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The Pleistocene Ma U'Oi cave, northern Vietnam: palaeontology, sedimentology and palaeoenvironments

La grotte Pléistocène de Ma U'Oi, au nord du Viêt-Nam : paléontologie, sédimentologie et paléoenvironnement

Anne-Marie Bacon [a,*], Fabrice Demeter [b], Mathieu Schuster [c], Vu The Long [d], Nguyen Kim Thuy [d], Pierre-Olivier Antoine [e], Sevket Sen [f], Ha Huu Nga [d], Nguyen Mai Huong [d]

[a] *UPR 2147 du CNRS, 44, rue de l'Amiral-Mouchez, 75014 Paris, France*
[b] *Laboratoire d'anthropologie biologique, Musée de l'homme, 17, place du Trocadéro, 75116 Paris, France et Chaire de paléoanthropologie et préhistoire du Collège de France, 11, place Marcellin-Berthelot, 75005 Paris, France*
[c] *Institut de géologie (EOST-CGS), UMR 7517, université Louis-Pasteur, 1, rue Blessig, 67084 Strasbourg cedex, France*
[d] *National Center for Social Sciences and Humanities of Vietnam, Institute of Archaeology, 61, Phan Chu Trinh, Hanoi, Vietnam*
[e] *Institut des sciences de l'évolution, UMR 5554, université Montpellier-2, place Eugène-Bataillon, 34095 Montpellier, France*
[f] *Laboratoire de paléontologie, UMR 8569, Muséum national d'histoire naturelle, 8, rue Buffon, 75005 Paris, France*

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Abstract

In November 2001, a Vietnamese-French team undertook the excavation of the Ma U'Oi cave in northern Vietnam. This limestone karst cave is located in the province of Hoà Binh, 70 km ESE from Hanoi and is typical of the northern Vietnam landscape. The site yielded an in situ mammalian fauna of a relatively modern composition. We also found a mixed fauna with a lower molar attributed to an archaic *Homo* (Demeter et al., in press). We estimate the age of Ma U'Oi fauna between 169 kyr, the age of Thum Wiman Nakin (Esposito et al., 1998) estimated by U/Th method and 80-60 kyr, the biochronological age of Lang Trang (Long et al., 1996), or even Holocene. The Ma U'Oi site is important because of the scarcity of Vietnamese sites of those particular levels. For that reason, it fills a gap in the biostratigraphy of Vietnam and permits new correlations with other sites of the mainland, especially those well documented from Thailand.

Résumé

En novembre 2001, une équipe franco-vietnamienne a entrepris la fouille de la grotte de Ma U'Oi au nord du Viêt-Nam. Cette grotte calcaire, au remplissage karstique typique des reliefs trouvés au nord du Viêt-Nam, est située dans la province de Hoà Binh à 70 km ESE de Hanoi. Le site a fourni une faune mammalienne in situ de composition relativement moderne. Nous avons également trouvé une faune mixte dans laquelle figure une dent humaine attribuée à un *Homo* archaïque (Demeter et al., in press). L'âge de la faune in situ est estimé entre 169 000 ans, âge de la faune de Thum Wiman Nakin (Esposito et al., 1998) obtenu par la méthode U/Th, et 80 000-60 000 ans, âge biochronologique de la faune de Lang Trang (Long et al., 1996). Un âge holocène n'est pas exclu. Le site de Ma U'Oi est important en raison du petit nombre de sites vietnamiens de même niveau. Il permet de préciser, voire de combler les lacunes que présente la biostratigraphie du Viêt-Nam. Il permet aussi de réaliser de nouvelles corrélations avec d'autres sites continentaux, particulièrement ceux bien documentés de Thaïlande.

Keywords: Pleistocene; Holocene; Vietnam; Ma U'Oi cave; Mammalian fauna

Mots clés : Pléistocène ; Holocène ; Viêt-Nam ; Grotte de Ma U'Oi ; Faune mammalienne

* Corresponding author.
E-mail address: bacon@ivry.cnrs.fr (A.-M. Bacon).

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1. Introduction

In the 1960's, Vietnamese researchers undertook the excavations of Pleistocene sites in northern Vietnam (see Cuong, 1985 for a review of Vietnamese publications). Thirty years later, excavations in three sites, Tham Kuyen (475 ± 125 kyr), Tham Hai (300-200 kyr) and Lang Trang (80-60 kyr) were re-opened by Americans and Vietnameses (Ciochon and Olsen, 1986; Olsen and Ciochon, 1990; Long et al., 1996; Ciochon et al., 1996). In Vietnam, the Pleistocene sites range from 475 ± 125 kyr at Tham Kuyen (Ciochon et al., 1996) to 30-20 kyr at Keo Leng (Kha, 1976; Long and Du, 1981; Cuong, 1985; Olsen and Ciochon, 1990). The faunas belong to the *Ailuropoda-Stegodon* complex known in Southeast Asia since the 1920's and initially described in southern China as the "Sino-Malayan fauna" (Young, 1932; Pei, 1935; Teilhard de Chardin, 1935; Bien and Chia, 1938; von Koenigswald, 1939; Young and Liu, 1951; Colbert and Hooijer, 1953; Pei and Li, 1958; Kahlke, 1961; Aigner, 1978; De Vos, 1984). This faunal complex, characteristic of the Middle Pleistocene, accompanied the arrival and the migration of first humans in Far Eastern Asia (*Homo erectus*) and later that of first modern humans (*Homo sapiens*), as far as the island of Java thanks to a sea level drop (Dubois, 1908; Badoux, 1959; De Vos, 1985; van den Bergh et al., 1996).

