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Valery Zeitoun, Winayalai Chinnawut, Régis Debruyne, Stéphane Frère, Prasit Auetrakulvit

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A sustainable review of the Middle Pleistocene benchmark sites including the *Ailuropoda - Stegodon* faunal complex: The Proboscidean point of view.

Zeitoun Valéry
UMR 7207 (CR2P), CNRS-Upmc-Mnhn, Sorbonne universités, Université Pierre et Marie Curie, T. 46-56, 5ème étage, case 104, 4, place Jussieu, 75 252 Paris Cedex 05, France.
pythecanthro@gmail.com
Chinnawut Winayalai
8th Regional Office of Fine Arts Department, Ubon Ratchathani, Thailand.
Debruyne Régis
UMS 2700 OMSI, Service de Systématique Moléculaire du Mnhn, 57 rue Cuvier, CP26, 75231 Paris cedex 05, France.
Frère Stéphane
INRAP-UMR7209, Archéozoologie, archéobotanique : sociétés, pratiques et environnements. CRAVO, 36 av Paul Vaillant Couturier 93120 La Courneuve, France
Auetrakulvit Prasit Department of Archaeology, Silpakorn university, Na Phra road, 10 220 Bangkok, Thailand.

Abstract:
The different ecologies, times of extinction and 'last stand' of both *Elephas* and *Stegodon* in South-east Asia is covering almost two million years. For Middle Pleistocene, both taxa belong to the complex *Ailuropoda-Stegodon*. This regional complex is considered to have a chronological significance and further palaeoecological, palaeobiogeographical or biochronological studies are using this assemblage as a benchmark. Nevertheless, such studies do not provide sufficient information regarding site formation and duration to be consistent enough to do so at an appropriate resolution (MIS timescale). Focussing attention on the occurrence of Proboscideans, a critical review of the robustness of the geological, taphonomical and chronological data of Middle Pleistocene faunal assemblages suggests to undertake a deep reappraisal of this "biochronological benchmark". Recomandations were provided in the 1980s not to use mixtures of faunal assemblages and progress in geochronology for two decades are available. Nevertheless, reviewing Proboscideans suggests the necessity of a severe revision and leads to be very sceptical on the use of the *Ailuropoda-Stegodon* complex as an ecological marker. Extended to other taxa such a review casts serious doubts on former and current paleoecological modellings and studies.

Key-words: Biochronology ; *Stegodon* ; *Elephas* ; dating; palaeoenvironment.

Introduction

Although some limitations have been mentioned and discussed on numerous occasions, various authors currently use the complex *Ailuropoda-Stegodon* to construct palaeoenvironmental or palaeogeographical models with little or no caution. The purpose of this paper is to provide a sustained and compelling deconstruction of previous claims of palaeoenvironmental studies based on this complex. A reappraisal of the *Ailuropoda-Stegodon* complex in the aim to reconstruct palaeoecological facts was recently published by Turvey et al. (2013) for Late Pleistocene and a first assessment of the occurrence of *Elephas* and *Stegodon* in Eastern Asia during Early Pleistocene was proposed by Zeitoun et al. (2015). Both showed the weakness of the available dataset usable for biochronological or palaeoenvironmental purposes. For the intervening period, *id est* Middle Pleistocene, sites are numerous (Figure 1). They are characterized by the complex *Ailuropoda-Stegodon* which evolution is used to describe palaeoecological shifts during the time or among which disappearance of taxa is supposed to be the marker of the advent of modern fauna. When dealing with Chinese and South-east Asian fossil material from collections over 30 years old, authors are generally supposed to be aware of the inherent limits of these collections but even recent fieldworks currently scale their faunal assemblages on inappropriate benchmarks.

Initially identified in South China in connexion with tropical taxa such as *Hylobates* and *Tapirus* (Matthew and Granger, 1923), later discovered elsewhere in China (Bien and Chia, 1938; Granger, 1938; Pei, 1935; Young, 1932), Vietnam (Patte, 1928), Laos (Fromaget, 1936) and Burma (De Terra, 1943), this "Sino-

Malayan" fauna described by von Koenigswald (1938-1939) was considered as a marker of Middle or Upper Middle Pleistocene in South-east Asia by many former authors (Colbert and Hooijer, 1953; Ginsburg et al., 1982; Han and Xu, 1985; Kahlke, 1961; Pei and Wu, 1956; Pope et al., 1981; Schepartz et al., 2003 among others). Nevertheless, this term is a very general one and the problematical nature of the absolute chronometric dating of this assemblage makes biostratigraphic correlation an unsastisfactory method for determining the affiliation of the regional sites as currently proposed (De Vos, 1984 ; Olsen and Ciochon, 1990 but see also Orchiston and Siesser 1982 for criticisms of the use of artificial faunal lists). Even if few effort have been undertaken since last decade, it is still difficult to determine reliable age estimates for many of the cave sites from which the faunas mainly derive (Rink et al. 2008). The *Ailuropoda-Stegodon* assemblage is currently associated with faunas spanning most of the Pleistocene, and thus, potentially masking important temporal and spatial faunal variations (Wang et al. 2007). Moreover *Ailuropoda, Pongo* and *Stegodon* are not systematically present together in each site (cf Bacon et al., 2004; Bekken et al., 2004; Cuong, 1992; Dong et al., 2000; Kahlke, 1961; Long et al.,1996; Tougard, 1998, among many others) and, sometime, even if all of the three taxa are present in a single site, they are not found together in the same layers (cf Zeitoun et al., 2010). Such detailed information depends on the time resolution available to describe the faunal assemblage. Thus, according to its definition, the relevance of this regional complex will be different if it is used to describe palaeogeography (Long et al., 1996; Louys and Turner, 2012; Von Koenigswald, 1939; Mishra et al., 2010; Pei, 1957; Tougard, 2001), biochronology (Colbert and Hooijer, 1953; Cuong, 1992; Han and Xu, 1985; Kahlke, 1961; Louys, 2012; Pei, 1957; Tougard, 1998; Van den Bergh, 1999; Von Koenigswald, 1956a) or palaeoecology (Louys and Meijard, 2010; Tougard and Montuire, 2006). Both *Stegodon* and *Elephas* are belonging to this assemblage but their presence is differently interpretated.

Chronological range and biases avoiding to properly use the complex *Ailuropoda- Stegodon*

- Uncertainties in the historical collections

The definition of *Ailuropoda-Stegodon* complex is depending of several biases. Most of the former dugs did not follow the modern technique of excavations and sometime different collections from several proveniences (including drugstore) were lump together. For instance, in the case of the Hsinganshien cave in China, Pei (1935) associated faunal material collected with fossils bought in the drugstores because their provenience seemed to be from the same "*Yellow Deposit*". Young and Liu (1950 p.46) also lumped together the remains from several caves of Koloshan to make a series as the fossils came from "*the brecciated yellow clay type*". The problem of these historical sites lies in the fact that they are repetedly used as biochronological benchmarks.

Scaling new discoveries on such former inappropriate benchmarks wastes considerably the efforts realized by undertaking fieldwork.

- The Mixtures in the recent excavations

In Vietnam, the site of Tham Khuyen contains deposits from several periods in the form of different breccia fragments scattered around the cave walls (Cuong 1992). However the listing provided by this author does not relate in which breccia the different remains were found. Following this work, the precise stratigraphy of the site published by Ciochon et al. (1996) does not refer to this scattered faunal remains even if these authors indicate in detail a series of fossiliferous deposits settled under a calcite floor. Still in Vietnam, at Duoi U'Oi cave Bacon et al. (2008a) did mix the faunal corpus found in three different corridors (1, 2 and 3) and, at Ma U'Oi cave, the faunas found in two distinct corridors (A2 and B) are lumped under the name "*in situ* fauna" (Bacon et al., 2006, p. 282). Mixing raw information wastes considerably the efforts realized by undertaking fieldwork. At last, as a preliminary condition to discuss palaeoenvironment or biochronology (see Saegusa, 2001), it is usefull to consider each locality one by one, as well as each layer in a single site, to be able to correctly use the fossil record. Even if this remark costs for the sites where the stratigraphy is readable, which is far to be the case in most of the breccias in caves, this kind of lumping does erase the stratigraphical information.

- The lack of taphonomical study

Moreover, a selection among the fossil pieces on the field may have been done by the former workers while paleontologists were more fossil-hunters than nowadays but see Chaimanee (2007 p.3193) for such a current practice. Huffman et al. (2005) underline the fact that "*Von Koenigswald was well educated in geology, but judging from the historical record, did not place a high value on geological context in fossil studies…* " and " *…One of his former students said that von Koenigswald instructed students never to go into the field to collect fossils because the locals would not reveal the richest localities, and a competent paleontologist did not need to know the field situation in order to construct a correct biostratigraphic framework* ". Concerning the cave filling, there is still not enough detailed information available relatively to taphonomy (*id est* occurrence of porcupine den, carnivore den, human activities, natural deposit in karst-filling or water system) in the publications as indicated by Bakken (1997) two decades ago.

- The evolution of the taxonomy

Some changes in term of taxonomy may occur since the publications of the old sites and their use in more recent bibliographic works (Zong, 1995). For instance, in one hand Shoshani et al. (2001) consider that *Palaeoloxodon* is a *bona fide* genus instead of a subgenus of *Elephas* and, Gheerbrant and Tassy (2009) lump both *Palaeoloxodon* and *Elephas* as synonymous taxa as many former authors did for years. But this taxonomic consideration is not taken into account nor discussed in recent papers like these based on Louys (2007a). The comparison of faunal listing from old works has to be done very cautiously before to be used to build palaeoenvironmental or biochronological frames due to all these biases and modifications. It is important to be aware of the intrinsic quality of the database for other points as well.

