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Additional evidence for early modern human morphological diversity in Southeast Asia at Tam Pa Ling, Laos

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ABSTRACT

Despite its geographic primacy as the intersection of dispersal paths to Australasia, mainland Southeast Asia has played little role in scenarios of early human migrations. Tam Pa Ling (TPL), a cave site in northern Laos, is the source of early modern human fossils – a partial cranium (TPL1) and a complete mandible (TPL2) – that represent the earliest anatomically modern humans in continental Southeast Asia and introduce new migration routes into the region during Marine Isotope Stage 3. In the current analysis, a new partial mandible from the site, TPL 3, is introduced, described, and evaluated using geometric morphometrics in the context of Pleistocene archaic, early modern and Holocene humans. In addition, the sedimentary context of TPL3 is described and refined through further quartz single-grain optically stimulated luminescence (SG-OSL) measurements and additional feldspar post-infrared infrared stimulated luminescence (pIR-IRSL) techniques.

The TPL3 mandible has discrete traits similar to eastern Asian early modern humans, including a well-developed chin and a lack of lateral corporal robusticity. It does, however, retain a relatively broad anterior mandibular arch that is more commonly associated with archaic populations. In this way, it is similar to the TPL2 mandible as well as other similarly-aged fossils from the region that show a mixture of archaic and derived traits. The combined quartz SG-OSL and feldspar pIR-IRSL techniques provide an age range of 70 ± 8–48 ± 5 ka for the depositional age of the layer containing the TPL3 mandible. This

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upper age estimate is ~20 ka older than the depositional ages for the TPL1 and 2 fossils, extending the upper limit for the currently excavated sedimentary and associated fossil evidence.

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1. Introduction

In the early part of the twentieth century, archaeological research was performed in the limestone caves of the northeastern provinces of Laos by the Geological Service of Indochina (Arambourg and Fromaget, 1938; Fromaget, 1940a, b; Fromaget and Saurin, 1936). Work in the country came to a halt with the advent of World War II, and archaeology was not resumed systematically until the mid-1990s. One consequence of this long period of inactivity is a limited understanding of the prehistory of Laos relative to that of surrounding countries in mainland Southeast Asia, especially neighboring Vietnam, where the Hoabinhian cultural tradition was defined, and bordering Thailand, where mid-Holocene sites demonstrate early phases of agriculture and metallurgy in the region (Treerayapiwat, 2005; White and Bouasisengpaseuth, 2008; Yi et al., 2008). Given its position between these areas of known early human occupation, however, renewed surveys and excavations over the last two decades have established a long-term human presence across northern Laos. Since this time, the Lao Ministry of Information and Culture has collaborated with international research teams to further excavations in Luang Prabang (White and Bouasisengpaseuth, 2008; White et al., 2009), Vientiane (Kallen and Karlstrom, 1999; Karlstrom, 2000), and Huà Pan Provinces (Demeter et al., 2009, 2012). Beginning in 2003, research was re-established at the historic site of Tam Hang in Huà Pan Province (Bacon et al., 2008, 2011; Demeter et al., 2009; Patole-Edoumba et al., 2015), and in 2007 new surveys began in the surrounding karstic areas for evidence of Pleistocene human evolution. These surveys yielded new sites for further study, including Tam Pa Ling.

Tam Pa Ling (TPL) is a cave site that was discovered in 2008 and that has been excavated annually since 2009 (Demeter et al., 2012, 2015; Shackelford et al., 2012, 2013). During this time, it has been the source of early modern human fossils from a secure stratigraphic context. The TPL fossils are the earliest anatomically modern humans in mainland Southeast Asia, and they introduce new migration routes into Southeast and East Asia during Marine Isotope Stage (MIS) 3 (Demeter et al., 2012). Tam Pa Ling 1 is a small, partial cranium with derived morphological features of early modern humans, particularly in the frontal, occipital, maxillae, and dentition (Demeter et al., 2012). The TPL2 mandible demonstrates a mosaic of anatomical features that are associated with both archaic and modern human comparative samples. It has clear affinities with modern humans based on the presence of a protruding chin as well as other discrete traits, but this derived morphology is juxtaposed with archaic features such as a robust mandibular corpus (Demeter et al., 2015). While these fossils may be further evidence of the overlap in traits and varying trait frequencies between archaic and early modern humans (Stefan and Trinkaus, 1998; Rosas, 2001; Trinkaus, 2006), archaic traits of TPL2 and the fully modern human morphology of TPL1 (with no archaic features) more likely suggest that a large range of morphological variation was present in early modern human populations residing in the region by MIS 3.