If the presence of *Homo erectus* is now well documented in Java, it is more tenuous on the mainland. In Vietnam, the evidence consists of isolated teeth found at Tham Kuyen and Tham Hai (Kha and Bao, 1967; Cuong, 1971; Kha and Cuong, 1975; Chinh et al., 1979; Cuong, 1985; Ciochon and Olsen, 1986; Olsen and Ciochon, 1990). The attribution of some of these teeth to *H. erectus* is questionable because, it is easy to confuse them with orangs-utans teeth when they are worn (both present globally same dimensions). Nothing more is known on the presence of *Homo erectus* in Vietnam and on his faunal and environmental context. Concerning *Homo sapiens*, the oldest remains consist principally of isolated teeth discovered at Tham Om, Hang Hum and Keo Leng and also of a fragment of glabella from this latter site (Kha and Bao, 1967; Kha, 1975,1977; Long et al., 1977; Cuong, 1985; Ciochon and Olsen, 1986; Olsen and Ciochon, 1990).

In November 2001, the excavation of the Ma U'Oi cave was conducted to find new data concerning the Pleistocene of northern Vietnam. The geological and sedimentological context of the deposits is precised. We describe the mammalian fauna and compare it with those found in other continental sites, especially Thai and Vietnamese sites, the most documented ones for the Middle Pleistocene. We propose a relative dating that will be precised later by an absolute dating (Falguères et al., in preparation). These new data are important because the biochronology of mainland Southeast Asia is still poorly known. For the Pleistocene period, a few continental sites with detailed faunal lists are available in the literature: Tham Kuyen, Tham Hai, Tham Om, Hang Hum, Keo Leng and Lang Trang in Vietnam (Cuong, 1985; Olsen and Ciochon, 1990; Long et al., 1996), Liucheng, Tashin, Changyang, Yenchingkuo, Hoshantung, Koloshan and Hsingan in South China (Colbert and Hooijer, 1953; Kahlke, 1961), Phnom Loang in Cambodia (Beden and Guérin, 1973), Tam Hang in Laos (Fromaget, 1936; Arambourg and Fromaget, 1938), Thum Wiman Nakin and Thum Phra Khai Phet in Thailand (Ginsburg et al., 1982; Chaimanee and Jaeger, 1993; Tougard, 1998, 2001), Irrawady and Mogok in Myanmar (Colbert, 1938, 1943), Tambun in Malaysia (Medway, 1972). The correlations between these continental sites are difficult to establish because of the numerous gaps (De Vos, 1984; Tougard, 1998). The Ma U'Oi site fills a gap in the biostratigraphy of Vietnam and allows new correlations with other sites of the mainland, especially those well documented in Thailand.

2. Location of the Ma U'Oi cave

The Ma U'Oi cave is situated in the Man Duc village (Tan Lac District, province of Hoà Binh) 25 km of the town of Hoà Binh in northern Vietnam (Fig. 1) (coordinates: N20°37′22″, E105°16′40″). The name of "Ma U'Oi" means, "cave of the spirit of orang-utan" in reference to a local popular legend, which believes that an orang-utan lived here far in the past.

We found the cave of Ma U'Oi in May 1999 while prospecting the nearby Chieng Xen cave excavated during 1930's by Madeleine Colani, a French archaeologist (unpublished correspondance of M. Colani). The Ma U'Oi cave is about 150 metres from that of Chieng Xen. During this first visit, we found teeth of Suidae and Rhinocerotidae at the entrance

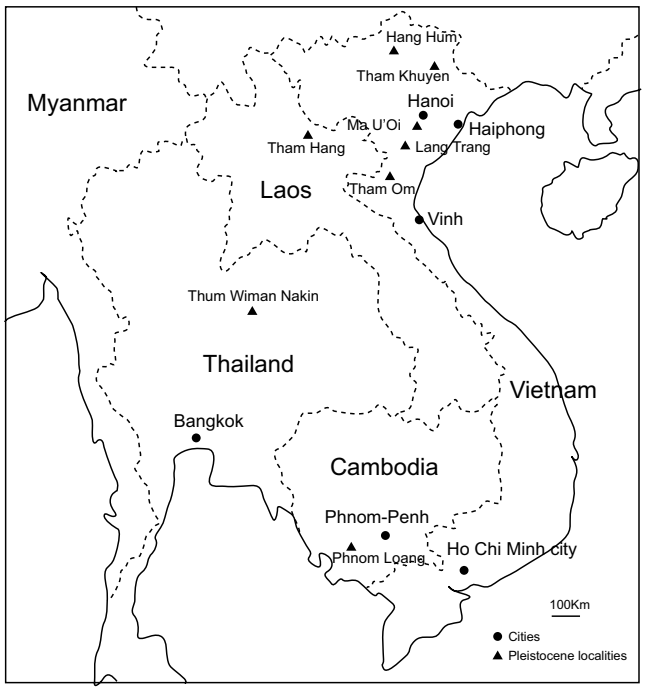

Fig. 1. Location of Pleistocene sites in Vietnam, Laos and Thailand.
Fig. 1. Localisation des principaux sites pléistocènes au Viêt-Nam, au Laos et en Thaïlande.

of the cave. Given the fossiliferous potential of the cave, we decided to undertake further investigations. The first field season started in November 2001 for three weeks.

3. Geological setting of the cave

3.1. General aspects of the fossiliferous level

The landscape of the Tan Lac district is characterized by a spectacular morphology of karst peaks. These hills and towers, several tens of metres high, are mostly covered by tropical vegetation. They are made of Triassic massive and dark micritic limestones showing a typical grey to yellow varnish. By dissolution of these calcareous rocks, a dense system of caves and galleries developed through time. The Ma U'Oi cave represents just a small example of this dense system of karst. The cave consists of two distinct corridors (Fig. 2(A, B)). During this field work, we excavated corridor A, composed of two principal rooms (A1 and A2). In the first room (A1), the fossiliferous level forms a thick layer (between 0.5 m and about 1 m) covering the vault and the upper part of the walls. In the second room (A2), only a few small scraps of this fossiliferous level remain on the walls and the vault, but it is well preserved on the ground where it forms an irregular pluridecimetric layer.