- Confusion in the provenience of the fossils

Confusion has partly originated from the imprecise and inconsistent designation of sites and localities. The site of Tam Hang in Laos concerned three cavities (Fromaget, 1940) including "Tam Nang" (Arambourg and Fromaget, 1938) with three different horizons for this single cavity. This fact was not known in the initial work of Louys (2007a) (but see Louys and Meijaard, 2010). Such mistake also exists concerning China where the use of one single regional name for several localities brings confusion, as do the different names used to describe a single site. For instance, Koloshan in Szechuan, includes several cavities: Kanchuantung, Wuchiatatung locality 51 and 52, Lungkutung, Kuanyintung and Hoshangtung (Young and Liu, 1950) but in the publications the fauna is generalised under the name of "Koloshan site". Moreover a second site named Hoshangtung lies near Fumin in Yunnan province (Bien and Chia, 1938 ; Colbert, 1940). Another case concerns Changyang in Hubei province which first concerns the Lungtung cave near Hsiachungchiawan village. Finally different names were mentioned for Changyang locality *id est*: Xiazhongjawan=Zhongjawan, Guojiuyan and Longdong (Olsen and Miller-Antonio, 1992).

More recently, fifteen new localities including Migong cave, Leiping cave and Xinglong cave are indicated by Pei et al. (2013) in addition to the former Zhongjawan cave. Yuanmou was initially used as the name of a single site for the Yuanmou Basin which finally concerns many localities: Shangnabang, Sijiacun, Xiaqiliu, Xincun, Danengyucun, Laoyatang (Olsen and Miller-Antonio, 1992). This is the same case for Tongzi province, initially use as a synonymous name for the single Yanhui cave, and which finally includes at least two distinct localities: Yanhuidong and Ma'anshan (*op. cit.*). This kind of indication was not readable in numerous papers for a while and, thanks to the wider international publications of our Chinese colleagues, it is now easier to avoid such mistakes.

- Omission, selection of the data and inclompleteness

Some bibliographical selection or omission also introduces some biases by occulting some data. For instance, Mourer (1977, 1994) expressed controversy about the Pleistocene age of the faunas of Phnom Loang in Cambodia but this information has been dropped out without any discussion by authors (Bacon et al., 2004, 2006, 2008a,b, 2011; Chaimanee, 2007). Sometime some mistake can also happen as it can be noticed in Jin et al. (2009 table 1 p. 3852) with the lack of a linea within the Proboscidean group concerning *Stegodon*.

The lack of reliable age combined with the stratigraphic complexities of karstic cave sediments, but also from fluviatil and volcanic deposits, have prevented a more fine-grained understanding of the temporal characteristics of species level changes in local sequences as well as relationships between discrete geographic areas among the *Ailuropoda-Stegodon* complex (Rink et al., 2008) and, at most sites, the stratigraphic association between material or horizons yielding dating and fossils is not enough clearly demonstrated or is dubious because of the possibility of reworking (Haines et al., 2004 ; Bekken et al., 2004; Pierret et al., 2012 ; Schepartz et al., 2003). Finally, the simple presence of some genera belonging to the *Ailuropoda-Stegodon* assemblage is not useful in distinguishing Early from Middle Pleistocene faunas (Wang et al., 2007).

Even if, for a while, some works were a state of the art and suggest hypotheses (Bouteaux, 2005; Colbert 1943 ; Kahlke, 1961 ; Long et al., 1996 ; Louys, 2007b; Louys et al., 2007; Patte, 1928 ; Tougard, 1998, 2001; Van den Bergh, 1999 ; Von Koenigswald, 1956b), the use of the *Ailuropoda-Stegodon* assemblage as a chronological marker still casts doubts in a palaeoenvironmental study as, mainly, biostratigraphic correlation without independant chronological data are generally used.

- Chronological proxies and recent development

Following the recommandations provided in the 1980s (De Vos, 1983, 1984; Orchiston and Siesser,

1982) to pay attention to the mixed nature of faunal assemblages and, in spite of progress in geochronology, it is certainly time to consider the reappraisal of different sites and taxa belonging to the *Ailuropoda-Stegodon* complex under the light of direct dating, especially in the aim to reconstruct palaeoecological facts as did Turvey et al. (2013) for Late Pleistocene. An additional condition has to be taken into account to correctly treat palaeoecology. Indeed, if the time frame of site formation is longer than periods of climatic fluctuation (MIS timescale), then several faunal assemblages may occur together and, depending on the quality of the fossil record it will be possible, or not, to provide sustainable and meaningful palaeoecological hypotheses.

The chronological range of the complex *Ailuropoda-Stegodon* appears to be wide and, as the problem of non-homogeneity in paleontological assemblages echoes the remarks of several authors (Patte, 1928; De Vos, 1984; Colbert, 1943; Kahlke, 1961; Pei, 1957), in South-east Asia many faunal assemblages are a mixture of several periods and environments. The study of several karstic caves of varying elevation within the Basins of South China led Wang et al. (2007) to conclude to the species-level changes with the appearance of *Elephas* and the local disappearance of *Stegodon*. Nevertheless this approach can only be considered as a local fact or, at least, as a first approximation to investigate faunal variations related to climate change, biogeographic events, and evolutionary change. Indeed, the compared faunas of these study do not come from a single site but from different caves of a single area and, in Northern Thailand, the Cave of the Monk, with a fortunate higher resolution of the fossil record in a single site (Zeitoun et al., 2010) allows to show that *Elephas* and *Stegodon* replaced each other through the time at several occasions during the Late Pleistocene.

Dating methods are increasingly applied directly to fossils (Chen et al., 1987 ; Chen and Yuan, 1988 ; Jones et al., 2004 ; Rink et al., 2008; Wang et al., 2007; Zeitoun et al., 2010) but also to neighbouring deposits. In this latter case the stratigraphic association between remains and deposits cannot always be taken for granted due to the lack of sedimentological or taphonomical studies (*id est* Bacon et al. 2006, 2008a; Ciochon et al. 1996; Esposito et al. 1998, 2002 ; Indriati et al. 2011). At last, the chronological range of the complex *Ailuropoda-Stegodon* appears to be quite wide. In the single site of Tham Wiman Nakin in Thailand this complex is ranging from 350 to 8 ka (Esposito et al., 2002) without possibility to distinguish different layers among the breccia. In China, its span is quite large also at Wuyun site, as Wang et al. (2007 p. 374) indicate that the excavated fossiliferous assemblages dates from 287.6±60.0 ka to 14.19±4.2 ka.

Antiquity and contemporaneousness of the genus *Stegodon* and genus *Elephas*

- The taxonomical background for local Proboscideans

Our purpose here is not to embark upon a detailed discussion of the current taxonomy of Proboscidean taxa as undertaken by Chen (2011) for Chinese taxa, especially as the description of *Stegodon* within species level have been argued in validity and status. For the Middle Pleistocene of South-east Asia, as *Palaeoloxodon* and *Elephas* are synonymous taxa (Gheerbrant and Tassy, 2009) only two Proboscideans are present : *Stegodon* and *Elephas*. Among them, the following species are currently accepted in Indonesia: *Stegodon florensis* Hooijer, 1957 and *Stegodon sondaari* van den Bergh, 1999. *Stegodon trigonocephalus* (Martin, 1887) and *Stegodon hypsilophus* Hooijer, 1957 may be present for the older part of this period. *Stegodon zdanskyi* Hopwood, 1935 is more common on mainland South-east Asia. For China, *Stegodon chiai* Chow & Zhai 1962 will emerged in Shanxi, Shaanxi and Jiangsu provinces as a distinct form of *Stegodon zdanskyi* and, *Stegodon zhaotongensis* Chow & Zhai, 1962 is present in Yunnan province. Finally, *Stegodon orientalis* Owen, 1870 is the more generalist form present in insular and mainland South-east Asia. Concerning the genus *Elephas*, both species *Elephas hysudrindicus* Hooijer, 1955 and *Elephas namadicus* (Falconer & Cautley, 1846) are now affiliated to *Elephas maximus* Linneaus 1758.

- Antiquity of the genus *Stegodon* and genus *Elephas*

The span of the genus *Stegodon* is wider than the chronological range of the complex *Ailuropoda-Stegodon* itself and only provides a first step to discuss the significance and the convenience to undertake palaeoecological, palaeobiological and palaeobiogeographical studies according to the faunal assemblage including this taxon. For Saegusa et al. (2005), Stegodontidae are major faunal elements of the Quaternary and Neogene of Asia and the earliest taxa are dated back to about 9 Ma in China, 6 Ma in Thailand, 5.5 Ma in Japan and 4.5 Ma in India. Considering the unique *Stegodon orientalis* and its closest forms, the genus is present in China and in Indonesia for more than 1 Ma (Kahlke, 1961; Van den Bergh et al., 1994). But, the earliest known terrestrial fossil assemblage of Flores including this taxon dated to about 2.5 Ma in the Walanae Formation and, *Stegodon sompoensis* is present a little bit earlier in the subunit A of Beru Member in South Sulawesi (Van den Bergh, 1999; Van den Bergh et al., 2001 b). The dataset concerning *Stegodon* has been complementarized for Insular South-east Asia by Van den Bergh et al. (2001a) indicating an increasing accessibility of the Java region between 1.5 Ma and 800 ka due to the low sea-level with the occurrence of

Stegodon sondaari at the easternest part of Indonesian Archipelago at Tangi Talo locality in Flores with dates older than 900±70 ka. *Stegodon* were present in Sulawesi (Allen, 1991; Van Heekeren, 1958; Hooijer, 1958, 1964; Van den Bergh, 1999), in Timor (Glover and Glover, 1970; Hooijer, 1969, 1972; Maringer and Verhoeven, 1970; Van den Bergh et al., 2001a,b) and in Philippines (Fox, 1978; Von Koenigswald, 1956a; Wasson and Cochrane, 1979) but their stratigraphical location is often uncertain. West of Huxley's Line, there is sometime association of *Stegodon* fossils with lithic artifacts (Allen, 1991) but, without chronological reappraisal, the dating of the deposits remains unclear for many of theses sites even if the 'Hominid' sites have best chance to be dated.

