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# The geoarchaeology of hominin dispersals to and from tropical Southeast Asia: A review and prognosis

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ABSTRACT

Tropical Southeast Asia is a critically important region for addressing the major questions and grand challenges that concern us today regarding Late Pleistocene hominin dispersals across the Old World. Geoarchaeological science is widely employed in many regions of the world to contextualise archaeological material and provide an environmental backdrop against which to explore archaeological narratives. However, in Southeast Asia there is an apparent lag in the routine use of this Earth-Science approach despite the abundance of archaeological sites important in explicating past hominin dispersals to and from the region. In this review of the state-of-the-art of geoarchaeological research in Southeast Asia, I examine the role of the discipline in addressing the important issues in archaeology today. I identify where geoarchaeology is being used and to what effect, highlighting gaps in the geoarchaeological dataset. From a methodological point of view it is imperative that archaeologists and geoarchaeologists working in Southeast Asia (and other humid tropical regions of the world) fully appreciate how to interpret the geoarchaeological signatures associated with this climate regime so that methods and practice can be refined. A series of steps that will serve to drive forward geoarchaeological research in the region are also proposed.



## 1. Using geoarchaeology to interpret Southeast Asian records of Late Pleistocene modern human colonisation

The dispersal of *Homo sapiens* out of Africa, across Asia and into Australia during the Late Pleistocene (Marine Isotope Stage [MIS] 5–2; ~125–14 ka) is a topic currently experiencing a surge of research interest (Dennell, 2008, 2015; Dennell and Petraglia, 2012; Boivin et al., 2013; Dennell and Porr, 2014; Groucutt et al., 2015; Hiscock, 2015; O'Connor, 2015). The small number of dated Late Pleistocene *H. sapiens* sites outside Africa is gradually increasing, and in Southeast Asia this has been particularly apparent in recent years. With considerable advances in scientific techniques such as palaeogenetics (e.g. Pääbo, 2014), and a growing awareness that hominin demographics during this period of time were likely inordinately complex, Southeast Asia is currently a hotspot of human evolutionary research. It is likely that we will witness in the next decade an unprecedented explosion in archaeological research in the region, as the timing, mechanisms and routes of these dispersal events are further constrained.

Geoarchaeology is a syncretic discipline that borrows concepts and techniques from a broad range of Earth Sciences, including geology, geomorphology and sedimentology, and brings this combined knowledge to bear on archaeological questions (Woodward and Goldberg, 2001; Goldberg and Macphail, 2008). For the purpose of this review I summarise geoarchaeology as having three main aims: i) to understand the processes of archaeological site formation, preservation and destruction; ii) to assess the integrity of archaeological stratigraphy and reconstruct the depositional and post-depositional histories that have formed these sediments; iii) to situate humans (and other hominins) within the dynamics of the Quaternary landscape, to elucidate the nature, degree and directionality of human-environment interactions.

Despite the wealth of Late Pleistocene archaeology in Southeast Asia (e.g. Anderson, 1997; Barker, 2013, 2016; Aubert et al., 2014; Bellwood, 2014; Higham, 2014; Sutikna et al., 2016; van den Bergh et al., 2016), geoarchaeology has to date played a disappointingly minor role (but see Anderson, 1997; Lewis, 2003, 2007; Stephens et al., 2005; Mijares and Lewis, 2009; Westaway et al., 2009). This is in contrast to its regular application across many

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non-tropical regions, including Europe, Southern Africa, North America and Southwest Asia (e.g. Goldberg and Arpin, 1999; Shahack Gross et al., 2004; Karkanas, 2006; Mallol, 2006; Macphail and McAvoy, 2008; Goldberg et al., 2009; Aldeias et al., 2012; Berna et al., 2012), although some key geoarchaeological techniques are still regarded by some as under-employed (Goldberg and Aldeias, in press). The reasons for this are undoubtedly complex and multifarious, most likely reflecting the history of archaeological research in a particular country (often a function of its colonial past), the economic and geopolitical context, ease of fieldwork and accessibility of sites, and a lack of local specialists (and training programmes) and laboratory facilities. This dearth of geoarchaeological data precludes a thorough understanding of exactly how tropical geomorphological processes form, modify and preserve archaeological sites and sediments deposited in these environments. The tropics can be challenging environments in which to conduct archaeological research, not least because baseline environmental conditions are not conducive to the preservation of archaeological material (e.g. Barker et al., 2005; Kourampas et al., 2009; Mijares and Lewis, 2009). This is especially pertinent for organic elements such as bone, wood, ancient DNA (aDNA) and other biomarkers, as well as mobile minerals such as calcium carbonate (Weiner, 2010). This has the potential to bias the preservation of taxonomically-specific hominin fossils, which are particularly susceptible to chemical and physical degradation.