The fossiliferous facies, whatever its location in the cave (room A1 or A2), has a constant composition. It consists of an heterogeneous mixing of weathered clays, pelites (small mud clasts and pebbles), Fe-Mn-rich and granule-sized pisolithes, reworked speleothems such as calcite pearls (diameter < 1 cm), clasts of triassic dark limestones (1 cm to 30 cm) generally showing a weathered smoothed and light tinted surface and fossil remains (bones and teeth) of various mammals. All these elements are cemented by a dense network of calcite veins (mm to cm) that were formed by Ca-rich water circulations. This facies has a general brown colour (darker in room A2 but lighter in room A1 that is situated at the entrance of the cave and therefore more exposed to weathering), but hammer hits leave white traces. This facies is a calcaro-pelitic, fossiliferous cave breccia. The breccia is characterized by a relative monotony (in poor sedimentary structures), a short-scale lateral and vertical extension (constrained by the geometry of the karst) or a variable preservation potential. In spite of these characteristics, two distinct types of outcropping conditions are noticeable for the fossiliferous level, according to the room where it is found.

3.2. Description of fossiliferous levels in rooms A1 and A2

In the first room (Fig. 2(A1)), the breccia is well represented and it covers, with a centimetric to metric thickness, the walls and the vault of the karst (Fig. 3). Petrographic variations or sedimentary structures are very few. At one place, the breccia consists of a 15 cm thick level (rigorously horizontal and extended at the scale of the room) of polygonal mud cracks and clasts (3-5 cm in diameter, about 0.5 cm in thickness). This level is then overlain by a 5-10 cm thick level rich in calcite pearls.

In room A2, only a few scraps of the fossiliferous breccia covering the walls and vault (made of triassic dark limestones) are still preserved. A test pit up to 3 metres deep (Fig. 3) was dug and the ground was removed level by level but the bottom of the cave has not been reached. From top to bottom, the first level (10-15 cm) consists of the present-day soil of the cave, made of unconsolidated weathered products of breccia. The second level (30-50 cm) is made of a fossiliferous breccia that corresponds typically to those described above. The third level (> 3 m) is made of dark brown monotonous clays. At the boundary between the first and the second level, we found the remains of charcoals and baked clays that show evidence of recent human occupation. The fossiliferous breccia contains angular blocks (1-25 cm) of triassic dark limestones showing an unweathered surface. This subhorizontal level shows an irregular base and looks like it is made of an intimate assemblage of various-sized blocks of fossil-

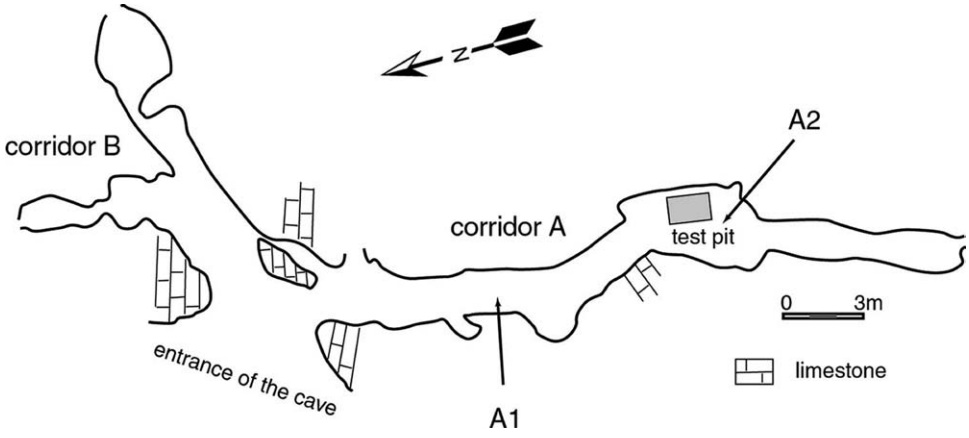

Fig. 2. Diagram of the Ma U'Oi cave. The cave consists of two corridors A and B. Only the corridor A, composed of the two rooms A1 and A2, has been excavated during this first field work.
Fig. 2. Coupe de la grotte de Ma U'Oi. La grotte est composée de deux couloirs A et B. Seul le couloir A formé de deux pièces A1 et A2 a été exploré durant cette première mission.

