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Assessing the occurrence of *Stegodon* and *Elephas* in China and Southeast Asia during the Early Pleistocene.

Présence des genres *Stegodon* et *Elephas* en Chine et en Asie du Sud-est au Pléistocène inférieur: un bilan.

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Abstract: The fossil record is assumed to point to different ecologies, extinction times and 'last stands' in different regions of the world for Proboscideans, and in some regions, human-proboscidean interaction may theoretically have covered a time span of up to two million years. This paper focuses on the Early Pleistocene of China and Southeast Asia, where the *Ailuropoda-Stegodon* complex is considered to be a chronologically significant faunal association in the following period. However, the stratigraphic contexts of these local faunal complexes require clarification. Indeed, after one century of research to establish a regional biostratigraphy and in spite of the recomandations provided in the 1980s, many geochronological surveys were undertaken in the 1990s but many problems still exist. Thus, as a first step, taking into consideration the uncertain nature of the geological, taphonomic and chronological data, this paper proposes a critical review of the validity of the associations of *Stegodon* and *Elephas* during the Early Pleistocene for this geographical area. Finally, it was necessary to expose what are the current problems before to try to solve them rather than to pursue an unfounded headlong rush. This review concludes that very few reliable data are available and that high-level resolution (MIS) palaeoecological modelization is almost impossible, severely hindering any discussions of strict interaction between humans and proboscideans.

Résumé: L'évolution des proboscidiens est utilisée pour décrire des changements de nature écologique en fonction de l'apparition ou de la disparition de certains taxons. Sur près de 2 millions d'années cette évolution est associée à celle des homininés. Le point de vue que nous développons sur les seuls proboscidiens s'attache plus particulièrement à la période du Pléistocène ancien en Chine et en Asie du Sud-est. Notre objectif est de présenter le bilan biostratigraphique d'une région où, pour la période suivante (Pléistocène moyen), le complexe faunique à *Ailuropoda-Stegodon* est considéré comme un marqueur chronologique important ayant valeur paléoécologique. Après un siècle de construction biostratigraphique, en dépit des incomplétudes pointées dans les années 1980 et des progrès de calage géochronologique entrepris la décennie suivante, une clarification reste nécessaire. Cet état de fait incombe à de mauvaises pratiques : travaux de terrain se calant sur des référentiels inappropriés ou modélisations fondées sur des données erronées ou insufisamment précises. En guise de première étape, nous proposons une revue critique de l'association des genres *Stegodon* et *Elephas* au Pleistocène inférieur dans cette région afin d'évaluer la fiabilité des données géologiques, taphonomiques et chronologiques disponibles. Cette revue conduit au constat que très peu d'information fiable est disponible compte tenu de la nature du terrain mais lorsque celle-ci le permet, les données utilisées n'ont pas un niveau de résolution suffisant pour qu'une modélisation paléoécologique de haute résolution soit possible et utile. Ainsi, sur la base des données disponibles, la possibilité de traiter d'une éventuelle co-évolution entre hommes et proboscidiens apparaît comme prématurée. Finalement, comme dans les années 1980, force est de constater qu'il reste nécessaire de poser le problème de la biochronologie régionale et de chercher à la résoudre plutôt que de poursuivre les propositions d'hypothèses paléoenvironnementales, paléoécologiques ou paléogéographiques proposées actuellement qui s'inscrivent dans une fuite en avant infondée et stérile.

Introduction

When dealing with Chinese and Southeast Asian fossil material from collections over 30 years old, authors are generally supposed to be aware of the inherent limits of these collections. Although these limitations have been mentioned and discussed on numerous occasions (*i.e.,* Allen, 1991; Bouteaux, 2005; Chen et al. 2013; De Vos, 1983, 1984; Huffman, et al., 2010; Orchiston & Siesser, 1982; Rink et al., 2008; Saegusa et al., 2005; Van den Bergh, 1999), authors still currently use such collections to base their palaeoenvironmental or palaeogeographical models. Following the significant and constructive scientific results of Turvey et al. (2013), who proscribe the possibility of discussing megafaunal extinction during the Late Pleistocene and the Holocene, we assess the available database predating the *Ailuropoda-Stegodon* complex. A review of the literature brings to the fore controversies and debates concerning taxonomy and chronology. Nevertheless the main problem remains to establish an unquestionable association between the fossils in the deposits.

Due to space restrictions, we cannot deal with the whole Pleistocene in this paper and, as a first step, we thus focus on the Early Pleistocene *Elephas* and *Stegodon* genera, encompassing the Gelasian and Calabrian stages, dated between 2.588 to 0.781 Ma, according to the International Union of Geological Sciences Executive (Gibbard & Head, 2009).

Antiquity and the co-occurrence of *Elephas* and *Stegodon* genera

It is imperative to provide a reliable background to discuss the paleontological and palaeoenvironmental significance of the *Ailuropoda-Stegodon* complex. This 'Sino-Malayan' faunal assemblage, initially discovered in China, then in Southeast Asia and described by Von Koenigswald (1938-1939), has long been considered to be a Middle or upper Middle Pleistocene marker in China and Southeast Asia by many former authors (Colbert & Hooijer, 1953; Ginsburg et al., 1982; Han & Xu, 1985; Kahlke, 1961a; Pei & Wu, 1956; Pope et al., 1981; Schepartz et al., 2003). However, the relevance of such a complex varies depending on whether it is used to describe palaeogeography, biochronology or palaeoecology. Before discussing this relevance, it is pertinent to evaluate the occurrence of *Stegodon* but also the advent of the genus *Elephas* during the Early Pleistocene, as both taxa are part of the *Ailuropoda-Stegodon* complex during the following period in China at Lungkutung (Young & Liu, 1950), Heshandong (Colbert, 1940), Upper Pubu Cave (Wang et al., 2007), Wuyun Cave (Chen et al., 2002), Liujiang (Huang, 1979) and Maba (Wu & Poirier, 1995) but also in Vietnam, in Langson province (Patte, 1928) and at Tham Kuyen site (Cuong,1992) as well as in Laos at Tam Hang (Bacon et al., 2011) or in Myanmar at Chausong Cave (Colbert, 1943). Although *Elephas* and *Stegodon* appear to co-occur in several sites from China to insular Southeast Asia from the Early Pleistocene until possibly the Late Pleistocene (Turvey et al., 2013), a detailed survey of the Early Pleistocene stratigraphic record of both taxa is called for to determine at which level of chronological resolution such data can be reliably used for palaeoenvironmental studies.

The evaluation of the quality of data recording co-occurrences of *Elephas* and *Stegodon* genera, as well as their contemporaneity with Hominins, is dependent on the raw data provided by the excavators concerning the relative stratigraphic position of the fossils. Different levels of quality are thus inevitable, owing to the information provided and to the nature of the data. First of all, when authors omit to provide information relating to taphonomy and especially when it is unclear as to whether different fossils belong to the same site, the same locality, the same area in the locality or the same stratigraphical unit, data should not be used to establish any form of biostratigraphy and by the way can not be used to build any palaeoecological model. This is the first and main criterion of reliability indicated in studies aiming to evaluate the available chronological dataset in archaeology or in paleontology (Pettitt et al. 2003). The second level concerns the quality of the available data and it is paradoxically easier to review information (even if erroneous) than to deal with the absence of information. Due to taphonomic processes, fossils can be naturally assorted by various fluviatile, volcanic or cave parameters. Information can be lost due to the formation of breccia or to erosion, but the weathering of deposits and fossils can also affect dating results. Therefore, the resolution of the chronological signal recorded in the deposits provides different levels of accuracy for establishing palaeoecological hypotheses, depending on the case in hand. Even if precise correlations with MIS environmental contexts or more accurate levels cannot be made due to taphonomic problems, the literature should present such data to let authors aware of their reliability. If these former criteria are intrinsic criteria, often, authors continue to artificially mix data from different provenances (localities, chambers, layers etc.), leading to artificial faunal lists of limited or no significance, as shown by De Vos (1984) and Orchiston & Siesser (1982). In many cases, the age of the faunal remains cannot be gauged by dating the deposits as the exact position of the fossils in the different layers is often not given by the authors. Finally, the use of "historical" sites to establish a step by step biostratigraphic frame is inadequate as many of these former benchmark sites are a combination of diverse assemblages from different levels of a single site or even from different localities, such as Yenchingkuo, Liucheng, Hoshangtung, Trinil, etc. The use of such historical sites to biostratigraphically gauge a new faunal assemblage only leads to undermining its significance. Indirect dating and, where possible, direct fossil dating, are the best ways to establish a biostratigraphy and to avoid the circular reasoning involved in comparing new faunal assemblages to erroneous biostratigraphies or inappropriate historical benchmark assemblages. Another limitation to build any reliable regional biostratigraphy and further ecological modelling exist when controversies concerning the chronology of some sites are systematically omitted. Thus, even if Mourer (1977, 1994) focused on the point that no typical Pleistocene taxon was listed at Phnom Loang in Cambodia, authors (Bacon et al. 2004, 2006, 2008a,b, 2011; Louys 2007a,b, Louys et al. 2007, Louys & Meijaard, 2010, Louys &Turner 2012) still do not notice this controversy.

