

Neolithic Vegetation in Northern Vietnam: An Indication of Early Agricultural Activities

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ABSTRACT

Neolithic in Vietnam exists in across from Pleistocene to Holocene, dated about 12,000BP to 4,000 BP. Directly followed the Hoabinhian culture which is well known, not only in Vietnam, but also throughout Southeast Asia, for its distinctive diverse of lithic tools. Sea level changes had a strong impacted on the distribution of the Neolithic archaeological sites in North Vietnam. At the early Neolithic, the sites mostly distributed in a wide range of terrains in the mountainous area, which about or higher than 25 m above sea level. In the late Neolithic period, it can be found at the plain and at coastal area, but especially within the floral bioregions adapted to a tropical and humid climate pattern. The cultural achievements of the Hoabinhian and post Hoa Binh cultures established favorable prerequisites for the formation and development of subsequent Neolithic archaeological cultures.

It is generally accepted that Neolithic people were hunter-gatherers, but indirect evidence of stone tools i.e. polished axe and the adze, stone hoes, knives, etc. are associated with cord-marked pottery and small slate knives, believed to be used for agricultural purposes. This issue is current interest but its understanding is hampered by lack of information regarding its palaeoenvironmental context. In order to better understanding of this issue, pollen analysis method is used, with the aims to reconstruct the vegetation and the sign of early agriculture activities. Sediment collected from archaeological layers of seven Neolithic sites in North Vietnam has been extracted for pollen analysis.

Analysis results show that the floral ecosystems were mosaics of grassland, shrub trees and native forests. It reflects both natural and cultural influences on the environment. In the cave sites, fern spore occurred in higher percentage than other plant groups, indicated humid condition. While at the sites located at plain, pollen of arboreal and non arboreal is dominant. The identified pollen appears to have a close

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relationship with contemporary plant cultivars, such as Poaceae, Malvaceae, Compositae, Leguminosae,...This type of pollen appears in most Neolithic sites and in upper part of stratigraphy, and thus may be related to the cultivar species; suggesting that Neolithic inhabitants of Northern Vietnam may have begun to cultivate crops. The results bring a new and improved insight into the previously established vegetation sequence, and giving a clearer picture of the cultural and environmental landscape of the Neolithic periods in this area.

Combined pollen analysis results and archaeological evidences, we posit a relationship between vegetation changes and early agricultural activities of Neolithic populations. Although there remain significant gaps and unresolved issues in the paleo-environment of North Vietnam, this discussion and interim synthesis of existing data only serve as a highlight topic for further research i.e. more testing for the pollen analysts, as far as tracing agricultural origins is concerned.

We conclude that palynology can clarify preconditions required for the development of more intensive cultivation and domestication apparent at the sites of the subsequent Phung Nguyen period, corresponding to the Late Neolithic/Early Bronze Age, provide a holistic interpretation of vegetation of the Neolithic to Bronze Age in North Vietnam.

Key Words : Palynology, Agriculture, Neolithic, Northern Vietnam

INTRODUCTION

The Neolithic period in northern Vietnam directly followed the Hoabinhian culture which is well known, not only in Vietnam, but also throughout Southeast Asia, for its distinctive lithic tools. The appearance and development of stone hoes and other types of polished axes are related to deforestation for purposes of cultivation. In addition, a rich corpus of pottery likely reflects post-harvest storage activities at that time (Bui 1991; Ha ed. 1998; Bowdler 2008). Early agriculture issue is current interest but its understanding is hampered by lack of information regarding its palaeoenvironmental context (Maloney 1994). The diversification of the most common stone tool forms and exploited plant species, as indicated through pollen analysis and other macrofossils like fruits and seeds, seems to demonstrate a close relationship between plants and people during the Neolithic in northern Vietnam, which predates demonstrable plant cultivation. The cultural achievements of the Hoabinhian and post Hoa Binh cultures established favorable prerequisites for the formation and development of subsequent Neolithic archaeological cultures.

The definition of agriculture in Neolithic here is considered in wider regard as horticulture rather than agriculture. The palynologist interested in early agriculture is concerning with finding the pollen of possible cultivars, and weed indicators of agriculture

conditions (Maloney 1994). It is still unable to distinguish domestic plants from wild cultigens by the analysis of pollen alone. However, the sites with rich types of stone tools, such as polished axes, hoes, knives, crushing, and grinding stones as well as pointed tools made of bone, wood and stone suggest an association with agricultural practices.