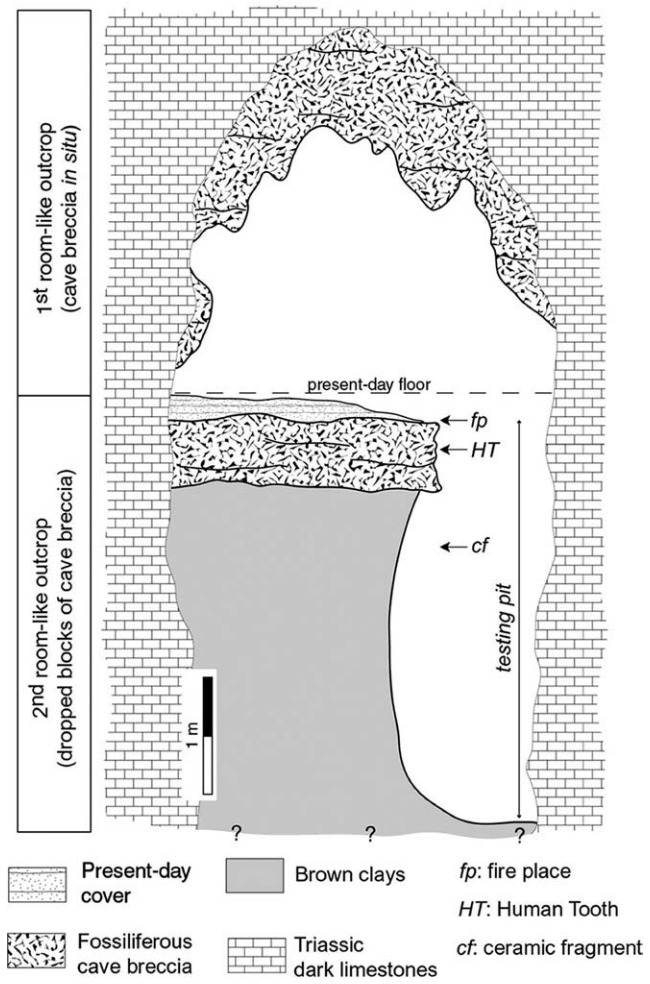

Fig. 3. Virtual reconstruction of the fossiliferous outcrops of Ma U'Oi cave. The upper part corresponds to the first room (A1) with the cave breccia recovering the walls and the vault (made of Triassic dark limestones). The lower part corresponds to the second room (A2) where the test pit has revealed an other fossiliferous level composed of dropped blocks of breccia.
Fig. 3. Reconstitution des dépôts fossilifères de la grotte de Ma U'Oi. La partie supérieure correspond à la première pièce (A1) avec la brèche recouvrant les murs et la voûte de la grotte (formée de calcaire noir du Trias). La partie inférieure correspond à la seconde chambre (A2) où le sondage a permis de mettre au jour un autre niveau fossilifère composé de blocs de brèche tombés de la voûte.

iferous breccia. In this level, we found a human tooth and in the clays of the lower level, at about 0.5 m under the base of the breccia, we found a 300 years old ceramic fragment (determined by Ha Huu Nga).

3.3. Interpretation: evidence of a multi-episods formation process

The fossiliferous breccia corresponds to the filling of the karstic system. In the first room (A1), it is well preserved, whereas in the second room (A2), it was almost totally swept away.

Observations in the first room suggest that the filling of the karst is the result of several episods of sedimentation interrupted by non-deposition periods. Mud pebbles, Fe-Mn-rich pisolithes, calcite pearls as well as bones and teeth were all transported by water circulation inside the karst. The presence of a well-defined level composed of mud cracks and clasts suggests (1) the occurrence of a period during which the karst was totally dry and (2) that this level is still in place (i.e. that the cave breccia was deposited at this place and was no more reworked).

The presence of the cave breccia up to the ceiling of the room shows that the Ma U'Oi cave was once totally filled. The present-day configuration is the result of a new digging of the breccia after modern water circulation. The cave filling (i.e. the cave breccia) was karstified in the same way as the former karst system (dissolved out of the Triassic dark limestones that are much more weathering-resistant than the breccia). There are many other caves in the neighbourhood of the cave of Ma U'Oi. In a few of them a very similar fossiliferous level was recognized. It consists of a cave breccia that covers walls and vaults. Unfortunately there were no element allowing correlation between all these outcrops. According to sedimentological observations, the genesis of the fossiliferous breccia seems to be controlled only by hydrology inside the karst (i.e. indirectly by climatic conditions).

Taking into account the sedimentary conditions in which fossils were discovered, we divide the fauna into two groups. In the first group, we consider fossils found in the breccia as the in situ fauna (extracted from the walls and the vault of the room A1, Fig. 2). In the second group, we consider fossils found in the dropped blocks of breccia in the ground as the sub-in situ fauna (extracted from the second room A2). Most of the teeth found in the ground were included in blocks of the fossiliferous deposits. This is especially the case of the human tooth. However, some other isolated teeth were also found between blocks and could not belong to the fossiliferous level. For these reasons, we consider separately the fossils belonging to the fauna in situ from those belonging to the mixed fauna of the ground.

4. Description of the fauna

We found about fifty isolated teeth of large and small mammals (Table 1). In Table 2, we present the two faunal lists. Most of the teeth were rootless, probably gnawed by porcupines, a common situation in Pleistocene caves of Southeast Asia (Roze, 1989; Hooijer, 1946a, 1948: Tougard, 1998).

The number of species found in situ in the Ma U'Oi cave is poor. We can propose a clear identification for *Sus scrofa* and *Muntiacus muntjak*. Dimensions of the four premolars and molars of *Sus* of Ma U'Oi (Table 3) fall within the range of *Sus scrofa* from Lang Trang (De Vos and Long, 1993, unpublished report) and are close to those of the same species found at Thum Wiman Nakin (Tougard, 1998). The molar (MU34: M^2 or M^3) of *Muntiacus* of Ma U'Oi is larger than those of *M. muntjak* of Lang Trang (Table 3), but we have to precise

Table 1
Detailed mammalian faunal lists of Ma U'Oi (both fragmented and complete teeth).
Liste détaillée de la faune mammalienne de Ma U'Oi (dents complètes et fragmentaires)

Fauna in situ	
Sus scrofa	1 M_3, 2M^3, 2 P_4, 1 P_3,
Rusa cf. *unicolor*	1 lower M, 2 M^1, 2 M^3, M_2, 2 M_3, 1 P_3, 1 M (?)
Muntiacus muntjak	1 M^3 or M^2
Rhinoceros cf. *sondaicus*	1 d_3, 1 d_1, 1 M_2
Elephas sp.	1 lamel
Macaca sp.	1 I^1, 1 C upper, 1 M (?), 1 M upper (?), 1 P_3 (?), 1 M_3
Herpestes sp.	1 C upper
Niviventer fulvescens	1 mandible (M_1, M_2, M_3)
Niviventer andersoni	1 M^1, 1 M_1,
Leopoldamys sabinus	1 mandible (M_1, M_2, M_3), 1 M_1, 1 M_2,
Mixed fauna	
Sus scrofa	1 I_1, 1 M^3, 1 P_1, 2 P_3
Rusa cf. *unicolor*	1 M^1, 1 M^1 (?)
Rhinoceros cf. *unicornis*	1 d_2
Macaca sp.	1 P_4, 1 P^4, 1 P^3
Niviventer fulvescens	1 M_1, 1 M_2, 1 M_3
Bandicota sp.	1 maxilla (M^1, M^2)
Archaïc Homo	M_1