Proboscideans rely on very different ecologies but in order to describe ecological shifts in faunal assemblages throughout time, chronological biostratigraphic resolution should be sufficiently accurate; *i.e.,* the span of the fossil assemblage should be no longer than the period of the environmental shift. For an ancient period like the Early Pleistocene, the resolution of the signal cannot be expected at a seasonal level. Nevertheless, due to the lack of direct and absolute chronometric dating of faunal assemblages including *Stegodon* and/or *Elephas,* following Orchiston & Siesser (1982), De Vos (1984) and Olsen & Ciochon (1990), we consider that biostratigraphic correlation is still an unsatisfactory method for determining the chronological affiliation of regional sites. Thus, even if precise correlations with environmental conditions are attempted and if some efforts have been undertaken over the past decade, it is still difficult to propose reliable age estimates for many of the Early Pleistocene sites (Rink et al., 2008). Finally, only very recent data are now available (Shao et al., 2014; Sun et al., 2014; Jin et al., 2014). However, these latest data should also be discussed in regard to the limit of each geochronological methods as listed by Herries et al. (2009).

Any assessment of the literature necessarily brings to the fore controversies and debates concerning taxonomy, chronology and the exact position of the fossils. However, our purpose here is not to embark upon a detailed discussion of the current taxonomy of Proboscidean taxa as undertaken by Chen (2011). Nevertheless, as recalled by Gheerbrant & Tassy (2009), *Elephas* and *Palaeoloxodon* are synonymous genera and, ignoring such data (Louys, 2007a), further palaeoecological studies built on such a background (Louys 2007b, 2012, 2014, Louys et al. 2007, Louys & Meijaard, 2010, Louys & Turner, 2012) will make them obsolete. It is nonetheless important to recall some key data.

Following Saegusa et al. (2005), Stegodontidae are major faunal elements of the Asian Quaternary and Neogene. The earliest taxa date back to about 9 Ma in China, 6 Ma in Thailand, 5.5 Ma in Japan and 4.5 Ma in India. The genus *Stegodon* and its closest forms are present in China and in Indonesia for at least 1 Ma (Kahlke, 1961a; Van den Bergh et al., 1994), and even longer given that the earliest known terrestrial fossil assemblage of Flores dates to about 2.5 Ma in the Walanae Formation or somewhat earlier in subunit A of the Beru Member in South Sulawesi, including *Stegodon sompoensis* (Van den Bergh, 1999; Van den Bergh et al., 2001 b). According to Saegusa et al. (2005), *Stegodon* itself is monophyletic and probably originates in South China at the beginning of the Pliocene and then branches out into three main lineages. Subsequently, from the Early to the Middle Pleistocene, *Stegodon* is recorded as far East as the Philippines and various Wallacean islands in the Indonesian Archipelago (Sulawesi, Sangihe, Flores, Sumba, and Timor), but also in the main Japanese islands (Van den Bergh, 1999). Research into the insular dwarfing process complements the *Stegodon* dataset in insular Southeast Asia (Van den Bergh et al., 2001a) and indicates the increasing accessibility of the Java region between 1.5 Ma and 0.8 Ma due to the low sea level, leading to the emergence of Sundaland. The oldest occurrence of *Stegodon sondaari* is in the easternmost part of the Indonesian Archipelago, at Tangi Talo locality in Flores, with dates older than 0.9±0.07 Ma. *Stegodon* was present in Sulawesi (Allen, 1991; Van Heekeren, 1958; Hooijer, 1958, 1964a; Van den Bergh, 1999), in Timor (Glover & Glover, 1970; Hooijer, 1969, 1972; Maringer & Verhoeven, 1970; Van den Bergh et al., 2001a,b), and in the Philippines (Fox, 1978; Von Koenigswald, 1956a; Wasson and Cochrane, 1979), but the stratigraphic attribution of this genus is at times ambiguous. West of Huxley's Line, *Stegodon* fossils are associated in places with lithic artefacts (Allen, 1991), but without chronological reappraisal the dating of the deposits remains vague for many of these sites, even if presumed 'Hominin' sites are more likely to be dated than sites without Hominin remains.

During the Middle Pleistocene, the fossil record is considered to indicate turnovers and the replacement of *Stegodon* by *Elephas* occurs around 128 ka in Indonesia (Westaway et al., 2007) and between 600 and 200 ka in India (Mishra et al., 2010). The appearance of *Elephas* and the local disappearance of *Stegodon* in Indonesia or South China (Van den Bergh, 1999; Wang et al., 2007), or the single occurrence of *Elephas* in northern Vietnam (Bacon et al., 2006), are still used as chronological milestones. However, some of these Early and Middle Pleistocene benchmark sites have not been adequately defined or dated, and these hypotheses must now be confronted with the facts to avoid circular reasoning. Lastly, from a chronological point of view, the co-occurrence of *Elephas* and *Stegodon* is theoretically possible in Southeast Asia as *Elephas* is described early on in the lower part of the Kabuh (=Bapang) formation at Sangiran dome in Indonesia (Aimi & Aziz, 1985). Nevertheless, considering the earliest appearance of *Elephas,* it is relevant to verify the implications of this occurrence, due to changes in the Proboscidean classification in the literature. Following the first description by Hooijer (1949), Van den Bergh (1999) describes a large form of Proboscidean using the term "*Elephas*" in Sulawesi, subsequently attributed to the genus *Stegoloxodon* (Markov & Saegusa, 2008). According to Barry et al. (2002), the first occurrence of *Elephas planifrons* is said to be as old as 5.9 Ma in this area, but in Indonesia, the single primitive elephantoid molar from Ci-Panglosoran in Java, initially attributed to *Elephas planifrons,* was later assigned to the new genus *Stegoloxodon* by Kretzoi in 1950 (Markov & Saegusa, 2008).

It is thus essential to clarify the taxonomy, the stratigraphy, the taphonomy and the chronology of faunal assemblages in order to establish a reliable biochronological framework to reconstruct palaeoenvironments and to describe their evolution. We thus present a reassessment of the biochronological data and indicate whether or not taphonomic information is available; and if this information is sufficiently accurate for the Early Pleistocene sites of Eastern Asia to be used as benchmarks to back up palaeoenvironmental hypotheses. The reservation emitted by Hooijer (1962a, p. 109-110): "*It seems to me that the localities in Asia that yield these faunas are too few and far between to support any but the most generalized correlation in Lower Pleistocene and Middle Pleistocene blocks only*" remains relevant today for many reasons. The lack of reliable dates combined with the stratigraphic complexities of karstic cave sediments, as well as fluvial and volcanic deposits, have obstructed a more in depth understanding of the temporal characteristics of taxa changes in local sequences, as well as relationships between distinct geographic areas (Rink et al., 2008).

In China and Southeast Asia, the use of taxa as chronological markers still casts doubt on palaeoenvironmental studies as biostratigraphic correlations are generally made without independent chronological data. Direct dating methods are increasingly applied to fossils (Chen et al., 1987; Chen & Yuan, 1988; Jones et al., 2004; Rink et al., 2008; Wang et al., 2007; Zeitoun et al., 2010), due to the fact that stratigraphic associations between remains and dated deposits cannot always be taken for granted. Tables 1, 2 and 3 present a list of reported *Stegodon* sp. and *Elephas* sp. sites from China and Southeast Asia, most of which lack adequate stratigraphic information and/or radiometric dates. For each Early Pleistocene site a complete reappraisal of field data reports is required, following the studies undertaken by Van den Bergh (1999) for Flores and Sulawesi or Huffman et al. (2010) for Ngandong for the Middle Pleistocene or, at the very least, a critical review of the literature, as provided by Turvey et al. (2013) for the Late Pleistocene. Unfortunately, as these authors point out, field reports or data are not always available and datasets are not always complete, which makes the evaluation of the quality of biostratigraphic evidence difficult.

***Stegodon* and *Elephas* from the Early Pleistocene to the Early Middle Pleistocene**

- China

Several Chinese sites affiliated to the Early Pleistocene (Table 1, Figure 1) by Tong (2006) include the genus *Stegodon.* This is the case for Xihoudu (=Hsihoutu=locality 6053) and Linyi (=Lingyi), both in Shanxi province, and Heshui and Lixian (Sili) in Gansu province. Nevertheless, these remains were not collected from securely recorded stratigraphic contexts. For example, on one hand, Linyi is considered to be Middle Pleistocene by Zheng (1976), according to the micromammals, and on the other, *Stegodon zdanskyi* from Sili (Lixian) is attributed to the Pliocene by Hu (1962). The fauna from Xihoudu site, including *Stegodon*, was associated with stone artefacts in the greyish-white and yellow sandy upper part of the second lithological portion of the site (Wei, 2000), but only *Elephas* was mentioned by Ikawa-Smith (1978 p.194). Finally, Zhu et al. (2003) conducted a palaeomagnetic investigation and suggested an age of about 1.27 Ma for the artefacts from this site. However, it is important to point out that Linyi is the name of a district in Shanxi province where alluvial deposits (Sanmenian series) occur in the vicinity of several villages: Langdian, Liangjiapo, Panhou (Tang et al., 1983). These deposits contain *Stegodon zdanskyi* and *Loxodonta (Palaeoloxodon) tokunagai,* species biochronologically affiliated to the Early Pleistocene. In this case, no detailed stratigraphic study proves that the fossil-bearing sediments are the same in each locality.

In Shaanxi province, *Stegodon orientalis* is described at the site of Gongwangling (Wu and Poirier, 1995), but the site consists of a series of twelve exposed palaeosoils, loess, and clay. In this site the human fossil-bearing layer yielded abundant mammal remains dated to 1.15 Ma (An et al., 1990) or to 1.65 to 1.54 Ma (Zhu et al., 2015), but the exact position of the Proboscideans among this fauna is not indicated. In the middle part of the red clays in the Laochihe fluvial formation near Lantian, *Stegodon orientalis* remains were discovered in a faunal assemblage initially alleged to be of Middle Pleistocene age. However, it transpires that this assemblage is comparable to the Gongwangling fauna and could be considerably older (Ji, 1976).