Focussing on Middle Pleistocene it is possible to make a listing of the sites where *Stegodon* has been discovered but, with the lack of control on the original position of the remains in the sites in one hand and, the lack of direct dating in the other hand, it is only possible to propose a temporary state of the art on this question. Each site will need a complete reappraisal of the field data reports as exemplaryly undertaken by Van den Bergh (1999) for Flores and Sulawesi, or Huffman et al. (2005, 2006, 2010) for Ngandong and Perning in Java, or will need a critical review of the bibliographical data as provided by Turvey et al. (2013) for Late Pleistocene and Zeitoun et al. (in press) for Early Pleistocene sites of South-east Asia and China.

A critical review of *Stegodon* and *Elephas* occurrence in the complex *Ailuropoda- Stegodon.*

- Continuity and replacement of Proboscideans in South-east Asia

Stegodon, but also *Elephas* belong to the *Ailuropoda-Stegodon* assemblage but different interpretations occur among authors. For instance, the fossil record is considered to indicate a turnover with replacement of *Stegodon* by *Elephas* in Flores island (Sondaar et al., 1994 ;Van den Bergh, 1999) but this turnover is differently dated according to the area taken into account. The replacement happened between 600 and 200 ka in India (Mishra et al. 2010) when *Stegodon* was replaced by a modern rainforest fauna including *Elephas* around 128 ka in Indonesia (Westaway et al., 2007). Following many former authors who did aim to build a biochronological frame from faunal correlation (but see Olsen and Ciochon, 1990), 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 a chronological landmark. Such a basis to contruct theoretical hypothesis has to be confronted to the facts. Thus, in Viet Nam, at Ma U'Oi (Bacon et al., 2006) reported the presence of *Elephas* sp. in the "*in situ* fauna" from a fossiliferous breccia which includes the fossil remains of two disctinct corridor A2 and B (*op. cit.* p.282). It should be noticed that it is only possible to reallocated the *Elephas* to the corridor A2 of Ma U'Oi according to Bacon et al. (2004) because the corridor B was not excavated at the time of the former pubication. According to figure 4 A (*op.cit.* p.285), the dating of the breccia between more than 193±17 ka and 49± 4 ka concern the roof of the corridor A and could be attibuted to *Elephas* sp. but such a data is not clearly indicated by the authors. This taxon is also described at Duoi U'Oi cave (Bacon et al., 2008a) but the faunal list concerns different spots scattered in a single cave : "*The sedimentological analysis of the Duoi U'Oi cave shows that the fossiliferous deposits represent several thousand years of accumulation*" (*op.cit.* p.1646), and the fossil remains are present over and below the calcitic floor dated to 66±3 ka (figure 5 p. 1631). Thus, no precise biochronological data can be used for *Elephas* sp. in that site nor similar data from Tam Hang in Laos as finally admitted by Bacon et al. (2015. p117) : "*Tam Hang and Nam Lot have only ever been discussed using estimated chronologies*".

- Co-ocurence of *Elephas* and *Stegodon* during the Pleistocene

Both *Elephas* and *Stegodon* appear to co-occure in several sites from the mainland to the Insular South-east Asia potentially from Early Pleistocene (but see Zeitoun et al. 2015) to, more probably, Late Pleistocene (Turvey et al. 2013). To clarify, precise analysis of the stratigraphical record has to be checked, first of all, by drawing attention on the time resolution of the fossilifereous layers, but also according to the faunal list. This list may only yielded from a single site and not from a group of localities lumped together. At last, from a chronological point of view, the co-occurrence of *Elephas* and *Stegodon* is theoretically possible in South-east Asia as *Elephas* are described as early as in the Lower part of Kabuh Formation at Sangiran in Indonesia (Aimi and Aziz, 1985) and as *Stegodon* will have a 'last stand' in the horizon n°2 of Shuanglong cave in China dated of 7815±385 BP (Ma and Tang, 1992). Concerning this last point, Turvey et al. (2013) recently provide a robust critical review of the Holocene 'last stand' but suggesting the possibility for a Late Pleistocene occurrence of *Stegodon.*

Considering the 'first stand' occurrence of *Elephas* it is also necessary to verify the meaning of such taxon because of the evolution of its synonymy. Indeed, following the first description of Hooijer (1949), Van den Bergh (1999) described a large form of Proboscidean under the term '*Elephas*' (with coma) in Celebes which does not belong to the genus *Elephas* but to *Stegoloxodon* (Markov and Saegusa, 2008). Clarifying the taxinomy, the stratigraphy, the taphonomy and the chronology of the Middle Pleistocene faunal assemblages is of particular interest to build a useful biochronological frame to reconstruct the palaeoenvironments and to describe their evolution instead of providing unfounded assertions by omitting several references and data. Allowing indicated exception, most of the following faunal occurrences are biostratigraphicaly scaled by comparison of each of them by the authors. Thus, the level of precision of the data is very different from one site to another and it is obviously easier to criticism, but to improve, more detailled data than incomplete ones. From North to South and from West to East during the Middle Pleistocene, the main occurrences of *Stegodon* appear to be the following :

Occurrences during the Middle Pleistocene *sensu lato*

- The Chinese provinces (Table 1)

In China, in Shanxi province, at Taiyuan locality, Wang (1961) indicated the occurrence of *Stegodon zdanskyi* but this taxon is supposed to be present from 3.5 to 2.9 Ma (Van der Geer et al., 2010 p.237) or at least to disappear around 2.0 Ma in China (Saegusa et al. 2005 p.32) although Tong (2006) considers this site to be Middle Pleistocene. The *Stegodon* remains yielded from Tunliu locality are said to belong to Middle Pleistocene by Tong (2006) as well, but according to Zong et al. (1982), the deposits of this site are subdivided in three formation *id est* Xiaochangcun : Early stage of Middle Pleistocene, Daqiang without fossil and, the very rich fluviolacustrine deposits of Xicun Formation including *Stegodon* cf *chiai*. At Kehe (=K'oho= locality 6054) the *Stegodon* remains are attributed to Middle Pleistocene by Tong (2006) but the age of stone tools and the associated fauna is puzzling since its discovery (see Chiu, 1962 and Chia, 1962). Ikawa-Smith (1978 p.193) indicated the occurrence of *Elephas* cf *namadicus, Stegodon* cf *orientalis* and *Stegodon chiai* at the same locality but without detail for the stratigraphy and, according to Saegusa et al. (2005), the faunal assemblage from Kehe is a mixture of fossils from two different stratigraphic levels.

In Shaanxi province, one of the Lantian sites : Chenjiawo (=Chen-chia-ou=Lantian) provided a single *astragalus* of '*Elephas*' sp. cf *Elephas namadicus* according to Chow (1964 p.307). It was found in the Upper part of the Paleosol-6 (S6) (Wang et al., 1997) together with the human fossil reported to be dated around 650-530 ka by Wu (2004).

In Henan province, at Xinghua Shan hill (=Yunyang= Nanzhao), *Stegodon* sp. yielded from the brown yellow sandy clay of the second terrace above the Jihe River (Qiu et al., 1982). In Tanshan city, Huludong cave (=Calabash cave=Nanjing), is suggested to be a den of hyenas by Vialet et al. (2010) from where *Stegodon* remains were located in the same layer than *Homo erectus* remains with U-series age of 430 to 280 ka according to Zhu and Zhang (2000).

In Anhui province, the site of Chaoxian (=Chaohu=Yinshan) is composed of two groups of fosiliferous deposits situated at about the same level but separated by a limestone ridge. The Locus A deposits were attributed to the Early Pleistocene and the Locus B deposits were attributed to the Middle Pleistocene (Shen et al., 2010). The hominin fossils were retrieved from heavily consolidated Layer 2 at Locus B and (*op. cit*) should be bracketed in the range of 310–360 ka. The faunal remains exist in layers 1, 3 and 4 at Locus B. Wu and Poirier (1995) indicate that *Stegodon* sp. are present in the two upper layer aswell as in layer 3 to 5. Discovered near the Wangjia hill, in Longtan cave (=Hexian), *Stegodon orientalis* were present associated with human remains in the Layer 2: a yellow brown sandy clay (Huang et al., 1982). According to Dong et al. (2000), *Stegodon* have been dated to 190-150 ka by Chen et al. (1987) and between 620±80 and 347±58 ka by ESR (Grün et al., 1998 p.559).

In Sichuan province, in the fissure fills of Yanjinggou (=Yenchingkuo) including both Yenchingkuo I, and Yenchingkuo II faunal assemblages (Kahlke, 1961), the Upper cave of Pingba is considered to be one of the main source for the former fauna described until now and is dated to Middle Pleistocene according to the biochronology based on rodent studies (Chen et al., 2013). This fauna contains *Stegodon orientalis* remains. Unfortunately, a part of the collection is coming from digging done by farmers and, even if *Stegodon* "*were, confined pretty much to the lower pits* " according to Colbert and Hooijer (1953 p. 11), the most complete papers dealing with this fauna (Matthew and Granger, 1923; Colbert and Hooijer, 1953; Kahlke, 1961) present the Yenchingkuo fauna in a single faunal list (= the "Wanxian fauna"). Finally, this earliest and most famous faunal assemblage for Chinese Quaternary is unappropriate to be used as a benchmark for biochronological and paleoenvironmental theoritization. Recently Chen et al. (2013) recalled that the initial collection made by Granger as indicated by Colbert and Hooijer (*op. cit*) came fom different localities of different formations and ages which spreads definitively the use of this reference on which were historically built the regional biochronology from India to South-east Asian Archipelago.

According to Young and Liu (1950) Koloshan site includes 6 different cavities, and not a single one as mentionned in Louys et al. (2007), among which three cave provided Probocideans from the brecciated yellow clay and travertine of the cave deposits. *Stegodon preorientalis* remains are present at Kanchuantung (=locality 55) and Hoshangtung (=locality 56), and both *Stegodon preorientalis* and *Elephas* sp. at Lungkutung (=locality 53). Unfortunately details are not indicated for their respective stratigraphical position. It should be noticed that Kahlke (1961) considered "Koloshan site" as younger (Upper Middle Pleistocene= "Riss") than Yenchingkuo according to faunal composition but, due to the incertainty of former data concerning this locality, it is of weak use.