GEOLOGICAL AND TOPOGRAPHIC CONTEXT

The researches on the Neolithic environment of Southeast Asia and Vietnam in particular made it possible for archaeologists to understand the dramatically transformation of the topography, geomorphology and the living environment (Fig.1). This is the impacts of several phases of sea level fluctuation in the past.

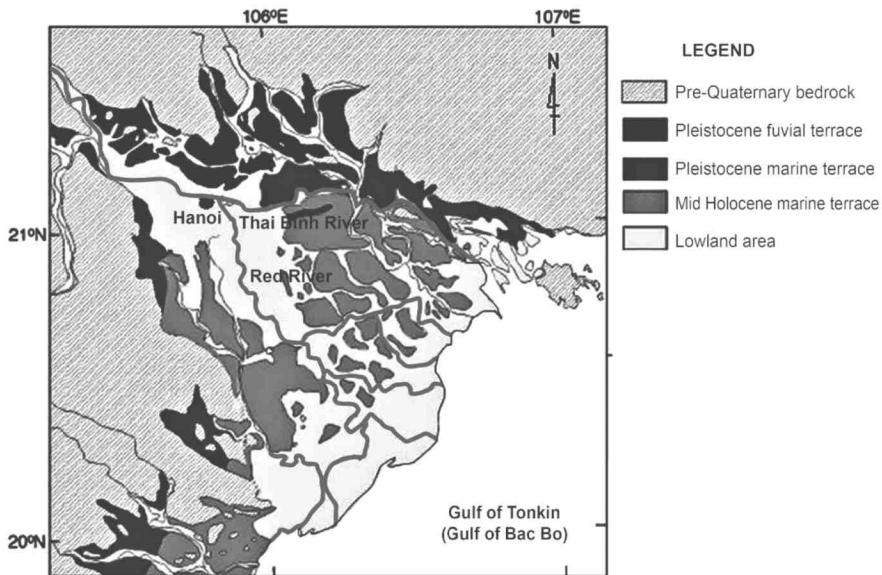


Fig. 1: Quaternary geological map of the Red River delta and adjacent area (modified after Tanabe et al. 2003)

In Northern Vietnam, the Neolithic archaeological sites are distributed in a wide range of terrains, but especially within the floral bioregions adapted to a tropical and humid climate pattern. From *c.* 18,000 to 20,000 BP, sea level regressed, at the last glacial maximum, to about 100-120 m below present sea level (Hori et al. 2004; Tanabe et al. 2003; Nguyen and Tran 2009). After that, sea level rose rapidly, causing the shoreline to move rapidly inland. Sea levels also rose due to periodic bedrock erosion, inundating surrounding estuaries. Estuarine deposits then covered and intertidal marshes formed at this time, with shallow bays formed by sea level rise during the Holocene marine Transgression in *ca.* 6,000 BP (Doan 2008). Tanabe et al. (2003) researched the evidence for sea-level changes since the last glacial maximum from height plots based on the marine notches in the Ha Long Bay and Ninh Binh areas, the mangrove clay at Tu Son (Bac Ninh), and the archaeological deposits (shell middens) in Da But (Thanh Hoa) (Fig. 2). The sea was at its

present level during 8-7 kyr BP, then rose further to more +2 to +3 m between 6 and 4 kyr BP, and after that gradually fell to present level. That is why we can be found early Neolithic sites in the mountainous area of Hoa Binh, Thanh Hoa, Ninh Binh, Yen Bai, Lao Cai provinces,...some sites are distributed in the Hai Phong, Cat Ba Islands, which about or higher than 25 m above sea level. In the late Neolithic, it can be found at the plain and at coastal area.