Notwithstanding that archaeologists often have an excellent appreciation of archaeological sediments and stratigraphy, geoarchaeologists have the expertise to model sediment delivery to a site, and determine to what extent—if any—post depositional processes have modified or destroyed them. I will argue here that regular dialogue must take place between practitioners of both archaeology and geoarchaeology throughout all stages of the archaeological process. This is especially important as uncertainties clouding the provenance of important archaeological material can rarely be addressed as an afterthought. We are currently in a period of human evolutionary research where to find a single tooth, wrist bone or partial mandible holds the potential to re-write (and reroute) the history of our own species. Bearing this in mind, archaeologists must be absolutely certain of the stratigraphic context of a recovered skeletal element (Goldberg and Berna, 2010) by reconstructing the sedimentary environment in which it was deposited, and synergistic geoarchaeological research can greatly assist in this endeavour.

Modelling modern human dispersals into and across Southeast Asia during the Late Pleistocene is both challenging and stimulating for two key reasons that are apposite here. First, the physical geography of the region is such that any archaeological narrative has to be set against (and to some greater or lesser extent, dictated by) the rise and fall of Quaternary sea levels. This process has repeatedly inundated and exposed the large tracts of continental shelf of Sunda and Sahul, between which the permanent islands of Wallacea are located, separated by deep, fast-moving currents (Allen and O'Connell, 2008; O'Connell et al., 2010; Dennell et al., 2014; O'Connor, 2015). Second, palaeoanthropological and palaeogenetic data show that this region (extending north into Southern China) has a complex demographic history involving a number of archaic and modern human "meta-populations" (Pääbo, 2014, 2015).

With this review it is my intention to explore the ways in which geoarchaeology can elucidate how, when, why and where humans first dispersed into and out of Southeast Asia. I will evaluate the geoarchaeological work that has already been undertaken in the region, highlighting the gaps in our knowledge and areas in which geoarchaeology could usefully be employed. This will be followed by the presentation of a practical framework with which geoarchaeological knowledge might be corralled and utilised more effectively in the future, intended to provide a platform for discussion and collaboration between scientists working in the region.

## 2. A very short introduction to the dispersal of *Homo sapiens* out of Africa and into Southeast Asia

On the evidence currently available, *Homo sapiens* evolved in East Africa ~200–150 ka (e.g. White et al., 2003; McDougall et al., 2005), eventually expanding out of the continent during the Late Pleistocene. The exact timing, mechanism and environmental context of these dispersal events remain poorly constrained due to the sparse and discontinuous datasets (both geographic and temporal) available outside Africa (Dennell and Porr, 2014). The consensus view for some time now has been that following an initial unsuccessful foray into Southwest Asia (The Levant), modern humans moved out of Africa in a single 'late' wave of dispersal, exploiting a riparian coastal route ~60–50 ka (e.g. Mellars, 2006; Mellars et al., 2013). Recently, this view has been called into question, and there is now a groundswell of support for models favouring an earlier exit (or exits) from Africa during MIS 5 (~125–70 ka) or earlier (e.g. Dennell and Petraglia, 2012; Boivin et al., 2013, Dennell and Porr, 2014; Groucutt et al., 2015; Reyes-Centeno et al., 2015; Hiscock, 2015). Given that the ~100 ka modern human fossils from Skhul and Qafzeh in the Levant (e.g. Stringer, 1989) have long been the proverbial elephant in the room during these debates, regarded perhaps too easily as evidence for a failed colonisation event, a new earlier dispersal event may breathe new life into these fossils.

Despite growing acceptance of an earlier exit, this paradigm shift has been based until recently on tantalising hints rather than concrete evidence, often relying on interpretations of the stone tool record without demonstrable associations with modern human fossils (e.g. Armitage et al., 2011; Rose et al., 2011), or fossils from Southeast Asia and southern China that were either taxonomically ambiguous or beset with stratigraphic uncertainties (see Curnoe et al., 2012 and references therein). Recent research, however, appears to vindicate proponents of an early exit model. At Fuyan Cave, Southern China, a concentration of 'unequivocally' modern human teeth from a secure context (see discussion below) has been recovered, dated to ~120–80 ka (Liu et al., 2015). The longevity of the Fuyan teeth raises the possibility that the Zhirendong fossils from southern China, dated to ~>100 ka (Liu et al., 2010), also belong to *H. sapiens* (but see Table 1 for discussion on flowstone correlation). There has been speculation as to whether these fossils belonged to either an archaic modern human or late *Homo erectus* (e.g. Dennell, 2010; Kaifu and Fujita, 2012), but with an absence of evidence for the latter in East Asia, an archaic modern human origin may now seem more credible. Furthermore, a recent palaeogenetic study has revealed gene-flow from early modern humans into Neanderthal populations, and an 'African' haplotype ~100 ka years in age implies inter-breeding around this time between the two populations (Kuhlwilm et al., 2016). Put together, the evidence for an early exit model is stacking up.

The past decade or so has been an exciting period in the study of the early evolution of our species, as a number of previously unknown hominin populations have been recognised, either through the discovery of new fossils (e.g. *Homo floresiensis*; Morwood et al., 2004, 2005), or inferred from the analysis of aDNA (e.g. the Denisovans and at least one other unnamed population; see Pääbo, 2015). Furthermore, Late Pleistocene hominins with primitive morphologies from Southern China (e.g. Curnoe et al., 2012, 2015), and the metatarsal from Callao Cave, dated to 67 ka, that bears affinities with both modern humans and *H. floresiensis* (Mijares et al., 2010), underscores the importance of the region as a