In Hubei province, Changyang site first concerns the fossil remains yielded from Lungtung cave at Hsiachungchiawan village southwest of Changyang city (Chia, 1957). Human remains were found in fine sandy dark yellow clay deposits of the cave which also contain abundant limestone fragments and breccias interbedded in the sediments as a secondary deposit (Pei et al., 2013). *Stegodon orientalis* are listed in the faunal assemblage but without indication of their exact provenience and, it should be noticed that patches of breccia are mentionned in the lower part the cave recess (Chia, 1957). Concerning this faunal assemblage Bailey and Liu (2010) mentionned dating between 220 and 170 ka according to Etler (1996) who does not provide a critical review of the datings coming from scattered Chinese papers, but just provided estimated ages linked to general Lower, Middle and Late Pleistocene affiliations. In Changyang, fifteen other caves with fossil remains dating from the Middle to Late Pleistocene were further researched including Xinglong (=Majiawan?) cave where hominin fossils, archaeological and paleontological remains were identified in clear primary context in the lower part of the sandy clay almost at the bottom the deposits sequence including a *Stegodon* tusk exhibiting intentional engravings (Gao et al., 2004). A direct U-series dating undertaken on faunal remains resulted in an age between 118±7 ka to 154±9 ka (Pei et al., 2013) for this archaeological context. At Shilongtou (=Dazhi) near Daye, mammalian fossils were found *in situ* in a fissure with Palaeolithic artifacts in abundance in a yellow and brown sandy clay but also in more rare quantity in a brown redish clay with stalagmite (Li *et al.,* 1974). *Stegodon orientalis* yieleded from these different layers but without precison concerning their association with the lithic material which is assigned to between 350 and 240 ka by Chen and Yuan (1988) and between 312 and 256 ka by Wu (2004). The skull of *Homo erectus yunxianensis* and *Stegodon orientalis* remains are affiliated to the highest terrace of the Han River at the open air site of Xuetanggliangzi (=Yunxian) (Dong et al., 2000). Recent paleomagnetic dating of the deposits of the third terrace provide age older than 780 ka (Guo et al., 2013) when former geomagnetic 830-870 ka (Gulin, 1993) to 581±93 ka (Chen et al., 1997) by ESR dating are associated to enamel tooth of the archaeological layer n°3 (Feng, 2008).

In Yunnan province, many localities are described with an important taphonomic action due to *Hystrix* (Pei, 1938). *Elephas* cf *namadicus* and *Stegodon* sp. are present (Colbert 1940 ; Colbert et Hooijer 1953 ; Kahlke 1961) at locality 40 at Heshangdong = Hoshangtung Fumin 'cave above the river' which presents a fossiliferous recess in a small branch of its second chamber which includes 5 horizons. Fossils belong to the breccia composed of angular limestone fragments with calcitic, yellow-gray and loamy matrix just under the top layer made of travertine crust according to Bien and Chia (1938) but fossil remains are also recovered from the fourth (breccia) and fifth (sand and sandy clay) layers (*op. cit.*).

In Guizhou province, the site of Tongzi refered to a region including several sites where a small assemblage of artifacts, burned bones and mammalia taxa has been yielded at Yanhui cave (Yanhuidong). Though seven layer were identified during excavation all the mammalian fauna derive from the fourth layer including *Stegodon orientalis* (Wu, 1984 ; Wu et al. 1975). U-series dates of 172-192 ka and 102-125 ka according to Chen and Yuan (1988) and 181+11-9 ka to 113±11 ka for tooth and bone sample (Yuan et al. 1986). Nevertheless it should be noticed that according to Shen and Jin (1991) dating undertaken in the same sector of the cave indicated direct U/Th dating of teeth from 123±6 to 142+9-8 ka in the third layer and from 130+6-9 ka to 140+11-10 ka in the fourh layer when dating of flowstone and crust on the third layer are respectively dated from 228+26-21 ka and 231+30-23 ka. As only *Stegodon* has been decribed in the site, the dating TYB-6 of a Proboscidean tooth yielded from the fouth layer (Shen and Jin, 1991) will indicate that, at least *Stegodon* will be 130+6-5 ka old in Yanhui cave. Even if systematically omitted by Bacon et al. (2004, 2006, 2011) for comparison to build a regional model for Southeastern Asian fauna evolution, Panxian Dadong is one of the best-documented site with detailed information concerning palaeontology (Huang et al., 1995 ; Pan and Yuan, 1997 ; Zhang et al., 1997), taphonomy (Karkanas et al., 2008 ; Schepartz et al., 2001, 2003, 2005 ; Wang et al., 2003), taxonomy (Bekken et al., 2004 ; Schepartz and Miller-Antonio, 2004 ; Zhang et al., 1997), dating (Huang et al., 1997 ; Jones et al., 2004 ; Rink et al., 2003, 2008 ; Shen et al., 1997 ; Schepartz et al., 2000 ;Wang et al., 2004) and also human activities (Huang et al., 1995 ; Liu et al., 2013 ; Miller-Antonio et al., 2000, 2004 ; Schepartz and Miller-Antonio, 2010). Located in Panxian district at Liupanshui city, Panxian Dadong cave is part of a large multigenesis karst system that contains three connected and integrated stacked caves. The main chamber is 250 m deep, 23–56 m wide and has a vaulted ceiling ranging in height from 22–30 m. Panxian Dadong is unique because it possesses over 6 m of stratified deposits with well-preserved fauna. *Stegodon* and immature individual of *Elephas* sp. were initially described associated with three species of *Hyaena* by Huang et al. (1995). First identified as *Stegodon preorientalis* (Huang et al., 1995 ; Zhang et al., 1997), they are refered to *Stegodon orientalis* by Schepartz et al. (2005) and no *Elephas* was mentionned anymore by Bekken et al. (2004). Four faunal group are defined according to stratigraphy and dating including Rhino and *Stegodon* in each of them. The upper group lies at or above the 95 m horizon and has a range of 118–159 ka for EU model ages and 131–181 ka for LU model ages and the lower group of samples was excavated below the 94.4 m datum horizon and has EU model ages ranging from 158–296 ka and LU model ages ranging from 185–349 ka. The mean ESR model ages of this group are 211±40 ka (EU) and 258±47 ka (LU) (Jones et al., 2004). Karkanas et al. (2008) described the formation processes of 12 layer with transport and reworking which preclude major post-depositional alteration of the fauna (Schepartz et al., 2003; Bekken et al., 2004). The fauna is mostly fragmentary, eventhough it is well-preserved, with intact bone surfaces that do not show extensive amounts of dissolution or surface weathering characteristics. Teeth can show the effects of fluvial transportation and tumbling and chalky texture is the most common form of damage on the bones. Nevertheless, faunal remains were not substantially altered by natural processes, suggesting these activities were not important factors in the formation of the assemblage. Porcupines and small rodents were active, but their damage to bones and tooth roots is fairly limited, affecting approximately 5% of the total sample (Schepartz et al., 2003). The faunal assemblage falls outside the range of values observed for carnivore-generated den deposits and finally stone tool cut marks impact fractures and burning are attribute to hominid activities suggesting at last several proveniences (Schepartz and Miller-Antonio, 2010). *Stegodon orientalis* or *Stegodon* sp. are present for the whole sequence associated to Rhino.

In Guangxi Zhuang, *Stegodon preorientalis* remains were recovered from Nongmoshan (=Bama cave= *Gigantopithecus* cave) according to Zhang et al. (1975) and Jin et al. (2009) but only *Stegodon* sp. is mentionned by Han and Xu (1985), Wu and Poirier (1995) and latter authors. Since its original publication this fauna is affiliated to Middle Pleistocene (Zhao and Zhang, 2013) according to classic biostratigraphical comparison based on the "Wanxian fauna" of Yenchingkuo which is finally an unappropriate reference as we shown above. The 'Kwangsi Yellow deposits' described by Pei (1935) concern the locus 39 of the cave E in Hsinganhsien cave (= Kweilin cave), north of Kweilin (Kahlke 1961). As indicated by Colbert (1940) Kweilin cave concerns only the Upper Pleistocene of the Kwangsi caves and the yellow deposits are atributed to Middle Pleistocene. Colbert and Hooijer (1953 p.16) indicated that remains of *Elephas* sp. came from local drugstore and only *Stegodon* cf *orientalis* is yielded from the cave E. First known by the material described by Pei (1935) purchased in drugstore of Wuming, according to Han and Xu (1985), the faunal assemblage including *Stegodon* sp. is the result of the excavation of Bulalishan cave. Embedded in the cemented hard yellow sandy clay, the fossils were dated to Middle Pleistocene by biostratigraphical comparison (Zhang et al., 1973) and Wu and Poirier (1995) indicated the presence of *Stegodon orientalis* among the assemblage. Rink et al. (2008) obtained an ESR dating range from 745 to 480 ka for a single tooth located above the Upper travertine of the sequence. Discovered by Pei and Wu (1956), Heidong cave (=Hei cave=Daxin site) in Nuishuishan hill in Daxin county, is the first site were *Gigantopithecus* were recovered *in situ* associated with *Stegodon orientalis*. Nevertheless, if the *Gigantopithecus* remains were unearthed from a layer of red-purple clay intercalated with sands below a cemented yellow breccia, *Stegodon* were found in the latter layer (Wu and Poirier, 1995). The age for excavated fauna at Daxin is now restricted to 380-308 ka by coupled ESR/ ^{230}Th/^{234}U datings (Rink et al., 2008) but with a wider range 446 to 195 ka on both model age LU/EU age. Finally, it is not possible to strictly know if the dated material is corresponding to the yellow breccia or not, as it is described as coming aswell from breccia chunk and from floor of narrow channel. Several other fossiliferous caves are present in the Bubing Basin: Pubu, Wuyun, Mohui and Cunkong. The taxonomic data of the *Ailuropoda-Stegodon* assemblage of the Upper Pubu cave is currently unavailable but Wang et al. (2007 p. 374) indicated that they have collected teeth of *Elephas* sp. and *Stegodon* sp. from the surface of the cave. ESR dating undertaken on undeterminated remains indicated an age between 280 and 88 ka according to Rink et al. (2008). The deposits of Wuyun cave are mainly sandy-clay interstratified with a few layers of flowstone. All fossils are recovered *in situ* between an upper and a lower flowstone. Among the mammalian fauna both *Stegodon orientalis* and *Elephas maximus* (Chen et al., 2002) are present. The dating of both flowstone by U-series dating provide results between 345 ka and 10 ka (Wang et al., 2007) for this faunal assemblage which is consistent with the ESR results made on animal teeth spanning from 279 to 76 ka (Rink et al., 2008). At Liujiang site (=Tongtianyan), the Middle unit is composed of 5 m thick fossiliferous, gravel-bearing and carbonate-cemented sandy clay (Shen et al*.,* 2002) whose upper part (between flowstone 4 and 5) are bracketed between 240±37 ka and 273±45 ka or 276±50 ka according to alpha spectrometry (cf *op. cit.* Table 1 p. 821) or been older than 218±10 ka according to U-series on the fourth flowstone. Huang (1979) indicated the presence of both *Stegodon orientalis* and *Elephas* (*Elephas namadicus* and *E. kiangnanensis*) that could be affiliated to the Middle unit following Shen et al. (2002 p. 825).