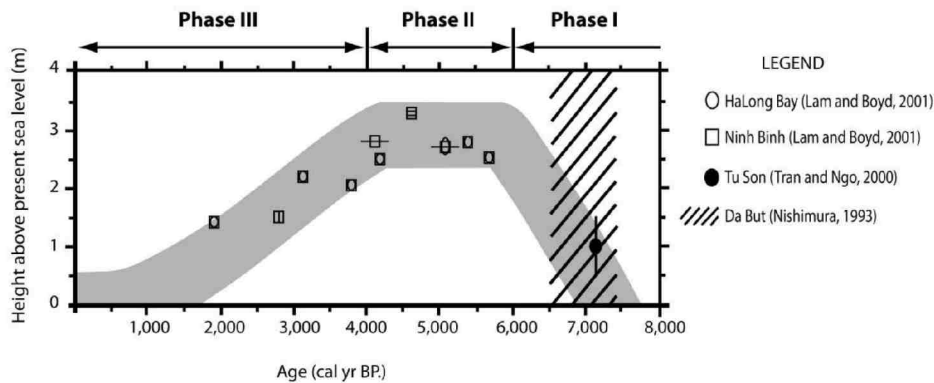


Fig. 2: Sea level curve in the Red River Delta region during the last 8,000 yrs BP (Tanabe et al. 2003)

These geological events had a strong effect on the distribution of Neolithic sites in North Vietnam (Fig.3). The Early Neolithic sites are mostly found in mountainous areas and highlands with elevations more than 25 m above sea level (Nishimura and Nishino 2003). The absence of the distribution of the Neolithic sites in the central plain may reflect the presence of seawater or brackish water in lower areas.

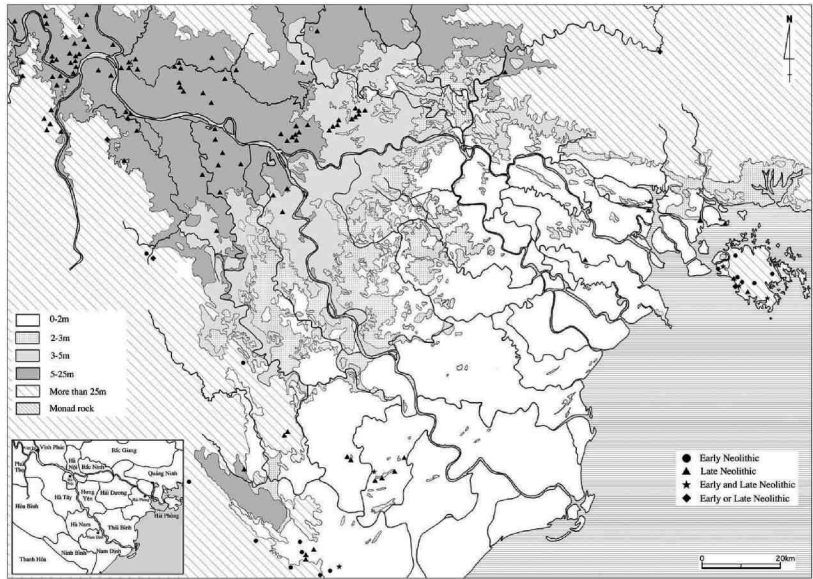


Fig. 3: Distribution of Neolithic sites in the Red River Delta (Nishimura and Nishino 2003)

REGIONAL VEGETATION THROUGH PALYNOLOGICAL EVIDENCES

There are few vegetation history sequences in this area. In the early 20th century, a French palaeo-botanist, Madeleine Colani, found fossil leaves of Fagaceae in Tertiary deposits in Dong Giao (Ninh Binh) and Cua Rao (Nghe An) and remarked that some genera are the same as those of live ones. Some identified taxa, such as: *Quercus incana*, *Betula alnoides*, *Liquidambar formosana*, *Phoebe pseudolanceolata*, *Celtis sinensis*, *Cinnamomum camphora* may be direct ancestors of living species or species themselves (Thai 1978). Based on pollen analysis of the deposits dating from the Late Pleistocene to the Early Holocene at Phong Chau (Phu Tho province), Tran Dinh Nhan (1992) reported that the flora of the Early Holocene was a tropical - subtropical complex, in which tropical plants were more abundant. In this area, there were no marine and coastal floral remains. Analysis of pollen from Dong Dau site (Vinh Phuc Province) has shown that fern spores existed in high percentage while arboreal pollen was rare, possibly due to human impact. The pollen component that includes Convolvulaceae, Rutaceae, Chenopodiaceae, Amaranthaceae, Malvaceae and Poaceae indicates that herbs and shrubs trees (Tran and Dinh 1984; Nguyen 2002) dominated vegetation in this site. In the Phung Nguyen 'cultural' layer of the Dong Dau site, archaeologists found quantities of burnt rice at the depths of 3.2 to 2.2m, as well as many floral vestiges such as Canariums, beans, pineapple seeds and bamboo sticks (Tran et al. 1970; Nguyen 1980).