In 2013, a partial mandible (TPL3) was recovered in the same area as the previous specimens but at a depth of 5.0 m. The current analysis describes this newest human fossil and its context and evaluates the TPL3 mandible relative to other fossils from the site and region. In addition, new dates are provided for the sedimentary layers in which the TPL3 fossil was found.

2. Context and dating

Tam Pa Ling is located in Huà Pan Province, Laos, approximately 260 km NNE of Vientiane (20°12′31.4″ N, 103°24′35.2″E, elev. 1170 m) (Fig. 1). The cave is part of the Annamite Mountains, which lie east of the Mekong River and extend through Laos, Vietnam, and into northeastern Cambodia. This is a limestone karst landscape featuring an extensive network of sinkholes, towers, caves, and caverns (Duringer et al., 2012).

Tam Pa Ling (cave of the monkeys) is located at the top of the Pa Hang hill. It has a single, south-directed entrance that opens to a large gallery measuring 30 m in length along a north-south axis and 40 m in width along an east-west axis. Upon entering, there is a steep, 65-m slope that descends to the chamber floor. The excavation site lies at the base of this slope at the east end of the gallery (Figs. S1 and S2). Further details of the site and a full explanation of its stratigraphy can be found in Demeter et al. (2012, 2015).

An excavation grid measuring 12 × 4 meters has been excavated to a depth of 3.0–6.0 m (S3–S5). Micromammal, amphibian, reptile remains, and numerous shells were recovered across the entire excavation grid from 0.74 to 6.0 m in depth. Faunal remains are dominated by three rodent taxa, *Leopoldamys* cf. *sabanus*, *Niviventer* sp., and *Rattus* sp. (77% of the identifiable remains), with the remaining material comprised of *Chiropodomys* sp., *Hapalomys* sp., *Belomys pearsonii,* and some unidentified Arvicolinae (at least two taxa) (Demeter et al., 2015: this publication also included *Berylmys* sp. in the faunal list, but the previous identification has been reconsidered after further analysis). Human fossils (TPL1 and TPL2) were recovered from a silty and sandy clay layer at depths of 2.35 and 2.65 m (Demeter et al., 2012, 2015, Figs. 1 and S3). In 2013, a second mandibular fragment representing a third individual, TPL3, was recovered at a depth of 5 m (Figs. 1, 2, S3).

The stratigraphy of the site is comprised of centimeter-to decimeter-scaled layers with no perturbations, indicating cave filling by periodic slopewash deposition from the argillaceous-dominated bank at the entrance of the cave (Demeter et al., 2012, 2015). A detailed stratigraphy of the site can be found in Demeter et al. (2012, 2015). Presently, there is no major water flow into the cave, only minor runoff related to precipitation, and there is a complete absence of significant erosion surfaces between stratigraphic layers. No artifacts have been found at the site, and there is no evidence of an occupation surface within the stratigraphic section or within the cave. The source of the TPL fossils is unknown, but the state of preservation and the absence of water-rolling evidence suggest that they originated at or near the entrance of the cave, were subsequently carried into the cave via slopewash transport, and then buried within the cave stratigraphy.

Dating of the site has been detailed elsewhere (Demeter et al., 2012, 2015) and is briefly summarized here. Optically stimulated luminescence (OSL) and red thermoluminescence (red TL) were applied to sediments throughout the section (TPLOSL1-6 and 10 are shown in Fig. 1) and are stratigraphically consistent, confirming its integrity. In addition, U/Th-series dating was performed on the

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