In Guangdong province, Maba site (=Shizishan cave) contained three strata consisting of yellow brown clays filling, a complex of fissures and openings. Maba 1 human remains and a diversity of mammalian fossils were found in the second level from a crevice at a depth of 1 m including *Stegodon orientalis* and *Elephas namadicus* (Wu and Poirier, 1995 cf Han and Xu, 1989). U-series date on associated vertebrate teeth yielded an age of 129-135 ka (Yuan et al., 1986) and more recent U-series dating of capping flowstone from another chamber of the cave suggests that some of the Maba deposits may be as old as 237 ka (Wu et al., 2011). Nevertheless the strict and relative position of both Proboscideans is not sure.

- Mainland South-east Asian sites (Table 2)

In Vietnam, Patte (1928) undertook the comparison of the Mammalian faunas from cave breccia or fissure infilling of Lang Son province initially described by Mansuy (1916) including *Stegodon insignis* (now *Stegodon orientalis*), *Stegodon cliftii* and *Elephas* sp. aff. *Elephas namadicus*, with those described by Matthew and Granger (1923) from the Sichuan. At that time these first regional comparison was consistent due to the few available sites but it is not possible anymore to compare such faunas without more detailed geographical or stratigraphical location.

For the early period of late Middle Pleistocene, three localities are described in Langson province : Tham Hai I and II, and Tham Khuyen cave. Cuong (1992) indicated the occurrence of *Stegodon orientalis* at both cave Tham Hai I and Tham Hai II considered to belong to similar faunal assemblages than at Tham Khuyen and dated on the base of regional faunal correlation to about 250 ka without any radiophysical dating method. The taphonomy of the faunal assemblage at Tham Hai caves is not clear cut aswell. Ciochon and Olsen (1986) indicate that three layers of sediments of Tham Khuyen cave are recognized with most of the fossils coming from level II and that the fauna is affiliated to Middle Pleistocene due to biochronological comparison with Southern Chinese sites. Cuong (1992 p.323) gave indication that this cave contains deposits from several periods: Late Middle, Upper and posterior Upper Pleistocene in the form of different breccia fragments scattered in the cave walls. He mentioned the occurrence of both *Stegodon orientalis* and *Elephas namadicus* in the deposits but without precise location. Ciochon and Olsen (1991) precise that the cave contains infilled passages on two levels with fossiliferous deposits confined to the upper level. Thus, a dark red fossiliferous cave breccia is divided in 17 units among them units S1-S3 made of a homogeneous sedimentary suite provide ESR dating of 475±125 ka but in the tunnel six meter apart the second recess of the cave where a T2 speleothem provides U-series dating of 117±30 ka in the middle of the stratigraphic sequence up to the S1-S3 series (Ciochon et al., 1996). Nevertheless it is not possible to locate the Proboscidean remains among the different breccia fragments or in the 17 units, and if *Elephas* and *Stegodon* occur together at Tham Khuyen.

In Ba Thuoc province, Lang Trang is a complex of 4 caves and several smaller openings where fossiliferous breccia is found occurring on the floor, walls and the ceiling (Ciochon and Olsen, 1991). The mammalian fossils from caves I-II were found mostly embedded in rock-hard breccia blocks but the fossils from cave IV were excavated from soft sediment. This cave has two chambers separated by a breccia floor. Unfortunately a single faunal list is provided for caves I to IV. Long et al. (1996) brought precision from the previsional listing indicating that *Stegodon orientalis* and *Elephas* sp. (but indicated as *Elephas namadicus* in Ciochon and Olsen, 1991) are located in the breccia 5 of the Cave II which have been dated to 285±24 ka by ESR (Ciochon and Olsen, 1991). Breccias have been dated by ESR to 480±40 ka in cave I and 146±2 ka in cave IV. Finally, without specifying which layer or cave is concerned Ciochon (2010) assess to retain dates between 385 ka to 185 ka for the site as a whole.

In northern Laos, the palaeontological site of Tam Hang includes three cavities : Tam Nang (Tam Hang south), Tam Hang central and Tham Hang north (Fromaget, 1940). The fauna of Tam Nang was initially attributed to the Lower Pleistocene by Arambourg and Fromaget (1938). It should be noticed that the biochronological attribution due to comparison with Chinese faunal assemblages changes through the time, and that this former step of comparison is *de facto* based on scattered collections (cf previous coments on Yenchingkuo and other historical Chinese sites). Moreover, two main layers including fossil remains were described at Tam Hang : A red limon poor in fossils with *Elephas* sp. remains and, a lower layer made of yellow calcareous tufs (=*Hystrix* tufs) with two different horizon distinguished by their different faunal contents. Finally a cumulative list of species present on the complete sequence *id est* from lower to upper horizon of *Hystrix* tufs include both *Stegodon sinensis* (now *Stegodon orientalis*) and *Elephas namadicus*. Both *Elephas* sp. and *Stegodon orientalis* are recently described from a reexcavation of the site but "*Most of the vertebrate remains were concentrated at the bases of the small sedimentary sequences*" (Bacon et al., 2011 p. 319) which remains poor interest to clarify the absolute and relative biostratigraphical position of remains to allow to conduct to any consistent palaeoenvironmental discussion as admitted recently (Bacon et al. 2015).

In Thailand, *Stegodon* remains were collected within the stratified and cross-bedded sands and gravels horizons from tektite-bearing alluvial deposits at Ban Tha Chang in Nakhon Ratchasima province but, as the fossils have been uncovered during sand mining operations near the Mun River in an area of 80 to 160 square kilometers, and mined sand to depths of 20 to 40 meters, it is difficult to attributed the fossils to distinct layers. Nevertheless, the mammalian fossils were mainly divided into three ages: Middle Miocene, Late Miocene to Early Pliocene, and Early Pleistocene (Thasod et al., 2012). *Stegodon elephantoides, Stegodon insignis* and *Stegodon* cf *orientalis* but also *Elephas* were found in these locality. The sand pit number 9 (Siam pit) is the easternmost sand pit of the sequence and has the youngest fossils *id est* advanced *Stegodon* and *Elephas* according to Thasod (2007). Former Thermoluminescence dating of quartz grains from tektite-bearing sands gives a reported age of 0.75±0.13 Ma (Haines et al., 2004) but this information can only be used as a first-stand dating for the Proboscidean series of this site due to the uncertain position of the fossils.

In northern Myanmar, the *Stegodon* remains from the Mogok fissures and caves coming from several locations (De Terra, 1943) are biostratigraphically interpreted as Middle Pleistocene by Colbert (1943) although Hooijer (1950) later considers them as 'Lower' Pleistocene. Colbert (1943) indicated *Stegodon* sp. yielded from ossiferous sand beneath cave loam at Dato cave (=Mercury cave =Mogok C1) and both *Stegodon orientalis* and *Elephas namadicus* from Chausong cave (=Mogok C2) but without precisions concerning their strict association and/or relative position.

- Insular South-east Asian sites

Since the chronological framework provided by Theunissen et al. (1990) many radiometric method where undertaken on the geological formations and specific studies were done on the Proboscideans of South-east Asian islands (Van den Bergh et al., 1996). In Eastern Java, the Kedung Brubus fauna which is recognized on the basis of sites located along the Pucangan-Kabuh outcrop belt are between Perning and Trinil (Huffman et al., 2006). By combining the type fauna and fission-track datings this assembage is inferred to the Lower Middle Pleistocene age including *Setogodon trigonocepahlus* and *Stegodon hypsilophus* aswell as *Elephas hysudrindicus* above the Grenzbank of Bapang section according to Van den Bergh (1999).

Von Koenigswald (1956a) described various mammalian remains from the Philippines from different localities including various molar and tusk fragments of *Stegodon* in Novaliches-Marilao district in Luzon. *Stegodon* material is attributed to *Stegodon* cf. *trigonocephalus* from a small gravel bed at the foot of a hill at a site A and from a freshly plowed field on the McCrory place (site M) together with tektites and pre-Neolithic stone implements and, also from a third locality between the both former. *Stegodon luzonensis* is described from a layer of grey-black sand containing many white streaks of fossilized leavess and pieces of wood near Fort McKinley in Rizal province. Fragments of a pygmy elephant named *Elephas beyeri* by Von Koenigswald (*op. cit.*), that may be *Elephas namadicus,* was labeled as being from the Anda area of Cabarruyan Island but there is no indication concerning their stratigraphical position. Von Koenigswald (1956a) mentioned the occurrence of *Stegodon mindanensis* and *Stegodon trigonocephalus* from Nortwest Mindanao and *Elephas maximus* from excavtion work on Juan Luna street in Manila. Finally this author tilts to affiliated the material from Luzon to Middle Pleistocene due to the presence of tektites but, as concluded by Wasson and Cochrane (1979) there was, at that time, no element to assert this age.

