Reconstructing the Quaternary landscape evolution and climate history of western Flores: an environmental and chronological context for an archaeological site

Kira E. Westaway
University of Wollongong
Chapter One:  

Introduction

1.1 The origin and dispersal of the genus Homo

Since Africa was designated as the evolutionary centre for the genus Homo (Lahr and Foley, 1998; Klein, 1999; Stringer, 2002), an important strand of palaeoanthropological and archaeological research has concentrated on determining how Homo dispersed across the globe into Asia and towards Australasia. Understanding these migrations requires a thorough knowledge of the influences that forced expansions, contractions and extinctions (Finlayson, 2005), such as landscape, climate and environmental change. Much is known about climate and environment affecting Homo evolution and expansion in Africa. For example, key events in human development, such as the origin of Homo and the evolution of Homo erectus can be correlated with substantial global climate transitions and humid periods (Dowsett, 1994; deMenocal, 2004; Trauth et al., 2005). But much less is known about the fate of the genus Homo in Asia. The recent discoveries of an early type of Homo erectus (classified as ergaster and georgicus) from Dmanisi, Georgia (Gabunia et al., 2000; Lordkipanidze et al., 2005) and the late-surviving human species, Homo floresiensis, in western Flores (Brown et al., 2004; Morwood et al., 2004, 2005a) have accentuated our lack of understanding of the expansion and evolution of the genus Homo in Asia (Dennell and Roebroeks, 2005). The potential for a paradigm shift caused by these finds (Dennell and Roebroeks, 2005) and the renewed interest in archaeological investigation in this region (e.g., Anderson, 2005; Paz, 2005; Lordkipanidze et al., 2005; Dennell, 2004) demand a more thorough analysis of the environmental challenges that may have influenced the dispersal of Homo. A key area for this analysis is the Indonesian archipelago.

1.1.1 The Indonesian evidence

The Indonesian archipelago is located at the gateway to Australia. It contains important evidence regarding the arrival and demise of Homo erectus, the arrival of modern
Figure 1.1: The Indonesian archipelago (a) showing the Banda arc volcanic islands (dashed line), the location of Sunda and Sahul oceanic shelves (shaded), the position of Wallace's Line (red line) and the location of Flores and Java islands (boxes). Java island (b) showing the location of the Solo River valley and the Kendeng Hills, and Flores Island (c) showing the location of Ruteng and the Soa Basin. The location of the Gunung Sewu and Punung (triangle) in East Java (d) and the location of Liang Bua (triangle) and the Wae Rebo River in West Flores (e). The main focus of this research is Liang Bua in western Flores, but as samples for palaeoclimatic and palaeoenvironmental analysis have been collected from cave sites close to Punung, this area of East Java has also been included.
humans, and their potential interaction. Important sites are located along the Solo River, in eastern Java, such as at Trinil, Sangiran and Ngandong.

The Indonesian region is composed of a volcanic island arc system with isolated islands and deep oceanic trenches. The geological structure and tectonic history of plate collision and subduction is critical for understanding the geodiversity and biodiversity of the Indonesian region (Hall, 2002). The collision zones created the Sunda-Banda arc system, containing the independent continental landmasses of Sunda and Sahul, and the Wallacea region (Audley-Charles, 1987). This volcanic system is composed of islands that were periodically connected to the mainland during interglacial high sea-level stands, and islands that were permanently isolated (Figure 1.1a). Wallace’s Line, situated between Bali and Lombok, delimits a transition between Sunda placental, mammals and Sahul marsupials (Wallace, 1893), whose free passage was restricted by sea barriers that also created natural obstacles to hominid migrations (Metcalf et al., 2001). These watery divides stimulated faunal speciation and posed the first serious seafaring challenges to Homo dispersal since leaving Africa. Thus, the geographic distributions of fauna and humans in this region depended on each species’ ability to respond and adapt to the difficult sea crossings, expanding and contracting rainforests, and large volcanic eruptions. These distributions have been a source of interest for biogeographical studies (van den Bergh et al., 2001; Keast, 2001; Reis and Garong, 2001) and archaeological analysis (Swisher et al., 1994, 1996; Morwood, et al., 1997, 1998; O'Sullivan et al., 2001), respectively, and make Indonesia a key region for understanding the dispersal of Homo through Southeast Asia. However, this archaeological potential has been hampered by a number of problems.