In Sichuan province, in the fissure fills of Yanjinggou (=Yenchingkuo), faunal accumulations in vertical passages resulting from predation and falls (Matthew & Granger, 1923) include both *Stegodon orientalis* and *Elephas namadicus* (Colbert & Hooijer, 1953). Nonetheless, Kahlke (1961a, p. 26) concluded that the Yenchingkuo fossil remains belonged to two distinct faunas: an older one (Yenchingkuo I) for “Cromerian” (*i.e.,* Early Middle Pleistocene) elements and a younger one (Yenchingkuo II) “Mindel-Riss” (*i.e.,* Late Middle Pleistocene) as noticed by Tougard & Montuire (2006). According to the most comprehensive papers dealing with the *Ailuropoda-Stegodon* complex (Matthew & Granger, 1923; Colbert and Hooijer, 1953; Kahlke, 1961a), Yenchingkuo is still used as a Middle Pleistocene marker and, the Yenchingkuo fauna (=“Wanxian fauna”) generally appears as a single faunal list. Yet it is inappropriate to refer to this list in biochronological and/or palaeoenvironmental studies. Its use to establish the chronological or the taxonomical scaling of some sites such as Tam Hang or Duoi U’Oi (Bacon et al. 2008a,b, 2011) or to elaborate theoretical paleoecological model (Duringer et al. 2012) will lead to reject them. Indeed, the initial bone collection by Granger came from diverse localities and different formations, as indicated by Colbert and Hooijer (1953) and recently underlined by Chen et al. (2013). According to these latter authors, in the fissure fillings of the Dayakou locality, level 2 is, as of yet, the only confirmed Early Pleistocene zone, on the basis of extinct genera and faunal components. In this locality comprising several fillings, a single vertical fissure includes a primitive form of *Stegodon orientalis*.

In Jiangsu province, the deposits of Tuozidong (=Tangshan=Humpback Cave) site include *Stegodon* cf *preorientalis* remains (Dong et al., 2013). In comparison to related Early Pleistocene mammalian faunas, this fauna is considered to be closer to the Renzidong and Longgupo faunas by Fang et al. (2006), but both of these sites contain several layers. The only available accurate dating concerns the human remains, with an age range of 500 to 350 ka (Wu, 2004), but no detailed information linking the human remains to other taxa is available.

In Anhui province, the site of Chaoxian (=Chaohu=Yinshan) comprises two groups of fossiliferous deposits situated at approximately the same level but separated by a limestone ridge. The Locus A deposits, including *Stegodon,* were attributed to the Early Pleistocene and the Locus B deposits were ascribed to the Middle Pleistocene (Shen et al., 2010), based on regional faunal comparisons.

In Hubei province, Boëda et al. (2010) indicate the occurrence of both *Stegodon preorientalis* and *Stegodon wushanensis* at Longgupo (=Wushan=Damiao), which is a collapsed sinkhole*,* with dates older than 1.10 Ma for the fossil and artefact-bearing deposits. At Jianshi Cave (= Longgudong) in Yunxian county, the presence of *Stegodon preorientalis* remains is reported by Hou & Zhao (2010) in the hills near Jintang village, close to the Yangtze River. According to regional comparisons, this fauna is considered to be from the middle Early Pleistocene by Jin et al. (2008), whereas Gao & Cheng (cited by Dong et al. 2013) reported estimated palaeomagnetic ages ranging from 2.15 to 2.42 Ma.

Stegodon orientalis is present in the deposits of Baeryan Cave (=Bijie) in Ghuizou province and considered to be of Early Pleistocene age, based on a biostratigraphic comparison by Zhao & Zhang (2013).

In Yunnan province, the Yuanmou Basin includes several localities; *i.e.,* Shangnabang, Sijiacun, Xiaqiliu, Xincun, Danengyucun and Laoyatang, as observed by Olsen & Miller- Antonio (1992). The Yuanmou Basin was geologically described by Urabe et al. (2001), and Qian & Zhou (1993) considered that *Stegodon yuanmouensis*, *Stegodon elephantoides* and *Stegodon zhaotongensis* found in Members M1 and M2 of the Yuanmou Formation to be of Lower Pleistocene age. But according to Zhu et al. (2008), remains of *Stegodon elephantoides* were also unearthed in the fluviolacustrine lower Member M4 at the Niujianbao locality. This latter locality situated in the Makai valley was initially considered to be the "Yuanmou site" itself. According to Dong et al. (2000), two *Homo erectus* upper incisors were found in the brownish clay of Layer 25 of Member 4 at Shangnabang, but no mention is made of the exact provenance of the *Stegodon* remains from Member 4.

In Bubing Basin, at Mohui (=Tiandong) site, *Stegodon preorientalis* is dated to the earliest Pleistocene, according to overall faunal comparisons by Wang et al. (2007) but the sediment infilling in the cave is divided into three major units, including the upper cave breccia bearing few fossils and the lower fine clay deposits containing sparse fossilized large mammal teeth. Finally, the *in situ* fossils were recovered from six different areas in the cave and it is impossible to identify their exact location. In the same basin, Zhao & Zhang (2013) indicated the presence of *Stegodon orientalis* in Chuifeng Cave where all the fossil remains derive from the sediment collected in the north-eastern part of the cave (Wang, 2009). Direct dating of tooth enamel indicated an age between 1.92±0.14 and 1.38±0.17 (Shao et al., 2014).

In Guangxi Zhuang province, several caves have been discovered in the area of Chongzuo: Baikong, Juyuan (=Liucheng), Sanhe (=Chongzuo) and Queque with *Stegodon* remains attributed to the Early Pleistocene. According to Jin et al. (2014), the fossil-bearing sediments of Baikong Cave included *Stegodon huananensis* remains but no details were given of their position in the stratigraphic sequence, which is divided into six layers. Given that the whole sequence is dominated by reverse polarity and due to the presence of early taxa, such as *Ailuropoda microta, Sinomastodon jiangnanensis, Megantereon nihewanensis* or *Pachycrocuta licenti* from excavations in the cave, Sun et al. (2014) consider the assemblage to be older than 2 Ma. But calibrating the palaeomagnetic signal with the biostratigraphy could present problems in the future. Based on a review of the literature, De Vos (1984) revealed that the unique faunal listing published by Kahlke (1961b) for Liucheng site (=*Gigantopithecus* cave =Juyuan dong) does not concern a natural fauna but rather an assortment of different successive faunas during a period ranging from the Early to the Late Pleistocene. *Stegodon* *preorientalis* from Liucheng belongs to a faunal assemblage initially considered to be older than 1.2 Ma by Jin et al. (2007), and among which Sun et al. (2014) also identified the presence of *Stegodon huananensis*. The normal magnetic polarity of the fossil-bearing sediments is now considered to indicate an age of 1.8 Ma by Sun et al. (2014) but fossil remains were formerly directly dated by Rink et al. (2008) to between 1.2 Ma and 900 ka. In Sanhe Cave the stratigraphic sequence is subdivided into seven layers and fossil-bearing sediments were recovered from the fourth and fifth layers from the top, including remains of *Stegodon preorientalis* (Jin et al., 2009). The normal polarity of the fossil-bearing sediments indicates an age between 1.1 and 1.8 Ma (Sun et al., 2014) for these layers. Dong et al. (2013) indicated that *Stegodon orientalis* remains are present in Queque Cave where fossil-bearing sediments were recovered from the third to the fifth layers from the top among a stratigraphic sequence composed of nine layers. The palaeomagnetic analysis shows that the fossil-bearing sediments have normal polarity, indicating an age younger than 1 Ma for the faunal assemblage according to Jin et al. (2014).

Lin (1963) indicates the occurrence of three different species in Taiwan: *Stegodon insignis*, *Stegodon* cf *orientalis* and *Stegodon sinensis* (now=*Stegodon orientalis*), as well as both *Elephas trongotherii* (now *Mammuthus trongotherii*) and *Elephas indicus* in the T'unghsiaonian sub-age formations belonging to the Early Pleistocene in the Taipei Basin and on the northern coast. In southern Taiwan, *Stegodon aurorae* (or *Stegodon akasiensis*) and *Stegodon orientalis* are reported in the Early to Middle Pleistocene sediments of the Chochen (=Tsochen=Tsailiao-chi or Shinhua Hill) area by Chang et al. (2012).

- Continental Southeast Asia

Colbert (1938) described remains from Myanmar (Table 2, Figure 1) from the collection of the American Natural National Museum, including *Stegodon insignis,* from the localities of Chaungsongyi and Mingun and *Stegodon elephantoides* remains from Yenanggyaung. No further details were provided, but all these localities are affiliated to the Early Pleistocene of the Upper Irrawady beds. *Elephas hysudricus* is also described at the Than-U-Daw locality in the same geological formation but De Terra (1943) supplied more detailed information concerning the provenance of the different fossils. Thus, *Stegodon insignis* and *Stegodon elephantoides* were collected from the Irrawady river beds near Pagan, and both species occurred with *Elephas hysudricus* at locality M3 at Mingun and also at locality U1, with a third additional *Stegodon* sp. at Magwe.