Nguyen Duc Tung (Nguyen 1970) who studied the Trang Kenh site (Hai Phong), has reported that vegetation at Trang Kenh in the past was not much different from the present with the main pollen component being Curcubitaceae. He also found pollen of *Oryza sativa* and thought it a little bit smaller than *Oryza sativa* of China. Tran Quoc Vuong and Mai Dinh Yen (1994) examined the ecosystem from the Hoabinh culture to Dong Son culture, stating that: "From the Hoabinhian and Bacsonian cultures to Dongsonian culture, there was a development from Valley-Cultures to Delta-Culture. The Dongsonian sites are widely distributed from the mountainous and hilly areas to the seacoast, but are mainly found in the delta. It means that the Dongsonians lived in various ecosystems".

Research by Pham Van Hai et al. (2004) has shown that pollen-spore in Bac Bo Plain can be divided into two assemblages. Fourteen radiocarbon dates from assemblage I range from 9,635±60yr BP to 4,561±46yr BP, while assemblage II dates range between 6,620±40yr BP and 505±50yr BP. High-percentages of fern spore in both assemblages indicates warm, humid conditions. They also found pollen of broad leaves, whose species are well adapted to warm and humid condition: Fagaceae (*Quercus* sp., *Castanea* sp., *Castanopsis* sp., *Lithocarpus* sp.); Magnoliaceae (*Magnolia* sp., *Michelia* sp.); Juglandaceae (*Carya* sp., *Platycarya* sp., *Pterocarya* sp., *Juglans* sp.), a few pollen of *Betula* sp. or *Alnus* sp. were found in this area. Mangrove pollen occurred in both assemblage but the component in each was not the same. For example, in assemblage I (9,635±60yr BP to 4,561±46yr BP), Rhizophoraceae was dominant (being a special plant for mangrove forests in the development stage) whereas Sonneratiaceae were dominant in assemblage II (6,620±40yr BP to 505±50yr BP) which is characteristic of the degradation stage.

Related to the transformation of sea levels from late Pleistocene to Holocene in the Red River Delta, Vu Quang Lan (2004) showed that in late Pleistocene deposits, mangrove pollen was scattered from the Luoc River to the present sea. The mangrove vegetation was not very abundant; the pollen spectra are usually poor, often seen with *Hibiscus* sp., *Sonneratia* sp., and *Acanthus* sp. In the early and middle Holocene deposits, the mangrove pollen was abundant in quantity as well as in genus and species composition. In the late Holocene, the mangrove pollen reduced gradually and nearly became extinct, indicating a regression process and the formation of the delta with natural vegetation as seen today.

MATERIALS AND RESEARCH METHODS

The materials in this study are collected from archaeological layers from seven Neolithic sites in northern Vietnam (see Fig.4; Tab.1).



Fig. 4: Location of the study sites

All samples were chemically treated according to standard procedures for Quaternary sediments outlined by Brown (1967), Faegri and Iversen (1989). The samples were first treated in 10 percent sodium pyrophosphate ($\text{Na}_2\text{P}_4\text{O}_7$). After several washes in distilled water, the sample was digested with acetic acid (CH_3COOH) to remove humus material, and then the organic fraction was isolated from other minerogenic materials by using heavy liquid ($d=2.0-2.35$). The isolated organic fraction was washed with distilled water several times, dehydrated using ethanol, and then mounted on microscope slides.

Pollen and spore were identified using a Carl Zeiss light microscope with a magnification of 400x, except for very small samples that required a magnification of 1000x. The standard atlas *Angiosperm Pollen Flora of Tropical and Subtropical South China* (IBSCIB-CAS 1982) was used for comparison purposes, with additional reference materials from Huang Tseng Chieng (1972), Faegri and Iversen (1989). Radiocarbon dates were analyzed by the Berlin Radiocarbon Dating Laboratory (Bln) and the Radiocarbon Dating Laboratory of the Vietnamese Institute of Archaeology in Hanoi (HNK) (Pham and Nguyen 2000; Nguyen 2005; Nguyen 2009). “Sp.” refers to a situation where species designation is uncertain.