1.1.2 The Indonesian predicament

Despite containing important archaeological evidence that influences Australian and world archaeology (Morwood et al., 2005b; Roberts et al., 2005), the interpretation of the Indonesian record has traditionally been problematic. These problems relate to the complexity of the stratigraphic record, resulting from successive volcanic episodes (Bettis et al., 2004), and the fragmentary nature of the fossil evidence (Theunissen et al., 1990). According to O'Sullivan et al. (2001), these problems have been exacerbated by the application of unsuitable dating techniques and an inability to link the fossil
evidence to the datable material (de Vos et al., 1994). Unresolved questions still surround many aspects of Indonesian archeology, such as the timing of arrival of modern humans, the possibility of an overlap between different human species (e.g., Swisher et al., 1996), and the role played by the geological evolution of the Indonesian continent in shaping archaeological development (e.g., Storm, 2001a, 2001b).

The interpretation of important archaeological and palaeoanthropological finds, such as Homo floresiensis from Liang Bua (Brown et al., 2004; Morwood et al., 2004), have been assisted by studies of stratigraphy, landscape evolution, geochronology and palaeoclimate, which provide a solid Quaternary context and environmental backdrop. The archaeological implications of finds that lack this context, and the interpretations drawn from them, can be open to dispute. However, very few archaeological projects within Southeast Asia have utilised an interdisciplinary approach to aid the interpretation of a site. Likewise, Quaternary studies in the region have, in general, been limited to certain areas and only opportunistic in nature (Flenley, 1997; Dam et al., 2001a; Suparan et al., 2001). Considering this lack of Quaternary data, the opportunity exists for a comprehensive analysis of the evolving landscapes and environments of the Indonesian archipelago related to the dispersal of the genus Homo. New and innovative approaches to key sites are required to identify environmental turning points that may have forced population expansions, contractions and extinctions.

1.2 The selection of sites to address this problem

Key areas for addressing this problem are the islands of Flores and Java, in East and Central Indonesia (Figure 1.1b, c). These islands contain a wealth of important archaeological material and are situated in a strategic location to address the question of Homo dispersal. Being located either side of Wallace’s Line, they provide a useful comparison between the faunal and hominid assemblages arising from continued isolation (i.e., Flores) and periodic connection (i.e., Java) with the Asian mainland. Both islands are dominated by active and diverse geological processes (Pirazzoli et al., 1991; Hall, 2002), rapid landscape evolution (Suparan et al., 2001) marked palaeoclimate changes (van der Kaars, 2001), and extensive volcanic events (Turney et al., 2006b).
Due to the extent of these influences, the role played by landscape and climate in forcing *Homo* dispersal has been greatly accentuated.

As Flores island contains the oldest evidence of hominid occupation east of Wallace’s Line (Morwood *et al.*, 1998; Brumm *et al.*, 2006) it provides a valuable starting point for investigating *Homo* dispersal in Indonesia. The Palaeolithic sites in the Soa Basin, central Flores, provide archaeological evidence from 840 to 650 ka (Figure 1.1c), but more deeply stratified deposits can be found in small pockets of limestone within western Flores, where there is a profusion of caves with archaeological and palaeoenvironmental evidence (Figure 1.1e). One such area with great archaeological potential is the Manggarai province around Ruteng, with the most prolific site being the cave of Liang Bua. This cave consists of a large, limestone dissolution chamber with deeply stratified deposits that record a sequence spanning the Palaeolithic through to the Metal Age, making it the only such site in Indonesia. The collapse of its front entrance created an environment suitable for habitation, which facilitated its subsequent occupation by *Homo floresiensis*, followed by *Homo sapiens* (Morwood *et al.*, 2004). Its detailed archaeological record, formation by geomorphological processes, and the potential for dating and palaeoenvironmental analysis makes this site especially well-suited to address the issue of *Homo* dispersal and a prime site for interdisciplinary analysis.

