hills to the south. Different denudational, weathering and pedogenic processes characterise different locations along this catena. The upper-catena soils in the southern catchment formed on tephra-mantled, debris-avalanche (lahar) deposits (Hughes et al. 1991, in press). The mantle of Tomba Tephra is several metres thick, at least 50,000 years old and forms heavily weathered, oxic soil profiles in the southern catchment (Pain and Blong, 1976; Pain et al., 1987). The periodic deposition of air-fall tephras derived from eruptions on the north coast of New Guinea and possibly elsewhere have potentially rejuvenated these soils and prolonged fertility (after Blong, 1982, 2016; Blong et al. 2016; Chartres and Pain, 1984:135; Pain, 1982; Pain and Blong, 1976; Wood, 1987).

Upper catenary profiles away from the wetland are of little use for the investigation of early agriculture. Any traces of cultivation have been destroyed by deep weathering profiles, erosion and soil formation, as well as by subsequent cultivation over millennia. Erosion in the catchment has contributed detrital sediments to the wetland margin. An increasing mineral component in soils on the wetland margin reflects increased erosion following forest clearance from the beginning of the Holocene (Golson and Hughes, 1980; Haberle et al., 2012). Predominantly alluvial sediments form a low-gradient, terminal fan with radiating drainage networks where the valley mouth discharges onto the wetland edge (Fig. 1). This fan tapers towards the middle of the wetland.

Holocene soils on the wetland margin at Kuk are polygenetic both in terms of parent material and soil formation processes (Fig. 2). They comprise detrital alluvium washed in from the southern catchment (Hughes et al., 1991), distal tephras from episodic volcanic eruptions off the north coast (Blong, 1982; Coulter et al., 2009), and the autogenic, *in situ* accumulation of peat. During periods of lower water table – whether the result of drier climates or artificial drainage for cultivation – these sediments have been subject to episodic soil formation of varying duration and intensity.

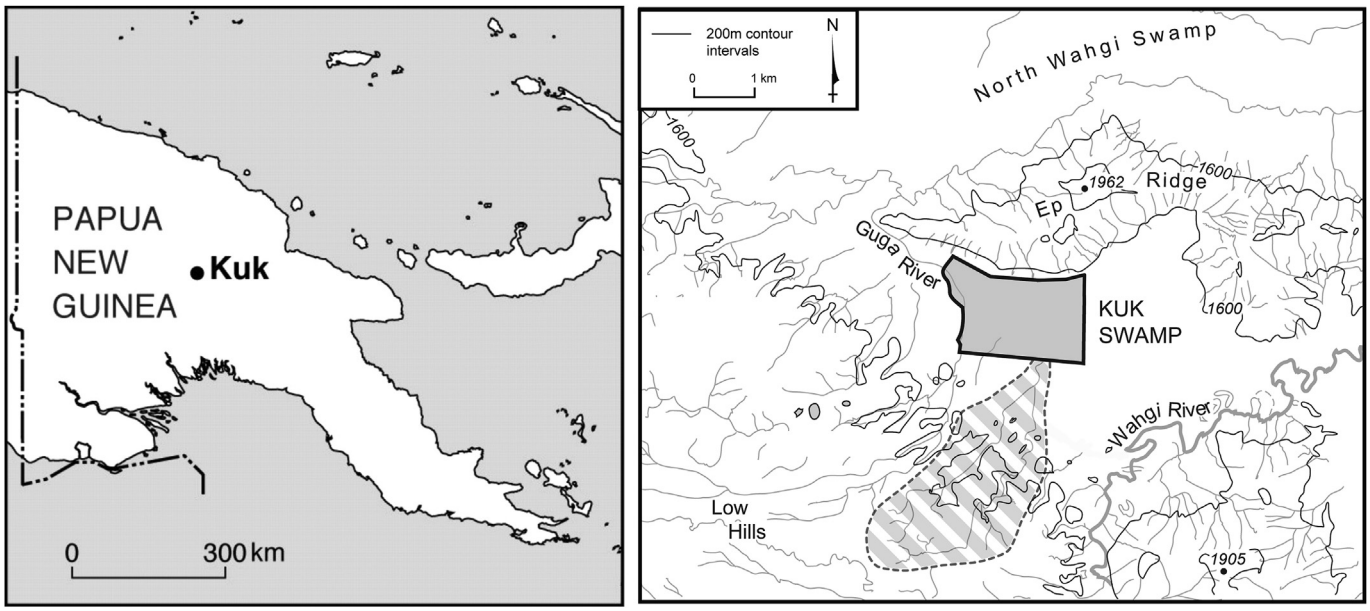

Fig. 1. Site location map of Kuk in Papua New Guinea (left image) and with respect to the southern catchment (hatched area in right image; Hughes et al., 2016: Fig. 2).

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