In the Yaw Valley, still in the Upper Irrawady beds, remains of *Stegodon elephantoides* and *Stegodon* sp. were found in Pyinchaung, and *Stegodon* sp. in Seikpyu. *Stegodon elephantoides* and *Stegodon* sp. were found together at Yenangyaung, at locality Yg4.

In Thailand, *Stegodon* remains were collected from the stratified and cross-bedded sand and gravel horizons from tektite-bearing alluvial deposits at Ban Tha Chang in Nakhon Ratchasima province. However, these fossils were uncovered during sand mining operations near the Mun River in an area of 80 to 160 square kilometers, mined to depths of 20 to 40 meters, and in consequence, it is difficult to attribute the fossils to distinct layers. Nevertheless, they were broadly divided into three ages: Middle Miocene, Late Miocene to Early Pliocene, and Early Pleistocene (Thasod et al., 2012). These fossils include *Stegodon elephantoides, Stegodon insignis* and *Stegodon* cf *orientalis* but also *Elephas*. Sand pit number 9 (Siam pit) is the easternmost sand pit of the sequence and according to Thasod (2007), the youngest fossils; *i.e., Stegodon* sp. and *Elephas* sp. were found in this zone. Thermoluminescence dating of quartz grains from tektite-bearing sands gives a reported age of 0.75±0.13 Ma (Haines et al., 2004), which is consistent with the age of the tektites themselves. Nevertheless, this information can only be used as an indicative age for the co-occurrence of Proboscideans as *Stegodon* sp. comes from unit A where tektites are abraded, suggesting that the latter may have been transported from older geological formations, and as there is still doubt concerning the position of the *Elephas* remains. At Khok Sung, about 15 km NW of Ban Tha Chang, Duankrayoum et al. (2014) reported the accumulation of *Stegodon* bones in the channel bank area in the upper part of the stratigraphy of unit 3. In spite of taphonomic studies and geological analyses, the fossil assemblages were described as a mixture of fluvially transported bones with depositional processes presumed to occur during the Early Pleistocene, but with no further chronological information.

- **Insular Southeast Asia**

The dating of *Stegodon* occurrences is still deficient for insular Southeast Asia and the data are disparate. Due the evolution of the definition of the Plio/Pleistocene boundary, as well as the progression of the significance of biostratigraphy with the new discoveries in the Indonesian Archipelago (Table 3, Figure 1), the correlation of fossil mammalian faunas with Early or Middle Pleistocene periods has been a subject of debate for several decades (Bartstra, 1983; De Vos, 1983, 1984; De Vos et al., 1982; Hooijer, 1957b, 1983; Leinders et al., 1985; Sondaar, 1984; Sondaar et al., 1983; Theunissen et al., 1990; Von Koenigswald, 1956b). Even now, the Javanese occurrences of *Stegodon* are clouded by the conflict between long and short chronologies based on the interpretation of the raw data and the dating methods used by geochronologists.

Stegodon fossils have been found in a number of localities all over Java, but mainly in central and eastern Java and various names have been attributed to these *Stegodon,* as well as a full list of synonyms of *Stegodon trigonocephalus* (Van den Bergh, 1999). Ci-Saat is one of the first Javanese Proboscidean sites with *Elephas* remains described by Von Koenigswald (1934). Leinders et al. (1985) indicate an age of 1.2 to 1.0 Ma for this fauna including *Stegodon trigonocephalus*. For the Early Pleistocene to the Middle Pleistocene, the volcanic dome of Sangiran includes several localities belonging to the Upper Pucangan (=Sangiran), the Grenzbank and the lower part of the Kabuh (=Bapang) formation (Watanabe & Kadar, 1985) with *Stegodon* occurrences. However, two main alternative versions *i.e.* Sémah (2001) & Larick et al. (2001) with biostratigraphic data affiliated to a shorter, or a longer chronology thwart the construction of a biostratigraphic frame (see below).

Following the work of Van den Bergh (1999) in Flores and Sulawesi, Bouteaux (2005) gives an account of the taphonomic processes and details of the stratigraphy of the Javanese sites with *Stegodon* remains. These are mainly surface finds, as at Tanjung locality 63-64 where *Stegodon trigonocephalus* and *Stegodon* sp. were associated with *Elephas* sp. Nevertheless, Bouteaux et al. (2007) observe that, apart from the Tanjung locality, the sites were subjected to the effects of fluvial transport to varying degrees, which can erase the high resolution of the ecological signal by mixing different taxa in a single but long term assemblage. In the Upper Kabuh (=Bapang) formation, *Stegodon* is limited to surface finds at Ngrejeng 85 and Grogol Plupuh and occurs in excavations at Sendang Busik I and II. Still at Sangiran, Aimi & Aziz (1985) collected *Stegodon trigonocephalus* and *Elephas* sp. Indet. at Brangkal in the Kabuh (=Bapang) formation, but only *Elephas* sp. belongs to this level at Tanjung 82, according to Bouteaux & Moigne (2010). The site of Ngebung 2 is also at the base of the Kabuh (=Bapang) formation (Sémah, 2001), but is ascribed to the Middle Pleistocene by Bouteaux (2005) due to the presence of *Stegodon trigonocephalus* remains in layers A, B and U. In layer A, a human right molar was associated with the fauna and lithic artefacts. The archaeological layers of Ngebung site were deposited rapidly and the ages suggest an occupation of the site between 1.0 to 0.7 Ma, according to Falguères (2001), but the range of dating has recently been extended to around 1.26±0.3 to 0.57±0.17 (Falguères et al. 2014). At the Bukuran locality, *Stegodon elephantoides* was found *in situ* in the black clays below tuff 9 of the Pucangan (=Sangiran) formation, with associated dates of 1.3 to 1.2 Ma (Van den Bergh, 1999). Grimaud-Hervé et al. (2012) recently indicated that *Stegodon* sp. and *Elephas* sp. were both associated with a human calvaria. The Trinil 'Haupt-Knochenschicht' fauna (different from the initial Trinil fauna described by Von Koenigswald in 1934 and 1935, which is a mixture of several localities) only contains a single Proboscidean: *Stegodon trigonocephalus* according to Van den Bergh (1999 p.365). This faunal assemblage dates from circa 900 ka (Van den Bergh et al., 2001a, b) or 1.0 Ma for Leinders et al. (1985), but is considered to be around 1.5 Ma by Larick et al. (2001). According to Van den Bergh (1999 p.365), a Late Pliocene or Early Pleistocene dwarf *Stegodon* species is recorded on the bank of the Solo river at the Sambungmacan locality in Central Java. At Perning (=Mojokerto), fauna including *Stegodon* sp. and *Elephas* sp. was identified by Von Koenigswald (1934) in the upper Pucangan formation, but according to Huffmann et al. (2005), most of these remains were surface finds associated with the Early Pleistocene Jetis assemblage, *sensu* Von Koenigswald, which is no longer considered valid. Nevertheless Huffman et al. (2006) relocated the site and indicated new associated Proboscidean finds; *i.e.*, probably *Stegodon trigonocephalus* and/or *Elephas hysudrindicus*. It should also be noted that the upper Pucangan in the area includes strata above and below the hominin-bearing horizon, which complicates the stratigraphic relationship between the Mojokerto skull and the Proboscidean assemblage. According to Huffman (2001), the radioisotopic ages published so far did not necessarily date the deposition of the sedimentary sequence. Although available magnetostratigraphic dating (Sémah, 1986; Hyodo et al., 2002) identified unequivocally reversed polarities in or above the site, the radioisotopic material date by Swisher et al. (1994) may possibly have been ‘’reworked’’ from significantly older bedrock, as is the case for the more recent dating by Morwood et al. (2004).

On Flores Island several Proboscidean fossil remains were collected from the deposits of the Ola Bula Formation in Soa Basin (Hooijer, 1957a, 1964b). At Tangi Talo, in member A of this geological formation, a fossil assemblage, designated as fauna A, contains the dwarfed *Stegodon sondaari.* Palaeomagnetic dating indicates a late Early Pleistocene age for this formation (Van den Bergh, 1999 p.364). This member is conformably overlain by the fluvial deposits of member B, containing a medium-sized elephantoid: *Stegodon florensis* (Van den Bergh, 1999). A fission track date for the layers between Member A and B indicated an age of 900±70 ka (Morwood et al., 1998). Still on Flores, at Mata Menge, *Stegodon sondaari* and *Stegodon florensis* were found in Member B of the Ola Bula Formation (Van den Bergh, 1999). Stone tools found with large *Stegodon trigonocephalus* were initially reported by Maringer & Verhoeven (1970) and dated to around 880±70 and 800±70 ka (Morwood et al., 1998), but *Stegodon florensis* also occurred at this locality according to Van den Bergh et al. (2008). In the same formation, both *Stegodon sondaari* and *Stegodon florensis* remains were unearthed at Boa Leza and *Stegodon florensis* at the Dhozo Dhalu locality (Van den Bergh, 1999).