Table 1: Location of the study sites

No	Site name	Location	Coordinates and Elevation(m asl)	Culture	Environment
1	To 2 cave	Chieng Bang Comm., Quynh Nhai Dist., Son La Prov.	21°40' 08" N; 103°41' 19" E; 148m	From Paleolithic Late Neolithic	Karst limestone
2	Lan Mo cave	La Muong hamlet, Muong Trai Comm., Muong La Dist., Son La Prov.	21°35' 50" N; 103°57' 11" E; 115m	From Paleolithic to late Neolithic	Karst limestone
3	Phai Ve cave	Keo Pha Vil., Yen Trach Comm., Cao Loc Dist., Lang Son Prov.	On Phai Ve Mountain, near to Ky Cung River, about 15m above the surrounding	Post Hoa Binh (Neolithic)	Karst limestone
4	Phia Diem cave	Vinh Trai ward., Lang Son city, Lang Son Prov.	On Phia Diem Mountain, about 3 km to Ky Cung River	Post Hoa Binh (Neolithic)	Karst limestone
5	Con Moong cave	Thanh Yen Comm., Thach Thanh Dist., Thanh Hoa Prov.	20°40' 860" N; 105°65' 164" E; 147m	Hoa Binh - post Hoa Binh (Neolithic)	Karst limestone
6	Ban Thuy	Doai Vil., Vinh Thinh Comm., Vinh Loc Dist., Thanh Hoa Prov.	Stand about 0,8-1,0m above rice field	Da But (post Hoa Binh) (Neolithic)	Plain
7	Thach Lac	Thach Lac Comm., Thach Ha Dist., Ha Tinh Prov.	18°2' 00" N; 105°57' 25" E; 1,9m	Bau Tro (Post Hoa Binh) (Neolithic)	Coastal

RESULTS

To 2 cave (Chieng Bang commune, Quynh Nhai district, Son La province) is located at the foot of Lan Danh mountain near the Da River (Fig.4; Tab.1). During the excavation of the Institute of Archaeology in 2008, 10 soil samples were collected from the west wall, in the intervals of 5 cm each, as well as 10 samples from two burials (Burial No.3 and No.8). Results indicate that herbaceous pollen accounts for 49 percent, arboreal pollen 4 percent, gymnosperm 4 percent, shrub species 4 percent and ferns 39 percent (Fig.5).

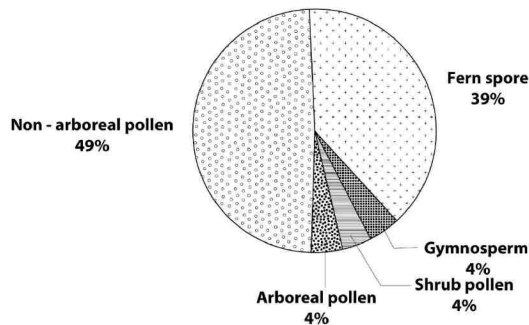


Fig. 5: Pollen and spore component from To 2 cave stratigraphy.

The composition of fern spores is very diverse and consistent from the bottom to the surface: mainly *Polypodium* sp., *Cyathea* sp., *Lygodium* sp., and *Microlepidia* sp. There is a difference in species composition and number of pollen grains recovered between the cultural layers and the grave (Fig.6). Non arboreal pollen collected from the cultural layer contains 77 percent including mainly of Poaceae, *Chenopodium* sp., and Compositae; the shrub species Rubiaceae and *Morus* sp.; and the arboreal species *Hamamelis* sp., *Alnus* sp., *Magnolia* sp., and *Michelia* sp.. Based on the combination of varieties obtained, and the taxonomic identification possible to the level of the family, it can be seen that these plants were adapted to the hot and humid climatic conditions of tropical rainfall (Nguyen et al. 2009b).