Table 2
Determination of the faunas found in the Ma U'Oi cave: that one in situ from the walls and the vault and the mixed one from the ground.
Détermination des faunes trouvées dans la grotte de Ma U'Oi : la faune in situ extraite des parois et du plafond de la grotte et la faune mixte trouvée au sol

Fauna in situ	**Mixed fauna from the ground**	**Common name of species**
Sus scrofa	*Sus scrofa*	Wild boar
Rusa cf. *unicolor*	*Rusa* cf. *unicolor*	Sambar
Muntiacus muntjak	-	Muntjac
Rhinoceros cf. *sondaicus*	-	Javan rhinoceros
-	*Rhinoceros* cf. *unicornis*	Indian rhinoceros
Elephas sp.	-	Asian elephant
Macaca sp.	*Macaca* sp.	Macaque
Herpestes sp.	-	Mongoose
Niviventer fulvescens	*Niviventer fulvescens*	Chestnut rat
Niviventer andersoni	-	Chinese rat
Leopoldamys sabanus	-	Long-tailed giant rat
-	*Bandicota* sp.	Bandicoot-rat
-	Archaic *Homo*	Humans
Crab	Crab	Crab
-	*Cyclophorus*	Snails
Ophidia indet.	-	Snakes

that the effective of fossils from Lang Trang is very small (15 teeth for upper M1, M2 and M3) and thus, do not reflect the real variability of molar dimensions of *M. muntjak* (De Vos and Long, 1993, unpublished report). The muntjaks of Ma U'Oi rather present the same size than those of Thai sites (Tougard, 1998). Concerning the other Cervidae, the ten teeth found at Ma U'Oi can be attributed morphologically to *Rusa* cf. *unicolor*. Their dimensions fall also into the range of *Rusa unicolor* from Lang Trang (De Vos and Long, 1993, unpublished report and Table 3).

The determination of the Muridae has been made in comparison with those described in the work of Chaimanee (1998) by S. Sevket. Three species are present at Ma U'Oi: *Niviventer andersoni, Niviventer fulvescens* and *Leopoldamys sabanus*. The specimens identified as *N. fulvescens* and *L. sabanus* fall within the ranges of variation of the same species from Thai sites (Chaimanee, 1998) and also modern forms (Musser and Chiu, 1979; Chaimanee, 1998). The second species of *Niviventer* found at Ma U'Oi is identified as *N. andersoni* on the basis of size of the first molars (MU 30-1, MU 30-2). Indeed, their dimensions exceed those of fossil species *N. fulvescens* and *N. gracilis* n. sp. from Thai sites (Chaimanee, 1998) and also those of modern forms. They only fall in the range of variation of the living *N. andersoni* (Musser and Chiu, 1979; Chaimanee, 1998).

According to P-O Antoine, three teeth attributed to *Rhinoceros* are characterized by the lack of any buccal and lingual cingulum, and by a corrugated and wrinkled enamel. Only one permanent tooth (MU 46-1, lower M2) has been unearthed in the in situ fauna. It is much worn and partly broken, and thus a few morphological features are preserved. The ectolophid groove is deep and acute down to the neck. It is nearly vertical, conformably to the lower molars of *R. sondaicus*, and contrary to what occurs in *Dicerorhinus sumatrensis*. The other specimens are milk molars (brachydont with a very thin enamel). The MU 9 is typical in size and structures for a d1. It is larger than those referred to *Dicerorhinus sumatrensis* by Hooijer (1946b: Table 2) and Guérin (1980). The molariform d3 (MU 3 and MU 10 (talonid)) is narrow and elongated, similar in shape and size to the seventeen d3 of *R. sondaicus* described by Hooijer (1946b: Table 4). The anterior cingulum is wide. The paralophid is furcated on MU3, with two long transverse crests (*Rhinoceros*). The protoconid fold is thick and well separated from the metaconid by a deep groove. The entoconid is constricted as well. The ectolophid groove is smooth and shallow. The dimensions and structures of teeth differ from those of *R. unicornis* (smaller size) and *Dicerorhinus sumatrensis* (much larger size, ectolophid groove, bifid paralophid on d3). On the other hand, they match closely with those of the living and fossil *Rhinoceros sondaicus* (Hooijer, 1946b: Tables 4, 6; Guérin, 1980). As the sample is very small, we prefer to refer these specimens to *Rhinoceros* cf. *sondaicus*.

Due to the difficulty in recognizing species, the other mammals are identified only at the genus level: *Macaca* sp., *Herpestes* sp. and *Elephas* sp. Concerning primates, all teeth can be attributed to the genus *Macaca* (premolars and molars of *Macaca* have rounded and low cusps contrary to those high and sharp of *Presbytis* and *Trachypithecus*). The specific determination of *Macaca* is however very difficult because of the great similarities in size and morphology between many macaque species. The macaque teeth from Ma U'Oi are small (the lower M3 falls within the size range of *M. fascicularis* and they are smaller than *Macaca* sp. from Lang Trang and *M. nemestrina*) (De Vos and Long, 1993, unpublished report). Moreover, the *Macaca* of Ma U'Oi

Table 3
Measurements of the well-preserved teeth from Ma U'Oi cave. Concerning the first molar of the archaic *Homo* found in the mixed fauna, the mesiodistal length (*) is only estimated due to the wear of the crown.
Dimensions des dents les mieux préservées découvertes dans la grotte de Ma U'Oi. En ce qui concerne la première molaire attribuée à un *Homo* archaïque et provenant de la faune mixte, la longueur mésio-distale (*) a été estimée en raison de la forte usure de la couronne