In Sulawesi, in Sengkang Basin, *‘Elephas’ celebensis* and *Stegodon sompoensis* occur in the fluvial deposits of subunits A and B of the Beru Member of the Walanae Formation (Van den Bergh et al. 1994). Both *in situ* and surface fossil remains were discovered at several localities, such as Sompoh (FVL-25a-b), which is one of the first localities where *in situ* findings of *Stegodon sompoensis* were originally described by Van Heekeren (1949). According to Van den Bergh (1999), this taxon has also been identified at Batua Sange (FVL-9), Palangiseng (FVL-2) in the Lakibong River Valley (FVL-5, FVL-6), Bulu Cepo (FVL-10, FVL-11, FVL-12), near Marale (FVL-15, FVL-16, FVL-17, FVL-18) and Alupang (1 km east of FVL-17), Calio (FVL-20?), on the surface of this fine-grained interval at locality (FVL-24b), from Lonrong (FVL-24c), Celeko (FVL-27), Bulu Barere (FVL-28) and Padali (FVL-30). The oldest age for the ‘Walanae Fauna’ including this taxon is around 2.5 Ma. It is associated with a large-sized *Stegodon* in the deposits of subunit B.

Discussion

In China and Southeast Asia, the fossil record points to the co-occurrence of *Elephas* and *Stegodon* at several sites, mainly during the Middle Pleistocene. Thus, the advent of *Elephas* occurred when *Stegodon* was still extant. This question has repercussions on environmental and ecological changes and a review of former data and works was essential in order to assess the consistency of the available data and to confidently discuss this theme.

Due to the available data, we drastically recommend to give up the former historical benchmark sites which are mixture of faunas or which can not provide information concerning the strict association between dating and the fossil material itself. When indirect dating are providen we consider that such information is of lesser quality than direct dating. We consider that the difference in age between the samples and the dates of their deposition as an additional level of uncertainty but it remains an intrinsic limitation for paleontological data. In the same manner, in the following step of our scaling of the reliability of the information, we consider the theoretical and practical limit of each geochronoloical method and technique as an intrinsic parameter. Limits due to external dose rates received by teeth, spatial variability in radioactive isotope concentrations, changes in the cosmic dose rate through time, uranium concentrations in tooth enamel and dentine or Uranium leaching of sediments, etc have to be taken into account but they are not the main problem at that step of our assessment of the available data. In spite of such limitation, the direct dating remains the best available information but the association of such dating and the fossils should be granted. It should be noticed as well that among the different dating method, paleomagnetism is not considered as the best reliable method as, by définition, it does not concern directly the fossils themselves but their geological context.

During the Early Pleistocene, a main issue emerges from our overview of *Stegodon* and *Elephas* occurrences in China and Southeast Asia: the more reliable Proboscidean co-occurrences generally come from geological formations with low chronological resolution in most cases (Figure 2). This is the case in Taiwan, where *Stegodon insignis*, *Stegodon* cf *orientalis* and *Stegodon sinensis* (now=*Stegodon orientalis*), as well as both *Elephas trogontherii* (now *Mammuthus trogontherii*), and *Elephas indicus,* were present in the T'unghsiaonian sub-age of the T'ouk'oshanian Age, according to Lin (1963). Similarly, in the Upper Irrawady beds, *Stegodon insignis* and *Stegodon elephantoides* were collected with *Elephas hysudricus* at locality M3 at Mingun, and also at locality U1, with a third additional *Stegodon* sp. at Magwe according to De Terra (1943). However, on one hand the estimated age of these geological formations is only based on biochronological criteria, but the historical benchmark assemblages used are now inappropriate, and on the other hand, detailed taphonomic data are not available. The case of the Khorat area (Ban Tha Chang and Khok Sung) in Thailand, with the co-occurrence of *Stegodon elephantoides*, *Stegodon insignis*, *Stegodon* cf *orientalis* and *Elephas* sp. from the Lower Pliocene to the Pleistocene, is rather symptomatic of the lack of available accurate biochronological data. In this case, the relative dating of a possible co-occurrence of *Stegodon* and *Elephas* in the Siam pit (Thasod, 2007) is solely based on the presence of tektites but these abraded tektites may have been transported from older layers. In Java, directly dated geological formations bearing both *Stegodon trigonocephalus* and *Elephas* sp. indet. at Brangkal (Aimi & Aziz, 1985), in the lower part of the Kabuh (=Bapang) formation (trench II-16, IV-2 and IV-3) have been dated by fission tracks from 1.16±0.26 to 0.71±0.10 Ma by Suzuki et al. (1985). However, the dating of this formation is considered to be underestimated by Orchiston & Siesser (1982) and Sémah (1982), or overestimated by Larick et al. (2001) and Bettis et al. (2004). Thus, for this latter case, the problem does not concern the reliability of the dataset but its interpretation. The case of Perning is far from consistent as both *Stegodon trigonocephalus* and *Elephas* sp., previously identified by Von Koenigswald (1934, 1935), belong to the "Jetis fauna" which is no longer valid, and as this assemblage is a mixture of surface finds as shown by Huffman et al. (2005). Finally the new discoveries of 2001-2002, during the repositioning of the original Mojokerto human fossil, resulted in the collection of Proboscidean remains but, this time, with uncertainty as to their taxonomic affiliation: *Stegodon trigonocephalus* and/*or Elephas hysudrindicus* (see Huffman et al. 2006 p. 447), thereby failing to resolve the problem. The co-occurrence of both genera seems to be artificial at Xihoudou in Shanxi province, as *Elephas* is mentioned by Ikawa-Smith (1978 p.194) at locality 6053, whereas only *Stegodon* is indicated by Wei (2000). Further palaeomagnetic investigation suggests an age of about 1.27 Ma for the associated artefacts in the greyish-white and yellow sandy upper part of the second lithological portion (Zhu et al., 2003) of Xihoudou. Nevertheless the link between the Proboscidean remains and the artefacts is still dubious.

As for the accuracy of the chronology for Early Pleistocene Proboscideans, the best and only directly dated faunal remains come from the site of Liucheng (*Gigantopithecus* Cave =Juyuan dong) (Rink et al., 2008), with ESR results between 1.2 and 0.9 Ma and from Chuifeng, between 1.38 and 1.92 Ma (Shao et al., 2014). After considering cases where information is not available, and cases where the quality of the data makes it impossible to obtain high resolution information, a third level of constraint emerge as there are also contradictions and debates as regards the chronology itself. For instance, in our review of Chinese sites we saw that controversy surrounds two chronologies, a long one with an age range for *Stegodon orientalis* from 1.9 to 1 Ma (with *Stegodon preorientalis* expected to be older - Longgupo and Bubing Basin), and a short one where *Stegodon orientalis* is believed to be younger than 1 Ma and *Stegodon preorientalis* occurs between 1.8 and 1 Ma (Sanhe and Queque caves). Similarly, the Javanese occurrences of *Stegodon* could be summed up by the conflict between two chronologies, a long Pucangan (= Sangiran) and short Kabuh (=Bapang) sequence on one hand (Orchiston & Siesser, 1982; Sémah 1982), and a short Pucangan (=Sangiran) and long Kabuh (=Bapang) on the other hand (Larick et al. 2001; Bettis et al., 2004). Thus, the clash between two chronologies, which are only different interpretations due to limited available data, also contributes to limiting the implementation of palaeoecological studies or, at the least, leads to different hypotheses. The lack of information, the use of non natural assemblages to define biostratigraphic references and rare dating of fossils exhort us to be very cautious in establishing any palaeoecological or palaeoenvironmental model to fit with the range of climatic shifts which, by definition, are scaled with the MIS scale during Quaternary.

Concerning the problem encountered for the study of the possible co-evolution or interaction between humans and Proboscideans, the limitation is also due to the uncertainty of the association between the different remains, their chronology and their taxonomy. Recently Wang et al. (2014) suggested considering *Gigantopithecus-Sinomastodon* as the earliest Pleistocene fauna from South China. This suggestion echoes the parallel demise of *Homo erectus* and *Stegodon* among the *Ailuropoda-Stegodon* complex and, later, during the Middle Pleistocene, the emergence of new Hominin and Proboscidean lineages: *Homo sapiens* and *Elephas*. Such parallels have been proposed in different part of the world, such as in the Near East but also in India (Ben-Dor et al., 2011; Lima-Ribeiro et al. 2013; Mishra et al., 2010). *Stegodon* was contemporaneous with *Homo erectus* in Java as many specimens have been found in the Puncangan and Kabuh units at several localities in Sangiran, where the oldest mammal-bearing layers are represented by the lowermost breccia, which correspond to the boundary between the Kalibeng and Puncangan units. Both stone artefacts and *Stegodon* remains have been found in the same geological formation at Mata Menge in Flores (Morwood et al., 1998) and, according to Dong et al. (2000), open-air sites in China with *Stegodon* and human remains include Gongwangling and Shangnabang at Yuanmou. Only two other Chinese sites with stone tools but without human fossils attest to the possible interactions of prehistoric human populations with *Stegodon,* as is the case in Longgupo or Xihoudou, but the strict association of the remains and artefacts cannot be taken for granted for this latter site, nor for Gongwangling and Shangnabang. Finally, datasets are disparate and stratigraphic associations are tenuous or poorly documented and the strict association of Hominins and Proboscideans has not been confirmed for almost all the Early Pleistocene sites.