The fluvial deposits along the Solo River in Java have yielded most of the world’s *Homo erectus* fossils – including the type specimen of the species. The deposits range in age from 1.5 million years at Sangiran (e.g., Larick *et al.*, 2001) to as recent as perhaps 30,000 years at Ngandong (Swisher *et al.*, 1996). Tectonic uplift of the Banda volcanic arc caused the karstification of the Gunung Sewu region and diverted the course of the Solo River (Figure 1.1d) northward through the Kendeng Hills (Semah *et al.*, 2001), where *erectus*-bearing Solo River terrace deposits include the type locality for the Ngandong Fauna (Sondaar, 1984). In addition to the Ngandong site, another key faunal stage in the biostratigraphic sequence of Java, Punung, occurs in this region, making it a prime location for geochronological analysis related to faunal evolution and hominid dispersal.
1.3 Aim and objectives

The main aim of this research is to address the problems relating to the Indonesian archaeological record by the application of an interdisciplinary approach within two main areas: dating and environmental reconstruction. To achieve this aim this study has the following five objectives:

1. To establish a chronological framework for the Quaternary history of western Flores to help address questions relating to the timing of key events.
2. To provide an environmental backdrop to the arrival and subsequent dispersal of humans throughout the Indonesian archipelago by identifying the main landscape and climatic turning points in the last 200 ka.
3. To generate valuable Quaternary data regarding the evolution of the landscape to redress the geographical imbalance of Indonesia in Quaternary studies, and demonstrate the value of a Quaternary context for important palaeoanthropological and archaeological finds.
4. To use this Quaternary data to assist in the interpretation of Liang Bua, and relate environmental turning points to the archaeological record in areas such as the first exposure and subsequent human occupation of the cave.
5. To assess the value of an interdisciplinary approach to an archaeological site in island Southeast Asia.

1.4 The originality of this study

This research represents an original contribution to knowledge within four main areas. Firstly, it represents the application of established techniques, including luminescence dating, palaeoclimate analysis, geomorphology and sedimentology, to a region unfamiliar with their use. Speleothem evidence has seldom been investigated in Indonesia, despite the potential benefit to Quaternary and archaeological analysis in this region. Thus far, luminescence techniques have been rarely used in Southeast Asia, but their widespread application would open up a new realm of chronological opportunities in the Earth and archaeological sciences. Secondly, this research will provide high-quality data for western Flores, which is a new geographical location for Quaternary
analysis and is still considered an area of limited knowledge. Thirdly, this study provides a novel solution to the problem of interpreting Indonesian evidence based on archaeological evidence alone by demonstrating the value of an interdisciplinary approach to an important Indonesian archaeological site. This approach has the potential to contribute to the debate over worldwide models of human dispersal and provide a chronological and environmental foundation for future archaeological analysis in this region. Finally, this research has investigated and applied an innovative luminescence dating methodology, the dual aliquot protocol (DAP), which has enabled a robust chronological framework to be established for Indonesian volcanic quartz and has opened up new prospects for geochronology throughout the archipelago.

1.5 Outline

The case for an interdisciplinary approach, along with an assessment of suitable methodologies, is presented in Chapter Two, while the chosen methodologies are outlined in Chapter Three. As some of the dating methods within this research incorporate the use of new techniques, Chapter Four contains the justification and initial results for novel luminescence methodologies. The results of applying the interdisciplinary approach to Flores can be found in Chapters Five, Six and Seven. These data have the potential to make valuable contributions to archaeological interpretation in three main areas:

- the first exposure of the cave (Chapter Five), including karst morphology, cave development, river terrace development and cave sedimentology;
- the human occupation of the cave, concentrating on the nature and timing (Chapter Six) and including cave stratigraphy, sedimentology and dating protocols applied to key samples;
- the occupation of the cave, concentrating on volcanic and climatic influences (Chapter Seven), and incorporating the palaeoclimatic and palaeoenvironmental analysis of speleothems and volcanic sediments.

Finally, the implications of the resulting data for the archaeological interpretation of Liang Bua, and the potential of this type of approach for archaeological sites worldwide, are discussed in Chapter Eight.