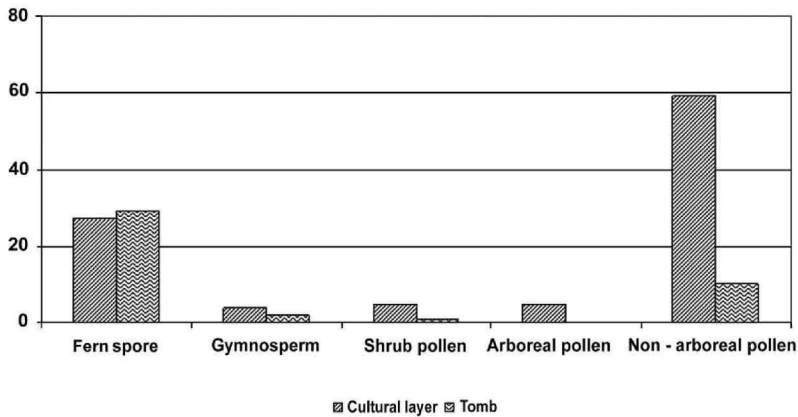


Fig. 6: Pollen and spore from the cultural layers and burial of To 2 cave.

Lan Mo cave (La Muong hamlet, Muong Trai commune, Muong La district, Son La province) (Fig.4; Tab.1) exposes a well-preserved stratigraphy with thick cultural layers. During the excavation in 2008, 13 soil samples were collected from the unit B10 (dark brown and dry soil), and 3 samples from the unit H7 (dry brownish-yellow soil). They were extracted at an interval of 5 cm, for spores and pollen analysis and the study of flora and environment of the region. The results show that non-arboreal pollen (32 percent) and ferns (43 percent) are prevalent (see Fig. 7).

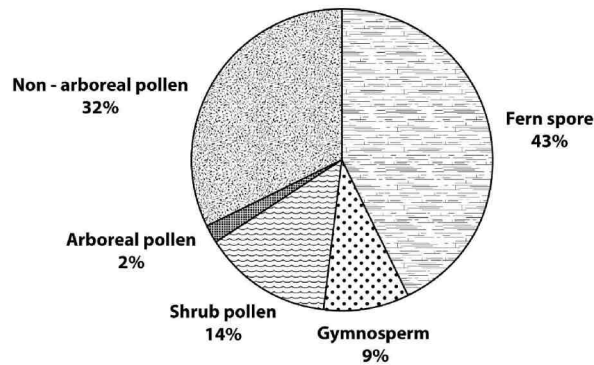


Fig. 7: Pollen and spore component from Lan Mo cave stratigraphy.

Sample composition mainly consists of the pollen and spores of non-arboreal plants (*Chenopodium* sp., Compositae, Poaceae, Leguminosae, Liliaceae); shrubs (*Morus* sp., *Sapindus* sp.), and ferns: (*Lygodium* sp., *Cyathea* sp., *Microlepia* sp., *Coniogramme* sp., *Polypodium* sp., and *Polypodiaceae*). Arboreal pollen includes *Liquidambar* sp., *Castanopsis* sp., and *Quercus* sp. In general, pollen and spore components from Lan Mo are prefer hot and humid tropical climates (Nguyen et al. 2009a). The counts of pollen collected from the stratum in H7 are less than that from B10. This phenomenon may be due to the poorer condition of the H7 samples, or the dryness, or oxidation of the sediment.

Phai Ve II cave (Lang Son city, Lang Son province) (Fig.4, Tab.1) is a settlement site located on the Phai Ve Mountain which is near to the Ky Cung River. This cave is about 15m above the surrounding. In 1906, H. Mansuy explored this site and found some fossil of animal bones, which is dated to late Pleistocene. In the 1960s, Vietnamese archaeologist investigated this cave again but there was no report. In 1998, Institute of Archaeology in collaboration with Lang Son Provincial Museum conducted excavation this site. The artifact assemblage found from the site has been identified as most likely belonging to the Mai Pha culture (Ha 1998; Ha ed. 1998). Six soil samples were collected from profile of the excavation trench for pollen analysis. The pollen analysis results show low concentration of gymnosperm such as, *Pinus* sp., Taxodiaceae, *Metasequoia* sp.?; Arboreal with *Liquidambar* sp., Rubiaceae; non-arboreal pollen including Poaceae, Compositae, Chenopodiaceae and fern spore remain of *Lycopodium* sp., *Conniogramma* sp. Those plants are kinds of sub tropical and temperature plants (Nguyen and Pham 1998).