Conclusion

Our review of the chronological affiliation of sites containing *Elephas* and/or *Stegodon* remains during the Early Pleistocene demonstrates that co-occurrences are mainly based on indirect dating or, at least, are only valid for a low level of chronological resolution *i.e.* too far from the MIS level which is correlated to paloenvironnemtal shifting. The record of the co-occurrence of *Elephas* and *Stegodon* was not continuous in time and space. When the data are quite consistent, the co-occurrence concerns Northern China (at Xihoudou) between 1.7 and 1.3 Ma, Java (Sangiran and Trinil areas) around 1.3 and 1.2 Ma, and Southeast Asia (Siam Pit) between 1.0 and 0.7 Ma. This trend, from the north to the south, with a final retreat to the north would confirm that the use of *Stegodon* versus *Elephas* does not provide a significant information in term of chronological biomarker. At this step, in spite of the recomandations provided in the 1980s (De Vos, 1983, 1984; Orchiston & Siesser, 1982), due to the lack of reliability, our knowledge is not better than those initially provided when Von Koenigswald (1938-1939) undertook one of the first regional comparison trying to establish a regional biostratigraphy between China and Indonesia. The best safe association between Proboscidian and Hominin remains or artefacts is also a dotted line including rare scattered sites from Central China (Longgupo) around 2.0 Ma to Java (Sendang Busik, Perning and Ngebung 2) between 1.3 and 1.0 and finally to Flores (Mata Menge) around 0.8 Ma which concerns *Stegodon* only. Nevertheless, on the whole, in the past, relative dating was founded on incomplete biochronological references or, as we now know, based on scattered sources (layers or chambers) from single sites or caves, or even from different localities for a unique geographical area (town, county, district etc.) which are inappropriate mixtures. Opportunities for further investigation and the reassessment of the ages of the geological fossil-bearing formations are hampered by the uncertain provenance of the fossil material which is preserved in collections. Thus, if considerable further research is required to establish comprehensive radiometric frameworks for China and Southeast Asia, it supposes to work on well-established stratigraphy and safely positioned fossils. Thus, geochronological works on preserved sites or reexcavation have to be undertaken in priority (Jin et al., 2014; Sun et al., 2014). Nevertheless, in such a renewal of fieldwork, in order to avert the further misuse of inappropriate chronological data or unreliable site interpretations for palaeogeographic or palaeoecological purposes, it is essential to exclude most of the early and 'historical' datasets, such as those of Yenchingkuo. Unfortunately, new field (Bacon et al., 2004, 2006, 2008a,b, 2011) or bibliographical (Duringer et al. 2012; Louys et al., 2007; Louys, 2007a,b, 2012, 2014; Louys & Meijaard, 2010; Louys & Turner, 2012) dataset are scaled on such inappropriate references which did not allow to reach the 30-years-old expected progress. Current studies can only lead to false discussions or unfounded hypotheses. In the future, we advocate to mention the exact location of fossils not to lump them in unique listing and to apply direct dating approaches to fossil material. This is the only way to establish whether interaction between humans and proboscideans could have occurred as well as to determine consistent regional faunal benchmarks. When such precious information will be available thanks to favorable field context, one more time, any artificial mixing of fauna in a single list should be avoided in order to establish a secure biostratigraphy.

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Figure captions

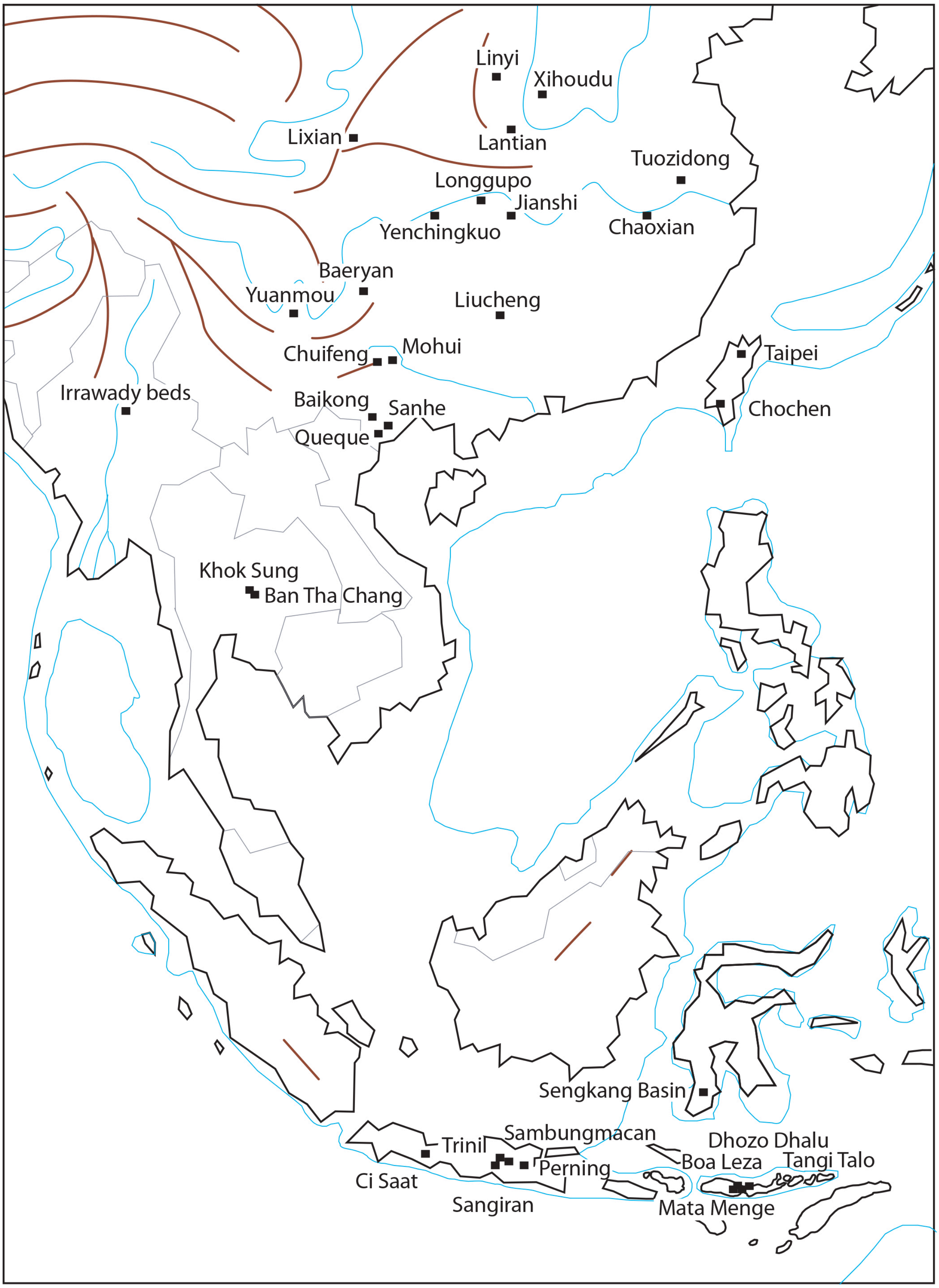


Figure 1
Map of the main Early Pleistocene sites with the occurrence of *Elephas* and/or *Stegodon*