Discussion

Regarding Proboscideans evolution in South-east Asia, the co-occurrence of *Stegodon* and *Elephas* including the case of the last stand of *Stegodon* and/or the first appearance of *Elephas* have implications concerning environmental and ecological changes (Mishra et al., 2010; Westaway et al., 2007) nevertheless the reviewing of former data and works shows that the available data are far to the be robust enough to securely discuss and debate on this subject (Table r3). Moreover, all the studies using directly or undirectly Yenchingkuo site or Koloshan site as a reference in terms of biostratigraphical scale or to discuss paleoenvironment changes should be revised (*id est* Bacon et al 2008a,b, 2011; Beden and Guérin, 1973; Colbert, 1940; Colbert and Hooijer, 1953; Duringer et al., 2012 ;Tougard and Montuire, 2006; Tougard, 1998; Louys, 2007ab, 2012, 2014; Louys et al., 2007; Tougard, 2001). The co-occurrence of two Proboscidean genera on several sites in South-east Asia is worth noting as *Stegodon* species are contemporaneous with *Mammuthus* at the site of 'Ubeidiya, or with *Elephas* at the site of Evron Quarry, and Gesher Benot Ya'aqov (Rabinovich et al. 2012) in South-west Asia. Concerning South-east Asia, the co-occurrence of *Elephas* and *Stegodon* is dubiously indicated in several sites during Early Pleistocene (Linyi, Xihoudou, Yenchingkuo, Mohui and the Tunghsiaonian formation in Taipei, Magwe locality U1 and Mingun M3 in Myanmar, Perning, Brangkal and Trinil H-K in Java) according to Zeitoun et al. (*in press*). Concerning the Middle Pleistocene, when checking the dataset, the stratigraphical association is, as well, far to be demonstrated or well-documented, or is even subject to controversy. Nevertheless it can be noticed that both genera co-exist in some sites. In China, at Wuyun cave, both *Stegodon orientalis* and *Elephas maximus* are recovered *in situ* between an upper and a lower flowstone (Chen et al., 2002) and Huang (1979) indicated the presence of *Stegodon orientalis*, *Elephas namadicus* and *Elephas kiangnanensis* in the Middle unit of Liujiang site which is composed of 5m thick fossiliferous gravel-bearing and carbonate-cemented sandy clay (Shen et al., 2002). Both *Stegodon orientalis* and *Elephas namadicus* were found in the second level from a crevice at a depth of 1 m at Shizishan cave according to Wu and Poirier (1995). In Vietnam, Long et al. (1996) indicated that *Stegodon orientalis* and *Elephas* sp. (*Elephas namadicus* in Ciochon and Olsen, 1991) are located in the breccia 5 of the Cave II at Lang Trang in Ba Thuoc province, which is also the case from the basis of a small sedimentary sequence at Tham Hang (Bacon et al., 2011 p. 319). At Ban Tha Chang in Thailand, the sand pit number 9 (Siam pit) provided both advanced *Stegodon* and *Elephas* according to Thasod (2007) but their exact provenience remain uncertain aswell. For the Early Pleistocene the co-occurrence is not certified by stratigraphical reappraisal or direct dating in most of the cases (Zeitoun et al. *in press*) but for the Upper Pleistocene there is also doubts. According to Tong and Patou-Mathis (2003) and Tong and Liu (2004) *Stegodon* remains are found in Late Pleistocene deposits in Burma, Laos, Borneo and Java, and survived into the Holocene in Southern China but Turvey et al. (2013) argue that the last-occurrence dates *Stegodon* are of extremely limited reliability for Holocene which is certainly the case when looking in detail the available data. Finally, the list of the sites with safe or at least almost safe co-occurrence of both *Elephas* and *Stegodon* is very short with only two sites (Luijiang and breccia 5 of Lang Trang) and, in the other hand, the sites with high resolution fitting with MIS timescale only concern China (Chenjiawo, Huludong, Chaoxian locus B, Xinglong, Shilongtou, Yanhui cave, Panxian Dadong, Liujiang) and one Laotian site (the breccia 5 of Lang Trang) (Table r3) which casts doubts on the relevance of recent palaeoenvironmental studies.

Conclusion

Most of the presumed age of the *Ailuropoda-Stegodon* assemblages is rather speculative since it is still not based on direct age determinations, but on faunal similarities between assemblage of unkown or uncertain proveniances. The major problem in several excavations is to establish an unquestionable association of the fossils with dating in which the materials are found *in situ* in identifiable geological strata. Another, but not new point, to be considered is the correlation of various fauna stage by stage. Thus, in a time when few data were available Von Koenigswald (1956b. p. 209) did indicate that "*in India as in Java a fauna was also defined by a certain rock unit, by a certain assemblage of layers, and it was very unlikely, that these units in both regions had exactly the same limits; a correlation is always only possible in a broad sense*" but this scale is not appropriate to treat efficiently the ecological changes which are described with the MIS timescale. Many agents contributing to the accumulation, or the alteration of remains disturb attempts to reconstruct the original biocenosis (Lyman, 1994). The absence of data on the mechanisms of deposition in sites, led us to the conclusion that important advances could be made by excavating and extensively studying new sites. In spite of numerous papers on palaeoenvironment and even fieldwork reports, only a few projects have been undertaken with this aim in the past as indicate for a long time by Bakken (1997) and Schepartz et al. (2001, 2003). Even if new fieldworks have been undertaken in the last decade, due to taphonomical limitations and artificial mixture of faunal listings, most of the written papers remain anecdotal and unuseful. Even if based on new fieldwork datasets, no synthetic model or general rule can be derived from research into the formation of the paleontological sites in the karstic context of South-east Asia due to the biochronological scaling on artificial benchmarks (Yenchingkuo, Hoshangtung and many others as demonstrated in Table r3). Still nowadays, the biases, which influenced the accumulation of fossil remains are mainly unknown when reading the papers as are the limitations of the usefulness of the collected series for documenting the biostratigraphy, recontructing paleoenvironments, or providing evidence of human activity in the past. The mechanisms involved in the formation of the *Ailuropoda-Stegodon* paleontological sites remain to be elucidated. The duration and the definition of the complex *Ailuropoda-Stegodon* still need to be more strictly defined by direct dating as recommended for two decades. Finally, as the available time frame of the described faunal assemblages can be longer than periods of climatic fluctuations (MIS timescale), then taphocenosis will not record the diversity of the biocenosis. Saegusa (2001) defines the necessary conditions for the realization of a palaeoecological research and indicates its limits with his own unended results. In continental South-east

Asia, rare are the works allowing to distinguish the presence of the different taxa in distinct layers of a single Middle Pleistocene site. This point is important to be considered as the biochronology and the palaeoecology are two crucial parts of the background which is useful to try to understand human Evolution. The taphonomical record of the *Stegodon* remains at Panxian Dadong is a part of a larger faunal analysis designed to provide information on the paleoenvironment of upland Southern China during the Middle Pleistocene, to investigate interactions between prehistoric humans and mammalian species, and to clarify the role of humans, carnivores and natural geological processes in the formation of the faunal assemblage as well. In spite of this example, of many recommandations brought in the past, and of the advent of many geochronological techniques for two decades, we would recall the comment of the editor of Geologie en Mijnbouw concerning the warm debate between Bartstra, Hooijer, DeVos, Sondaar et al. occurring thirty years ago: "*Whatever the outcome of the debate, it certainly emphasizes the need for every scientific collector to discipline him/herself to carefully locate, collect, describe and document samples, preferably according internationally established and approved methods*". These recomandations are still usefull and should be extended to the users of bibliographical data.