Taxa Artiodactyla	Numero	Element	Fauna	Length	width
Muntiacus muntjak	MU34	M^2 / M^3 left	in situ	14.4	15.1
Rusa cf. *unicolor*	MU7-2	M^1 left	mixed	22.2	25
Rusa cf. *unicolor*	MU11	M^1 right	mixed	24.3	25.2
Rusa cf. *unicolor*	MU15-1	M^1/M^2/M^3 right	in situ	22.1	19.9
Rusa cf. *unicolor*	MU15-2	M^1/M^2/M^3 right	in situ	21.8	19.4
Rusa cf. *unicolor*	MU39-1	M_2 right	in situ	-	15.8
Rusa cf. *unicolor*	MU45	P_3 right	in situ	17. 5	9.5
Rusa cf. *unicolor*	MU46-2	M_3 right	in situ	31.6	15. 4
Sus scrofa	MU1	M_3 right	in situ	-	17.4
Sus scrofa	MU6	P_4	in situ	15.6	12.1
Sus scrofa	MU7-1	M^3 right	mixed	-	21.6
Sus scrofa	MU35	I inf	mixed	6.9	7.3
Sus scrofa	MU42	P_3 right	mixed	14	8.1
Sus scrofa	MU43-1	P_3 left	in situ	13.9	7.6
Perissodactyla					
Rhinoceros cf. *sondaicus*	MU9	d_1 right	in situ	18.7	9(ant)-9(post)
Rhinoceros cf. *sondaicus*	MU3	d_3 left	in situ	40.4	16(ant)-20(post)
Rhinoceros cf. *sondaicus*	MU46-1	M_2 left	in situ	43.8	27(ant)-27(post)
Rhinoceros cf. *unicornis*	MU20	d_2 right	mixed	31	15(ant)-17.5(post)
Primates					
Macaca sp.	MU24-6	P^3/P^4 right	in situ	4.8	5.8
Macaca sp.	MU25-1	P^3 left	mixed	5.1	5.7
Macaca sp.	MU43-2	M_3 left	in situ	10.2	6.2
Macaca sp.	MU44	I^1 left	in situ	6.1	6.3
Macaca sp.	MU37	C inf	in situ	5.3	6.5
Macaca sp.	MU41	C sup left	in situ	10.3	6.3
Macaca sp.	MU22	P^4 left	mixed	5.3	6
Macaca sp.	MU10	P_4 right	mixed	6	4.7
Macaca sp.	MU13	M^1/M^2 left	in situ	9.1	8.2
Archaic *Homo*	MU18	M_1 left	mixed	12.2* (11.9)	12.4
Rodentia					
Niviventer andersoni	MU30-1	M_1 right	in situ	4.1	2.5
Niviventer andersoni	MU30-2	M^1 left	in situ	3.7	2
Bandicota sp.	MU38	M^1 right	mixed	5.1	3
Bandicota sp.	-	M^2 right	mixed	3.3	2.8
Leopoldamys sabinus	MU24-2	M_1 right	in situ	4	2.6
Leopoldamys sabinus	-	M_2 right	in situ	3.2	2.9
Leopoldamys sabanus	-	M_3 right	in situ	3	2.3
Leopoldamys sabanus	MU24-3	M_1 left	in situ	4.7	2.8
Leopoldamys sabanus	MU24-4	M_2 left	in situ	3.1	2.4

differs from *M. nemestrina* in having weaker cingulum. The macaque of Ma U'Oi could belong to one of the small-sized species present in Southeast Asia during the Pleistocene and Holocene (*M. fascicularis, M. assamensis, M. mulatta*).

From the ground deposits, we collected the remains of the following large mammals: *Sus scrofa, Rhinoceros* cf. *unicornis, Rusa* cf. *unicolor, Macaca* sp. and archaic *Homo*. The two upper molars of *Rusa*, though larger than those of the in situ fauna, fall in the size variability of teeth from Lang Trang (Table 3). The various teeth of *Sus* are comparable in size and morphology to *Sus scrofa* of Lang Trang (De Vos and Long, 1993, unpublished report). We also found two small mammals (*Niviventer fulvescens* and *Bandicota* sp.), claws of crabs and the snail *Cyclophorus*.

The only tooth (MU 20) of *Rhinoceros* in the mixed fauna is identify as a milk molar (d2). It is brachydont, with a very thin enamel (< 1 mm), which allows to identify it as a milk molar rather than a permanent molar. Besides, the occlusal outline is subrectangular, with an enlarged anterior tip as in most d2. The enamel is corrugated and wrinkled. Very few descriptions/illustrations of rhinocerotid milk teeth (especially lower milk teeth) are available in the literature for the Pleistocene and living rhinoceroses from Southeast Asia. One can only say that the posterior width widely exceeds that given by Hooijer (1946b) for the d2 of "[*Dicerorhinus*] *sumatrensis* and [*Rhinoceros*] *sondaicus*" from the Pleistocene of Sumatra: for fourteen d2, the width range from 13 to 15 mm (average 13.6 mm). On the other hand, the

Table 4
Comparison between the Ma U'Oi faunas with those of some Vietnamese fossil sites of relatively same age (Tham Kuyen, Tham Om, Tham Hai, Hang Hum, Keo Leng and Lang Trang), with that of the Thai site Thum Wiman Nakin (Snake cave) and with that of the Chinese site Hoshangtung. In the first column, the asterisk (*) corresponds to the in situ faunal assemblage. The second column indicates the Ma U'Oi species still living in Vietnam. The complete faunal lists of Vietnamese, Thai and Chinese sites can be consulted in Cuong (1985), Olsen and Ciochon (1990), Long et al. (1996), Tougard (1998,2001) and Chaimanee (1998).
Comparaison entre les faunes de Ma U'Oi et celles de quelques autres sites fossiles de même âge : vietnamiens (Tham Kuyen, Tham Om, Tham Hai, Hang Hum, Keo Leng et Lang Trang), thaïlandais (Thum Wiman Nakin) et chinois (Hoshangtung). Dans la première colonne, l'astérisque (*) correspond à la faune in situ. La deuxième colonne correspond aux espèces encore présentes aujourd'hui au Viêt-Nam. Les listes fauniques complètes des sites vietnamiens, thaïlandais et chinois peuvent être consultées dans les articles de Cuong (1985), Olsen et Ciochon (1990) Long et al. (1996), Tougard (1998,2001) et Chaimanee (1998)