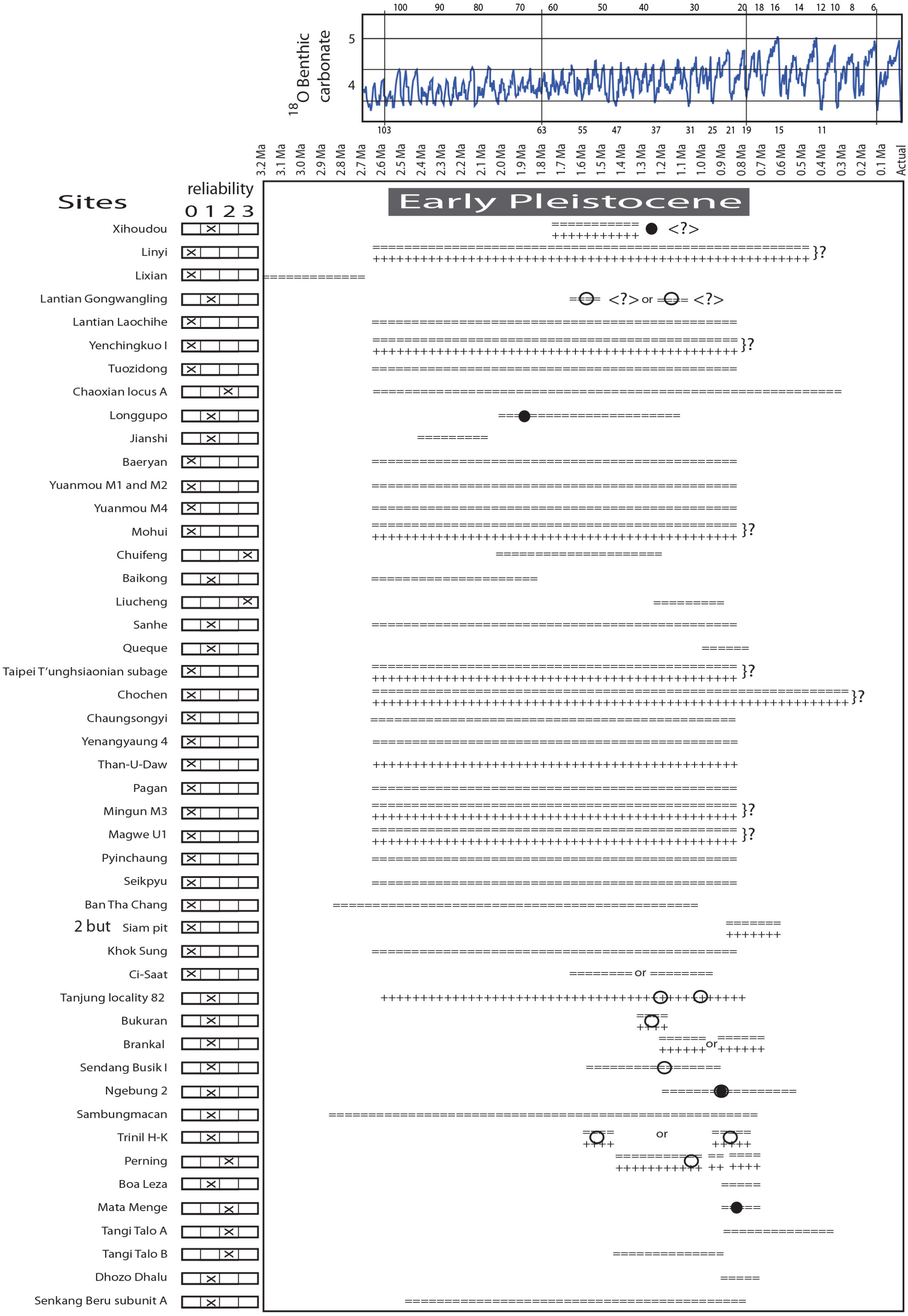
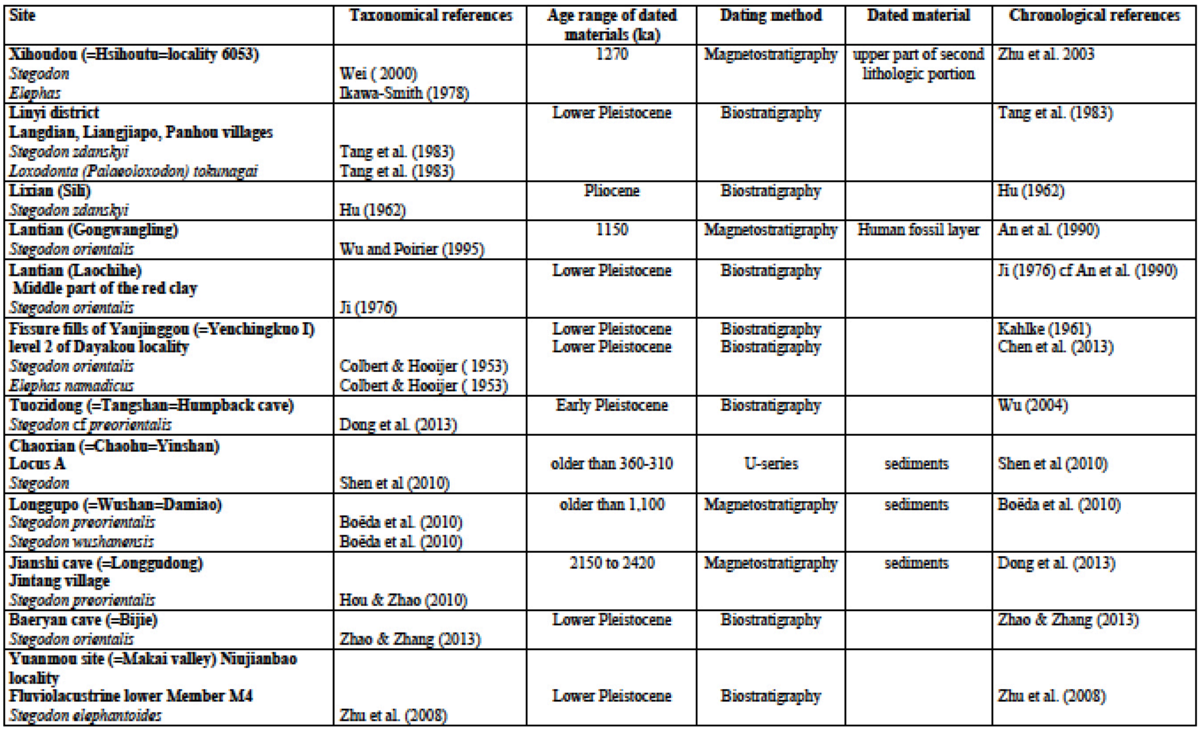


Figure 2

Evaluation of the quality of the available data.

We give up the biostratigraphical data base on the former historical benchmark sites which are mixtures of faunas. When association between dating and the material itself is not granted we also consider that such information is not reliable (score 0). When indirect dating are providen we consider that such information is of lesser quality than direct dating. Among the different dating method, paleomagnetism alone can ofenly be interpretated in different manners thus it is only scored 1 when other methods of direct dating of the sediments are considered to be scored 2. Finally, in spite of their intrinsic limitations, the direct datings of the fossils are the best reliable (score 3).

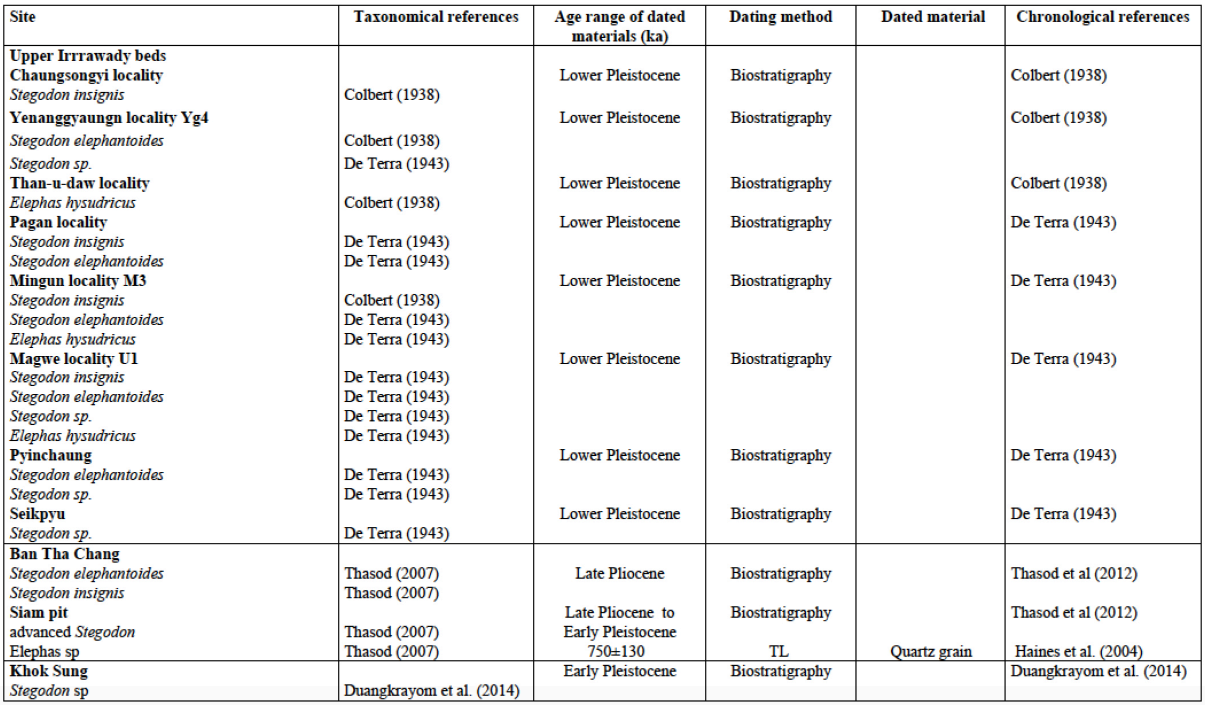
Symbol "=" is applied for the genus *Stegodon* and symbol "+" for the genus *Elephas. "*O" indicates the presence of Hominin remains and "•" the stone artefacts.