Figure captions

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

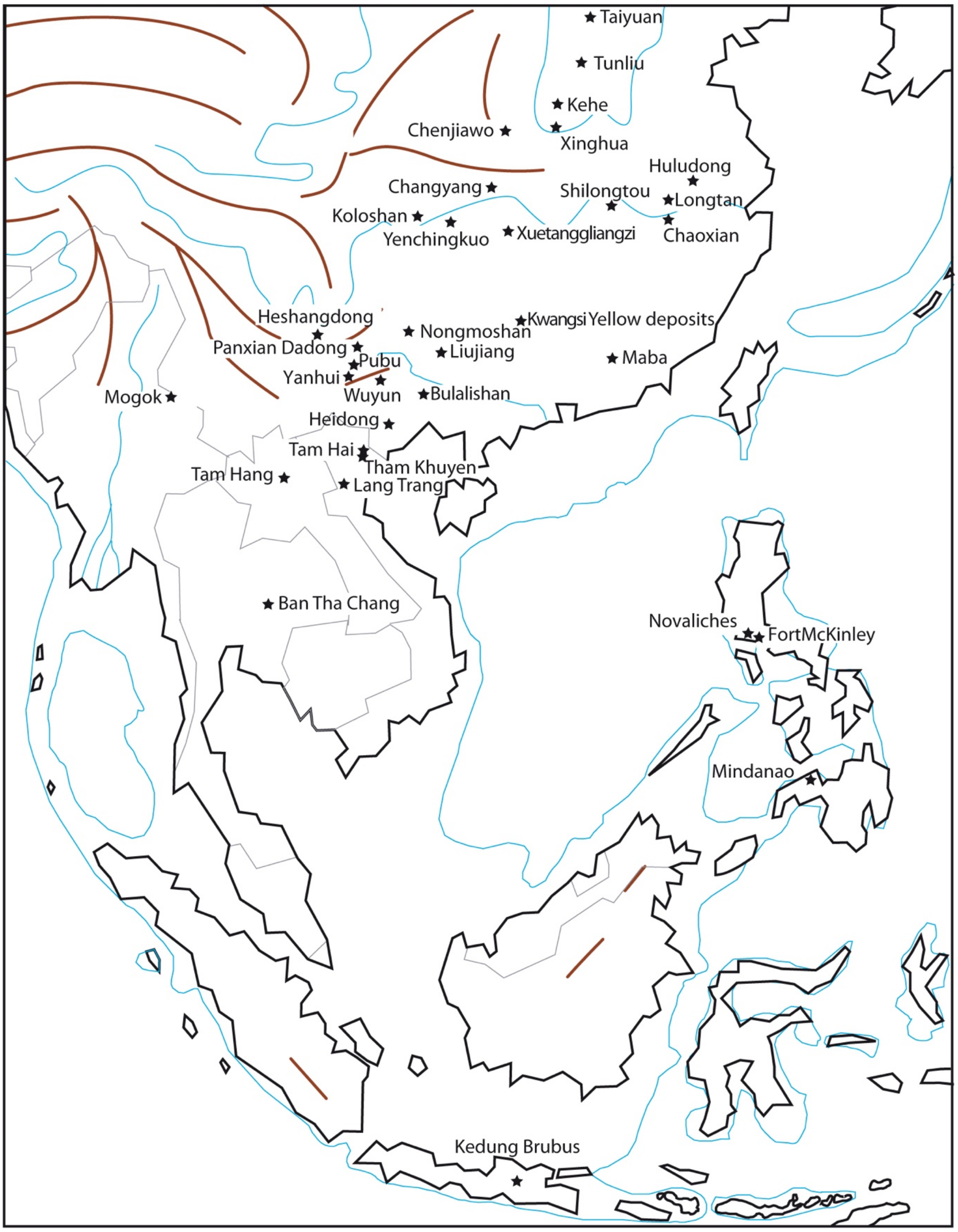

Table 1a)

Site	**Taxonomical references**	**Age range of dated materials (ka)**	**Dating method**	**Dated material**	**Chronological references**
Taiyun *Stegodon zdanskyi*	Wang (1961)	Middle Pleistocene Plio-Pleistocene	Biostratigraphy		Tong (2006) Van der Geer et al (2010)
Tunliu **Xicun Formation** *Stegodon cf chiai*	Tong (2006)	Early stage of Middle Pleistocene	Stratigraphy		Zong et al (1982)
Kehe (=K'oho= locality 6054) *Stegodon cf orientalis* *Stegodon chiai* *Elephas cf namadicus*	Ikawa-Smith (1978) Ikawa-Smith (1978) Ikawa-Smith (1978)	Middle Pleistocene	Biostratigraphy		Tong (2006)
Chenjiawo (=Chen-chia-ou=Lantian) **Upper part of Paleosol S6** *Elephas* sp. *cf Elephas namadicus*	Chow (1964)	650-530	Magnetostratigraphy	Sediment	Wu (2004)
Xinghua Shan hill (=Yunyang=Nanzhao) **brown yellow sandy clay of the second terrace** Stegodon sp.	Qiu et al. (1982)	Middle Pleistocene	Biostratigraphy		Qiu et al. (1982)
Huludong cave (=Calabash cave=Nanjing) *Stegodon* sp.	Zhu & Zhang (2000)	430-280	U-series		Zhu & Zhang (2000)
Chaoxian (=Chaohu=Yinshan) **Locus B** *Stegodon*	Wu & Poirier (1995)	360-310	U-series	Speleothem	Shen et al (2010)
Longtan cave (=Hexian) **Layer 2** *Stegodon orientalis*	Huang et al. (1982)	190 to 150 620±80 to 347-58	U-series ESR	Human teeth Human teeth	Chen et al (1987) Grün et al. (1998)
Yanjinggou (=Yenchingkuo II) **Upper cave of Pingba** *Stegodon orientalis*	Matthew & Granger (1923)	Middle Pleistocene	Biostratigraphy	Rodent	Chen et al. (2013)

Table 1b)

Site	**Taxonomical references**	**Age range of dated materials (ka)**	**Dating method**	**Dated material**	**Chronological references**
Koloshan sites **Kanchuantung (=locality 55)** *Stegodon preorientalis* **Hoshangtung (=locality 56)** *Stegodon preorientalis* **Lungkutung (=locality 53)** *Stegodon preorientalis* *Elephas* sp	Young & Liu (1950) Young & Liu (1950) Young & Liu (1950) Young & Liu (1950)	Upper Middle Pleistocene Upper Middle Pleistocene Upper Middle Pleistocene	Biostratigraphy Biostratigraphy Biostratigraphy		Kahlke (1961) Kahlke (1961) Kahlke (1961)
Changyang sites **Lungtung cave (Hsiachungchiawan)** *Stegodon orientalis* **Xinglong (=Majiawan?)** *Stegodon*	Chia (1957) Gao et al. (2004)	220-170 154±9 to 118±7	Biostratigraphy U-series	Animal bones	Etler (1996) Pei et al. (2013)
Shilongtou (=Dazhi) **artifacts bearing layer** *Stegodon orientalis*	Li et al. (1974)	350-240 to 312-256	U-series Magnetostratigraphy	Sediment	Chen & Yuan (1988) Wu (2004)
Xuetanggliangzi (=Yunxian) **Archaeological layer 3** *Stegodon orientalis*	Dong et al. (2000)	870-830 to 581±93	Magnetostratigraphy ESR	Third terrace Faunal enamel	Gulin (1993) Feng (2008)
Heshangdong (= Hoshangtung Fumin=locality 40) Stegodon sp. *Elephas cf namadicus*	Colbert (1940) Colbert (1940)	Middle Pleistocene	Biostratigraphy		Colbert & Hooijer (1953)
Yanhui cave (=Yanhuidong=Tongzi) fourth layer *Stegodon orientalis*	Wu (1984)	192-172 to 125-102 181+11-9 to 113±11	U series ESR	Faunal remains	Shen & Jin (1991) Yuan et al. (1986)

Table 1c)

Site	Taxonomical references	Age range of dated materials (ka)	Dating method	Dated material	Chronological references
Panxian Dadong					
Upper group		159-118 (EU) 181-131 (LU)	ESR	Faunal enamel	Jones et al (2004)
Stegodon orientalis	Schepartz et al. (2005)				
Lower group		296-158 (EU) (LU)	ESR	Faunal enamel	Jones et al (2004)
Stegodon orientalis	Schepartz et al. (2005)				
Nongmoshan (=Bama cave=*Gigantopithecus* cave)		Middle Pleistocene	Biostratigraphy		Zhao and Zhang, 2013
Stegodon preorientalis	Zhang et al. (1975)				
Stegodon sp.	Han & Xu (1985)				
Kwangsi Yellow deposits					
Hsinganhsien cave (Kweilin) locus 39 cave E		Middle Pleistocene	Biostratigraphy		Kahlke, 1961
Stegodon cf orientalis	Colbert (1940)				
Bulalishan cave (Wuming)		745 to 480	ESR	Faunal enamel	Rink et al. (2008)
Stegodon orientalis	Wu & Poirier (1995)				
Heidong cave (=Hei cave=Daxin site)					
Latter layer		380-308	ESR/230Th/234U		Rink et al. (2008)
Stegodon orientalis	Pei & Wu (1956)	446-195 (EU) (LU)	U series		Rink et al. (2008)
Upper Pubu cave		280-88	ESR	Faunal enamel	Rink et al. (2008)
Stegodon sp.	Wang et al. (2007)				
Elephas sp.	Wang et al. (2007)				
Wuyun cave					
between upper and lower flowstone		345-10	U series	Flowstone	Wang et al. (2007)
Stegodon orientalis	Chen et al. (2002)	279-76	ESR	Faunal enamel	Rink et al. (2008)
Elephas maximus	Chen et al. (2002)				

Table 1d)

Site	Taxonomical references	Age range of dated materials (ka)	Dating method	Dated material	Chronological references
Liujiang site (=Tongtianyan)					
Middle unit		276±50 ka 240±37 ka	Alpha spectrometry	Flowstone 4 and 5	Shen et al (2002)
Stegodon orientalis	Huang (1979)	older than 218±10	U series	Fourth floor	Shen et al (2002)
Elephas namadicus	Huang (1979)				
Elephas kiangnanensis	Huang (1979)				
Maba site (=Shizishan cave)					
second level		135-129	U series	Faunal teeth	Yuan et al. (1986)
Stegodon orientalis	Wu & Poirier (1995)	237	U series	Capping flowstone	Wu et al. (2011)
Elephas namadicus	Wu & Poirier (1995)				