Phia Diem cave (Lang Son city, Lang Son province) (Fig.4, Tab.1) is settlement site located on Phia Diem Mountain, about 3 km to Ky Cung River. In front of the cave, there is a valley, which is good for paddy rice cultivation. This site was discovered in early 1998, and excavated in September 1998, by the Institute of Archaeology. Based on the artifact collections found at the site, Vietnamese archaeologists have identified them as most likely belonging to the Mai Pha culture, late Neolithic (Ha 1998; Nguyen et al. 1998). Seven soil samples were extracted from the excavation strata for pollen analysis. The pollen analysis results from Phia Diem cave show low concentrations and similar to vegetation of Phai Ve

II cave. The pollen of gymnosperm is mainly consists of *Pinus* sp.; Arboreal with *Liquidambar* sp., Magnoliaceae, *Magnolia* sp., Rubiaceae; non-arboreal pollen includes Poaceae, Chenopodiaceae and fern spore remain of *Lycopodium* sp., *Conniogramma* sp. These plants are kinds of sub tropical and temperature plants (Nguyen and Pham 1998).

Con Moong cave is located in the limestone ranges of Mo hamlet, Thanh Yen commune, Thach Thanh district, Thanh Hoa province (Fig.4; Tab.1). This is very big cave that located near to a stream and looked into a valley, which was a good place for settlement. This site was first excavated in 1976. The cultural layer of this site, which is the same as other Hoabinhian sites contained dense of land snails, freshwater snails, and burnt traces in some places. The artifacts found from excavation contribute to the clarification of the archaeological issues concerning the relationship between pre-Hoabinhian, Hoabinhian, and post Hoabinhian cultures, between the Paleolithic and Neolithic, and between the Pleistocene and the Holocene (Nguyen 1977). In 2008, the site was continue to be studied, the stratigraphy of excavation in 1976 was reexamined and eighteen soil samples were collected for pollen analysis (Nguyen and Pham 2009) (Fig.8).

The stratigraphic sequence for Con Moong cave is based on the change of sediment color, the occurrence of pollen and spores in these sediments, and the lithic artifacts associated with the distinct cultural layers in the cave (Fig.8). The results of the pollen analysis for the 18 samples are shown in Fig.9. It can be observed that herb pollen predominates (38 percent), followed by arboreal pollen (25 percent).

Among these, fern spores mainly consist of *Microlepia* sp., *Polypodium* sp., Polypodiaceae gen. indet., *Lycopodium* sp., *Cyathea* sp., *Selaginella* sp. and *Coniogramme* sp.. Gymnosperms pollen belongs to *Cycas* sp., shrub pollen consists of Rhamnaceae, Rubiaceae, Ericaceae, *Morus* sp., *Euphorbia* sp., and *Carya* sp., and arboreal pollen includes *Castanea* sp., *Castanopsis* sp., *Ilex* sp., *Rhus* sp., *Betula* sp., *Myrica* sp., *Juglans* sp., *Melia* sp., *Engelhardtia* sp., *Platycarya* sp. and *Ulmus* sp.. Finally, herb pollen includes species such as Compositae, Liliaceae, Poaceae, *Chenopodium* sp., Leguminosae, and Labiatae (Nguyen and Pham 2009).

In general, the pollen and spores recovered from the Con Moong site are from terrestrial plants adapted to fresh water and humid conditions. This interpretation is consistent with the identification of snails (Dang 1977) and other faunal remains (Vu 1977). The pollen of some species, like *Castanea* sp., *Castanopsis* sp., *Betula* sp., and *Juglans* sp. indicates that plants growing on high elevations are more adapted to humid and cool temperatures. Among these, species diversity of herb pollen, shrub and arboreal plants is high, while very little pollen from gymnosperm species, and fern spores were found. This information provides a rich image of the landscape surrounding Con Moong cave at that time.