Site	Taxonomical references	Age range of dated materials (ka)	Dating method	Dated material	Chronological references
Xihoudou (=Hsihoutu=locality 6053) *Stegodon* *Elephas*	Wei (2000) Ikawa-Smith (1978)	1270	Magnetostratigraphy	upper part of second lithologic portion	Zhu et al. 2003
Linyi district **Langdian, Liangjiapo, Panhou villages** *Stegodon zdanskyi* *Loxodonta (Palaeoloxodon) tokunagai*	Tang et al. (1983) Tang et al. (1983)	Lower Pleistocene	Biostratigraphy		Tang et al. (1983)
Lixian (Sili) *Stegodon zdanskyi*	Hu (1962)	Pliocene	Biostratigraphy		Hu (1962)
Lantian (Gongwangling) *Stegodon orientalis*	Wu and Poirier (1995)	1150	Magnetostratigraphy	Human fossil layer	An et al. (1990)
Lantian (Laochihe) **Middle part of the red clay** *Stegodon orientalis*	Ji (1976)	Lower Pleistocene	Biostratigraphy		Ji (1976) cf An et al. (1990)
Fissure fills of Yanjinggou (=Yenchingkuo I) **level 2 of Dayakou locality** *Stegodon orientalis* *Elephas namadicus*	Colbert & Hooijer (1953) Colbert & Hooijer (1953)	Lower Pleistocene Lower Pleistocene	Biostratigraphy Biostratigraphy		Kahlke (1961) Chen et al. (2013)
Tuozidong (=Tangshan=Humpback cave) *Stegodon* cf *preorientalis*	Dong et al. (2013)	Early Pleistocene	Biostratigraphy		Wu (2004)
Chaoxian (=Chaohu=Yinshan) **Locus A** *Stegodon*	Shen et al (2010)	older than 360-310	U-series	sediments	Shen et al (2010)
Longgupo (=Wushan=Damiao) *Stegodon preorientalis* *Stegodon wushanensis*	Boëda et al. (2010) Boëda et al. (2010)	older than 1,100	Magnetostratigraphy	sediments	Boëda et al. (2010)
Jianshi cave (=Longgudong) **Jintang village** *Stegodon preorientalis*	Hou & Zhao (2010)	2150 to 2420	Magnetostratigraphy	sediments	Dong et al. (2013)
Baeryan cave (=Bijie) *Stegodon orientalis*	Zhao & Zhang (2013)	Lower Pleistocene	Biostratigraphy		Zhao & Zhang (2013)
Yuanmou site (=Makai valley) Niujianbao locality **Fluviolacustrine lower Member M4** *Stegodon elephantoides*	Zhu et al. (2008)	Lower Pleistocene	Biostratigraphy		Zhu et al. (2008)
Yuanmou Formation **Members M1 and M2** *Stegodon yuanmouensis* *Stegodon elephantoides* *Stegodon zhaotongensis*	Qian & Zhou (1993) Qian & Zhou (1993) Qian & Zhou (1993)	Lower Pleistocene	Biostratigraphy		Urabe et al. (2001)
Mohui (=Tiandong) site *Stegodon orientalis*	Wang et al. (2007)	Lower Pleistocene	Biostratigraphy		Wang et al. (2007)
Chuifeng cave *Stegodon orientalis*	Wang (2009)	Lower Pleistocene 1920 ±140 to1380 ±170	Biostratigraphy ESR, U series		Wang (2009) Shao et al. (2014)
Baikong cave *Stegodon hunanensis*	Jin et al. (2014)	2600 to 1800	Magnetostratigraphy and Biostratigraphy	sediments	Sun et al. (2014)
Liucheng (=Gigantopithecus cave=Juyuan dong) *Stegodon orientalis* *Stegodon huananensis*	Jin et al. (2007) Sun et al. (2013)	1200 to 900	ESR Magnetostratigraphy	tooth enamel sediments	Rink et al. (2008) Sun et al. (2014)
Sanhe cave (=Chongzuo) *Stegodon preorientalis*	Jin et al. (2009)	Lower Pleistocene 1800 to 1100	Biostratigraphy Magnetostratigraphy	sediments	Jin et al. (2009) Jin et al. (2014)
Tunghsiaonian subage formations *Stegodon insignis* *Stegodon* cf *orientalis* *Elephas trongotherii* (*Mammuthus trongotherii*) *Elephas indicus*	Lin (1963) Lin (1963) Lin (1963) Lin (1963)	Early Pleistocene	Biostratigraphy		Lin (1963)
Chochen (=Tsochen= =Shinhua Hill) *Stegodon aurorae* (or *Stegodon akasiensis*) *Stegodon orientalis*	Chang et al. (2012) Chang et al. (2012)	Early to Middle Pleistocene	Biostratigraphy		Chang et al. (2012)

Table 1

Chinese Early Pleistocene sites with the occurrence of *Elephas* and/or *Stegodon*



Site	Taxonomical references	Age range of dated materials (ka)	Dating method	Dated material	Chronological references
Upper Irrrawady beds					
Chaungsongyi locality		Lower Pleistocene	Biostratigraphy		Colbert (1938)
Stegodon insignis	Colbert (1938)				
Yenanggyaungn locality Yg4		Lower Pleistocene	Biostratigraphy		Colbert (1938)
Stegodon elephantoides	Colbert (1938)				
Stegodon sp.	De Terra (1943)				
Than-u-daw locality		Lower Pleistocene	Biostratigraphy		Colbert (1938)
Elephas hysudricus	Colbert (1938)				
Pagan locality		Lower Pleistocene	Biostratigraphy		De Terra (1943)
Stegodon insignis	De Terra (1943)				
Stegodon elephantoides	De Terra (1943)				
Mingun locality M3		Lower Pleistocene	Biostratigraphy		De Terra (1943)
Stegodon insignis	Colbert (1938)				
Stegodon elephantoides	De Terra (1943)				
Elephas hysudricus	De Terra (1943)				
Magwe locality U1		Lower Pleistocene	Biostratigraphy		De Terra (1943)
Stegodon insignis	De Terra (1943)				
Stegodon elephantoides	De Terra (1943)				
Stegodon sp.	De Terra (1943)				
Elephas hysudricus	De Terra (1943)				
Pyinchaung		Lower Pleistocene	Biostratigraphy		De Terra (1943)
Stegodon elephantoides	De Terra (1943)				
Stegodon sp.	De Terra (1943)				
Seikpyu		Lower Pleistocene	Biostratigraphy		De Terra (1943)
Stegodon sp.	De Terra (1943)				
Ban Tha Chang					
Stegodon elephantoides	Thasod (2007)	Late Pliocene	Biostratigraphy		Thasod et al (2012)
Stegodon insignis	Thasod (2007)				
Siam pit		Late Pliocene to Early Pleistocene	Biostratigraphy		Thasod et al (2012)
advanced *Stegodon*	Thasod (2007)				
Elephas sp	Thasod (2007)	750±130	TL	Quartz grain	Haines et al. (2004)
Khok Sung		Early Pleistocene	Biostratigraphy		Duangkrayom et al. (2014)
Stegodon sp	Duangkrayom et al. (2014)				

Table 2

Continental Southeast Asian Early Pleistocene sites with the occurrence of *Elephas* and/or *Stegodon*

Site	Taxonomical references	Age range of dated materials (ka)	Dating method	Dated material	Chronological references
Ci-Saat		1,200 to 1,000	Biostratigraphy		Leinders et al. (1985)
Stegodon trigonocephalus	Van den Bergh et al. (2001)				
Kabuh (= Bapang) formation (Sangiran dome)		1,500±80 to 1,020±60	$^{40}Ar/^{39}Ar$	sediment	Larick et al. (2001)
Sendang Busik I		Lower Pleistocene	Magneto and biostratigraphy	sediment	Bouteaux (2005)
Stegodon sp.	Bouteaux (2005)				
Brangkal		Lower Pleistocene	Magnetostratigraphy	sediment	Aimi & Aziz (1985)
Stegodon trigonocephalus	Aimi & Aziz (1985)	1,160±26 to 710±10	Fission track	sediment	Suzuki et al. (1985)
Elephas sp.	Aimi & Aziz (1985)				
Tanjung locality 82		Lower Pleistocene	Magnetostratigraphy	sediment	Sémah (2001)
Elephas sp.	Bouteaux & Moine (2010)				
Ngebung 2		1,260±300 to 570±170	U/Th and ESR	sediment+enamel	Falguères et al.(2014)
Stegodon trigonocephalus	Bouteaux (2005)	Lower Pleistocene	Magnetostratigraphy	sediment	Sémah (2001)
Bukuran formation (Sangiran dome)		1,300 to 1,200	Magneto and biostratigraphy	sediment	Van den Bergh (1999)
Stegodon elephantoides	Van den Bergh (1999)				
Stegodon sp.	Grimaud-Hervé et al. (2012)	latest Early Pleistocene	Biostratigraphy		Grimaud-Hervé et al. (2012)
Elephas sp.	Grimaud-Hervé et al. (2012)	latest Early Pleistocene	Biostratigraphy		Grimaud-Hervé et al. (2012)
Trinil 'Haupt-Knochenschicht'		900	Biostratigraphy		Van den Bergh et al. (2001)
Stegodon trigonocephalus	Van den Bergh (1999)				
Elephas cf *namadicus* (*E. hysudrindicus*)	Bouteaux (2005)				
Sambungmacan		Late Pliocene or Early Pleistocene	Magneto and biostratigraphy		Van den Bergh (1999)
dwarf *Stegodon*	Van den Bergh (1999)				
Perning (=Mojokerto)		1,490±130 and 1,430±150	fission track	sediment	Morwood et al. (2004)
Upper Pucangan (= Sangiran) formation		990 to 1070	Magnetostratigraphy	sediment	Hyodo et al. (2002)
Stegodon trigonocephalus or Elephas hysudrindicus	Huffman et al. (2006)	> 780	Magnetostratigraphy	sediment	Sémah (1986)
Stegodon sp.	von Koenigswald (1934)	Late Pliocene or Early Pleistocene	Biostratigraphy		von Koenigswald (1934)
Elephas sp.	von Koenigswald (1934)		Biostratigraphy		von Koenigswald (1934)
Tangi Talo Member A		younger than 900±70	Fission tracks	sediment	Morwood et al.(1998)
Stegodon sondaari	Van den Bergh (1999)				
Member B		older than 900±70	Fission tracks	sediment	Morwood et al.(1998)
Stegodon florensis	Van den Bergh (1999)				
Member B of the Ola Bula formation		>990±20	$^{40}Ar/^{39}Ar$	sediment	Lindelof (2014)
Mata Menge		880±70 to 800±70	Fission tracks	sediment	Morwood et al.(1998)
Stegodon sondaari	Van den Bergh et al. (2008)				
Stegodon florensis	Van den Bergh et al. (2008)				
Stegodon trigonocephalus	Maringer & Verhoeven (1970)				
Boa Leza			Stratigraphy		Van den Bergh (1999)
Stegodon sondaari	Van den Bergh (1999)				
Stegodon florensis	Van den Bergh (1999)				
Dhozo Dhalu			Stratigraphy		Van den Bergh (1999)
Stegodon florensis	Van den Bergh (1999)				
Sengkang Basin (Sompoh) Beru Member subunit A		2,500	Magneto and biostratigraphy	sediment	Van den Bergh (1999)
Stegodon sompoensis	Van Heekeren (1949)				

Table 3

Insular Southeast Asian Early Pleistocene sites with the occurrence of *Elephas* and/or *Stegodon*

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