Table 1

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

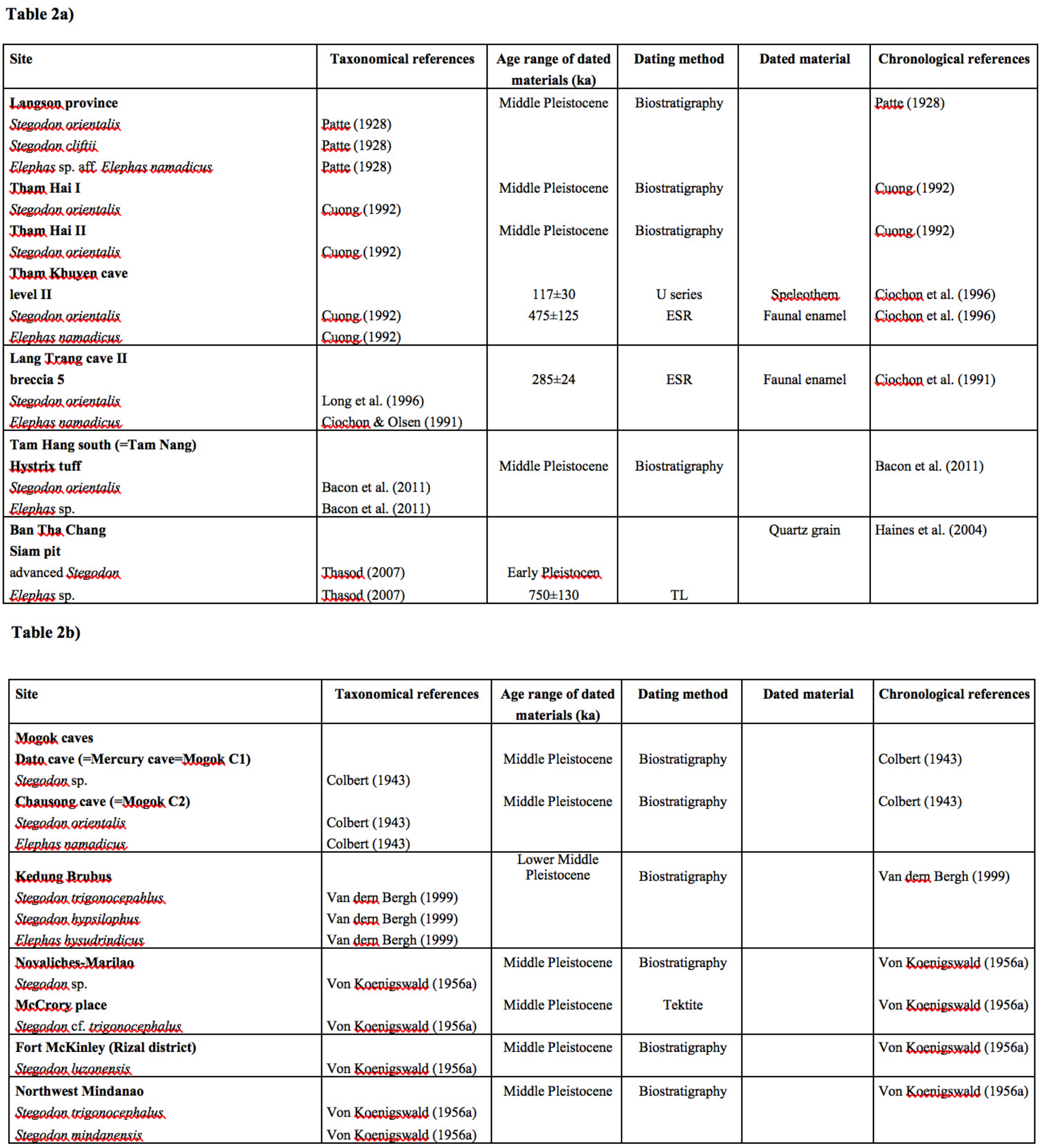

Table 2a)

Site	Taxonomical references	Age range of dated materials (ka)	Dating method	Dated material	Chronological references
Langson province		Middle Pleistocene	Biostratigraphy		Patte (1928)
Stegodon orientalis	Patte (1928)				
Stegodon cliftii	Patte (1928)				
Elephas sp. aff. *Elephas namadicus*	Patte (1928)				
Tham Hai I		Middle Pleistocene	Biostratigraphy		Cuong (1992)
Stegodon orientalis	Cuong (1992)				
Tham Hai II		Middle Pleistocene	Biostratigraphy		Cuong (1992)
Stegodon orientalis	Cuong (1992)				
Tham Khuyen cave					
level II		117±30	U series	Speleothem	Ciochon et al. (1996)
Stegodon orientalis	Cuong (1992)	475±125	ESR	Faunal enamel	Ciochon et al. (1996)
Elephas namadicus	Cuong (1992)				
Lang Trang cave II					
breccia 5		285±24	ESR	Faunal enamel	Ciochon et al. (1991)
Stegodon orientalis	Long et al. (1996)				
Elephas namadicus	Ciochon & Olsen (1991)				
Tam Hang south (=Tam Nang)					
Hystrix tuff		Middle Pleistocene	Biostratigraphy		Bacon et al. (2011)
Stegodon orientalis	Bacon et al. (2011)				
Elephas sp.	Bacon et al. (2011)				
Ban Tha Chang				Quartz grain	Haines et al. (2004)
Siam pit					
advanced *Stegodon*	Thasod (2007)	Early Pleistocen			
Elephas sp.	Thasod (2007)	750±130	TL		

Table 2b)

Site	Taxonomical references	Age range of dated materials (ka)	Dating method	Dated material	Chronological references
Mogok caves					
Dato cave (=Mercury cave=Mogok C1)		Middle Pleistocene	Biostratigraphy		Colbert (1943)
Stegodon sp.	Colbert (1943)				
Chausong cave (=Mogok C2)		Middle Pleistocene	Biostratigraphy		Colbert (1943)
Stegodon orientalis	Colbert (1943)				
Elephas namadicus	Colbert (1943)				
Kedung Brubus		Lower Middle Pleistocene	Biostratigraphy		Van dern Bergh (1999)
Stegodon trigonocepahlus	Van dern Bergh (1999)				
Stegodon hypsilophus	Van dern Bergh (1999)				
Elephas hysudrindicus	Van dern Bergh (1999)				
Novaliches-Marilao		Middle Pleistocene	Biostratigraphy		Von Koenigswald (1956a)
Stegodon sp.	Von Koenigswald (1956a)				
McCrory place		Middle Pleistocene	Tektite		Von Koenigswald (1956a)
Stegodon cf. *trigonocephalus*	Von Koenigswald (1956a)				
Fort McKinley (Rizal district)		Middle Pleistocene	Biostratigraphy		Von Koenigswald (1956a)
Stegodon luzonensis	Von Koenigswald (1956a)				
Northwest Mindanao		Middle Pleistocene	Biostratigraphy		Von Koenigswald (1956a)
Stegodon trigonocephalus	Von Koenigswald (1956a)				
Stegodon mindanensis	Von Koenigswald (1956a)				

Table 2

South-east Asian Middle Pleistocene sites with the occurrence of *Elephas* and/or *Stegodon*

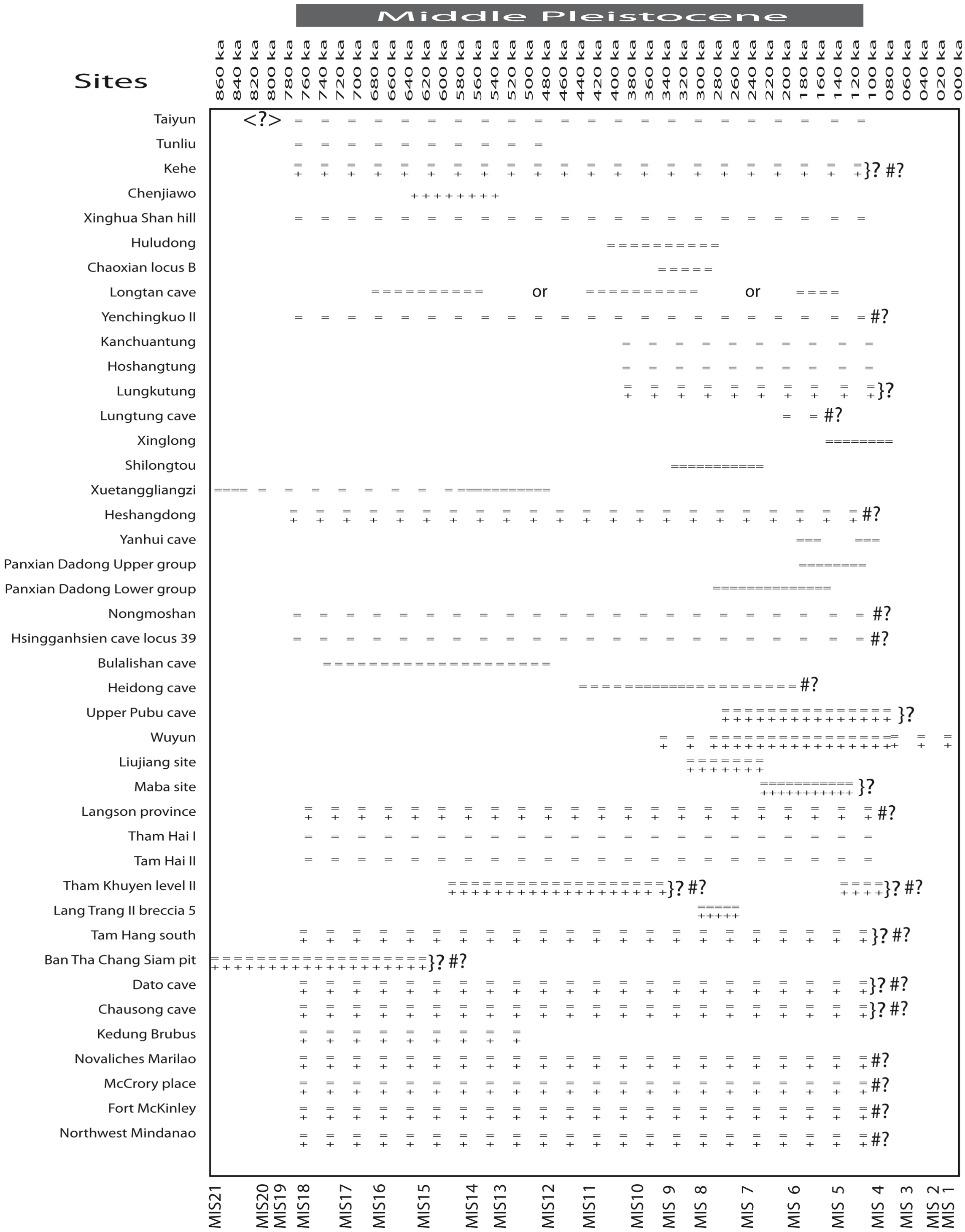

Table 3
Evaluation of the quality of the available data. Spacing between the symbols indicates reduced reliability.
===== reliable; = = = averagely reliable; = = = = slightly reliable; =   =   =   unreliable.
"=" for the genus *Stegodon*; "+" for the genus *Elephas*; }? uncertainty of the association; #? probable mixture of the faunas.

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