	Presence Vietnam	**Tham Kuyen**	**Tham Hai**	**Tham Om**	**Hang Hum**	**Keo Leng**	**Lang Trang**	**Thum Wiman Nakin**	**Hoshangtung**
Suidae									
**Sus scrofa*	X	X	X	X	X	X	X	X	*Sus* sp.
Cervidae									
**Rusa* cf. *unicolor*	X	*R. unicolor*	X	*R. unicolor*	*R. unicolor*	*R. unicolor*	*R. unicolor*	*Cervus unicolor*	
**Muntiacus muntjak*	X	X	-	*M. m. margae*	-	X	X	X	*Muntiacus* sp.
Cercopithecidae									
**Macaca* sp.	X	X *M.* cf. *assamensis*	X	X	X	*M. mulatta* *M. assamensis*	X	*M.* cf. *nemestrina*	X
Herpestidae									
**Herpestes* sp.	*H. javanicus*	-	-	-	-	-	-	-	-
Elephantidae									
**Elephas* sp.	-	*E. namadicus*	-	*E.* cf. *namadicus*	*E. namadicus* *E.* cf. *namadicus*	-	*E. namadicus* */E. maximus*	*E.* cf. *maximus*	*E. namadicus*
Rhinocerotidae									
**Rhinoceros* cf. *sondaicus*	X	-	-	-	-	-	-	*R. sondaicus*	*Rhinoceros* sp.
Rhinoceros cf. *unicornis*	-	-	-	-	-	-	-	X	-
Muridae									
**Niviventer andersoni*	-	-	-	-	-	-	-	-	-
**Niviventer fulvescens*	X	-	-	-	-	-	-	X	-
Bandicota sp.	*B. indica*	-	-	-	-	-	-	*B. indica*	-
**Leopoldamys sabinus*	X	-	-	-	-	-	*Rattus sabanus*	X	-
Hominidae									
Homo sapiens	*H. sapiens*	*H. erectus*	*H. erectus*	*H. sapiens*	*H. sapiens*	*H. sapiens*	-	*Homo* sp.	-
*Ophidia indet.	?	-	-	-	-	-	-	X	-
Cyclophorus	?	-	-	-	-	-	-	-	-
*Crabs	?	-	-	-	-	-	-	-	-

morphology (anterior ectolophid groove) and dimensions (~ 31 × 17.5 mm) of MU 20 fit closely with those of the d2 "Coll. Dub. n° 424" (31 × 18 mm), referred to "*Rhinoceros kendengindicus* Dubois" according to Hooijer (1946b: 134, Table 8; Plate 10, Fig. 9). Laurie et al. (1983) consider this species to be a junior synonym of *Rhinoceros unicornis* Linnaeus, 1758. On the basis of this single milk molar, we identify the large Ma U'Oi rhino as *Rhinoceros* cf. *unicornis*.

5. Discussion and age of the fauna

Concerning the fauna found in the ground, we cannot propose any biochronological dating because of the questionable origin of the fossils. Indeed, some teeth collected in the fossiliferous layer were found between blocks and for that reason might come from the overlying clays. Thus, the fauna from the ground can be a mixed fauna, with both old elements from the walls and more recent elements. All species described here are still extant today in Vietnam except the Indian rhinoceros, *R.* cf. *unicornis* found elsewhere in India (Corbet and Hill, 1992; Nowak, 1999). We report here the first occurrence of a large rhino, close to *Rhinoceros unicornis*, in the Quaternary of Vietnam: only *Rhinoceros sondaicus* and *Dicerorhinus sumatrensis* were reported so far in Middle Pleistocene to Holocene Vietnamese localities (Olsen and Ciochon, 1990; Long et al., 1996; Tougard, 2001).

We focus the discussion on the fauna found in situ, the only datable one. The Ma U'Oi cave yields a relatively modern fauna, which belongs to the *Ailuropoda-Stegodon* complex. Most of the large mammals found in the deposits are still present today in Vietnam, except *Elephas*. Concerning *Elephas maximus*, Corbet and Hill (1992: p. 240) mentioned "the presence of scattered populations throughout much of the Indochinese subregion from Assam and extreme South Yunnan to Vietnam".

The age of the site is hard to estimate as most of the Ma U'Oi species range through the Middle and Late Pleistocene. This is particularly the case for the wild boar (*Sus scrofa*), the sambar (*Rusa unicolor*) and the muntjak (*Muntiacus muntjak*) found also at Tham Kuyen, Tham Om, Keo Leng and Lang Trang localities. Other species occur only in the late Middle Pleistocene (it is the case of the Javan rhinoceros, *R.* cf. *sondaicus*) (Long et al., 1996; Tougard, 2001). The presence of the genus *Elephas* suggests for this site an age younger than those of Tham Kuyen and Tham Hai in Vietnam and Changyang in southern China where this genus is absent (if we consider that this absence is not due to local circumstances) (Table 4).

The association of *Rhinoceros* cf. *sondaicus* with *Elephas* sp. was also mentioned at Thum Phra Khai Phet and Thum Wiman Nakin in Thailand (Tougard, 1998,2001) and at Phnom Loang in Cambodia (in both Thai sites, *Rhinoceros* cf. *sondaicus* is listed with *Elephas* cf. *maximus*, while in the Cambodian site, the subspecies *Rhinoceros sondaicus guthi* is present with *Elephas maximus*). These faunas have been recently redefined by Tougard (1998) as "diversified modern faunas". According to this author, these faunas are composed of species still extant today like *Elephas maximus, Pongo pygmaeus, Rhinoceros sondaicus, Tapirus indicus, Ursus thibetanus* but also extinct subspecies like *Crocuta crocuta ultima* and *Ailuropoda melanoleuca baconi*.

The Ma U'Oi fauna also resembles in many aspects that of Lang Trang in northern Vietnam (Table 4). According to De Vos and Long (1993, unpublished report) and to Long et al. (1996), the presence of the genus *Elephas* is confirmed at Lang Trang (cave II, breccia 5), but the species level is uncertain (*E. namadicus* or *E. maximus*). *Macaca* sp., *Sus scrofa, Muntiacus muntjak, Rusa unicolor* are also common to both sites. The absence of *R. sondaicus* at Lang Trang (*Dicerorhinus sumatrensis* is the only rhinocerotid present) could be due to local circumstances, as this species is still extant in small numbers in Vietnam (Corbet and Hill, 1992; Nowak, 1999). At Lang Trang, according to Long et al., (1996: p. 101), "All the species except *Stegodon orientalis* and *Elephas namadicus* are extant and live somewhere in Indo-China, Malaysia or Indonesia".

Concerning small mammals of Southeast Asia mainland, the only well documented assemblages come from numerous Pliocene to Holocene sites of Thailand (Ginsburg et al., 1982; Chaimanee et al., 1993; Chaimanee, 1998). The small mammal faunas in Indonesian islands are best known, especially in Java and Borneo (Medway, 1972; Musser, 1982; van der Meulen and Musser, 1999). In Vietnamese sites, the data are very scarce and it is difficult to make a comparison with rodents found at Ma U'Oi (Table 4). One can mention the Tham Kuyen site and the more recent one Keo Leng, in which two murids are known but with imprecise specific levels, *Rattus* sp. and *Mus* sp. (Cuong, 1985). The other listed rodents belong to the Hystricidae (*Hystrix subscristata, Hystrix* sp., *Atherus* sp., *Atherus* cf. *macrourus*) and to the Rhizomyidae (*Rhizomys* cf. *troglodytes* and *Rhizomys* sp.). The Lang Trang fauna (cave II, breccia 5) yielded only one species *Rattus sabanus* (Long et al., 1996) (synonym to *Leopoldamys sabanus*).

The Ma U'Oi in situ fauna yielded three Muridae, *Niviventer fulvescens, N. andersoni* and *Leopoldamys sabanus* (Table 2). *N. fulvescens* and *L. sabanus* are still extant in Vietnam, both presenting a large distribution in the Indochinese and Sundaic subregions, while *N. andersoni* is an endemic Chinese species found in different localities between 1.8 myr and 10 000 yrs (Zheng, 1993; Chaimanee, 1998), and still present in China (East Tibet, Yunnan, Sichuan, South Gansu and Shaanxi) (Corbet and Hill, 1992). Among all Muridae found at Thum Wiman Nakin (Chaimanee, 1998), *N. fulvescens* and *L. sabanus* are rather abundant (with *Rattus sikkimensis* and *R. rattus*), while *N. andersoni* is absent. The lists of Muridae being extremely poor in Vietnamese sites, the comparison with those of Ma U'Oi is impossible. We can just say that it is the first mention of *N. andersoni* outside China in Quaternary deposits.

Concerning the environmental context, it is tempting to note the similitude between the site of Ma U'Oi with that of Thum Phra Khai Phet site in Thailand (Tougard, 1998) despite the absence at Ma U'Oi of the *Pongo, Ailuropoda, Ursus* and *Tapirus* genera. The absence of *Pongo* could indicate at Ma U'Oi an open woodland environment. *N. fulvescens* and *L. sabanus* suggest various kinds of forests, lowlands and foothills of evergreen forests (Corbet and Hill, 1992; Chaimanee, 1998). The presence at Ma U'Oi of *N. andersoni* is controversial because its environment is far from what the other mammals suggest. Indeed, Musser and Chiu (1979) note "Both *andersoni* and *excelsior* inhabit the high mountains along the eastern edge of the Tibetan Plateau and the Himalayas" and farther" Examples of *andersoni* have been collected from elevations ranging from 6000 to 10 000 ft."

6. Conclusion

We estimate that the Ma U'Oi fauna could be correlated with sites dated between late Middle Pleistocene to Holocene. Indeed, it presents some similarities with Thum Phra Khai Phet and Thum Wiman Nakin sites in Thailand (Tougard, 1998, 2001) and Phnom Loang in Cambodia dated to late Middle Pleistocene. However, due to the absence of extinct species at Ma U'Oi characteristic of late Middle Pleistocene, we are more inclined to correlate the fauna of Ma U'Oi with sites of Late Pleistocene, especially that of Lang Trang which is the only well documented one in northern Vietnam (De Vos and Long, 1993, unpublished data; Long et al., 1996). We cannot also reject the possibility of an Holocene age. We consider the age of Ma U'Oi between 169 kyr, the age of Thum Wiman Nakin (Esposito et al., 1998) estimated by U/Th method and 80-60 kyr, the biochronological age of Lang Trang (Long et al., 1996), or even more recent. This estimation will be confronted later with absolute datings (Falguères et al., in preparation). Datings of several speleothems, such as partly preserved calcite trays recovering locally the fossiliferous facies (interpreted as successive palaeosoils), calcite pearl levels (reworked by water circulations during wet phases) or calcite veins that cement the breccia, are still in progress, using the U-Th dating method. Thus, a more precise chronology of the different phases that have generated the fossiliferous breccia and an accurate datation of the fossils found in this breccia are expected in the near future.

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