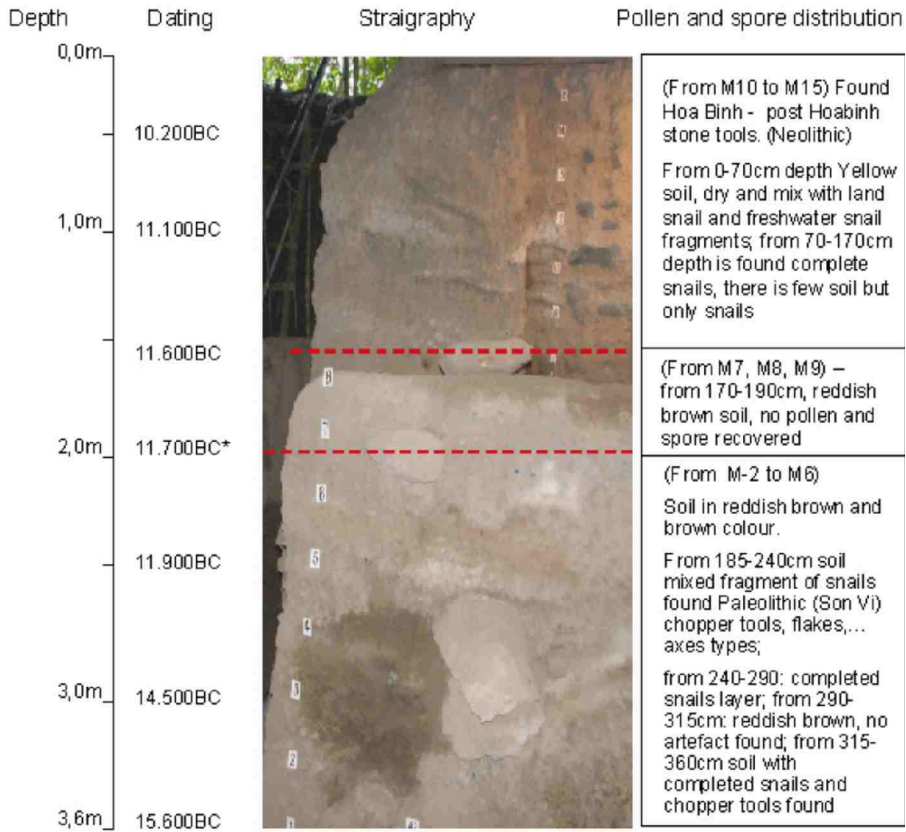


Fig. 8: Con Moong Cave stratigraphy, showing the location of the extracted samples= M (^{14}C dating provided by Nguyen Khac Su (2009).

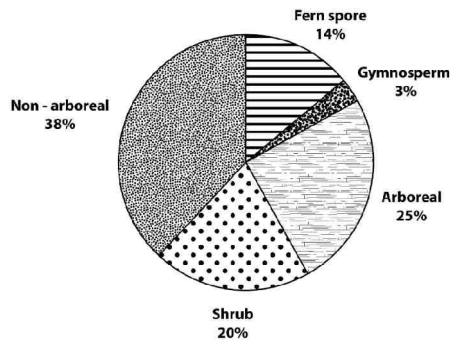


Fig. 9: Pollen and spore components of Con Moong cave soil samples.

A comparison of the plant component present in the two cultural layers (see Fig.10) shows slight differences between the early Hoabinhian and post Hoabinhian cultural levels at Con Moong. During the early Hoabinhian period, arboreal pollen is abundant, while fern spores are abundant within the post Hoabinhian strata. However, herb pollen concentrations are the same for both layers. The reduced arboreal and shrub pollen during the late Hoabinhian period might be related to clearance activities conducted by prehistoric human populations of the area, which is supported by the polished axes found on site (Pham et al. 1990). The date sequence in accordance to the stratigraphic depth shows that the stratigraphy at Con Moong cave is intact (Nguyen 2009). A C^{14} date from snail shell, found at 3.5 m depth in Con Moong Cave, was dated to $12,920 \pm 90$ BP (Bln. 3496/I) and at 3.6 m dated $13,980 \pm 200$ BP (HNK-491) (Tab. 2). The stratigraphic sequence at 2.4-2.0 m depth is dated by another snail sample to $c. 11,830 \pm 79$ BP (Bln.3488), at 2.5 m dated to $c. 11,240 \pm 205$ BP (NHK-493) (Tab. 2). At this depth, pollen of *Chenopodiaceae*, *Leguminosae*, *Melia* sp., *Quercus* sp., and *Myrica* sp. was recovered. Although this pollen is not representative of the entire floral ecosystem of that time, it demonstrates that arboreal pollen was abundant and consistent at this site, which is a characteristic of a tropical ecosystem. In addition, some fragments of *Canarium* sp. and *Thea* sp. seeds were also identified (Hoang and Nguyen 1977).

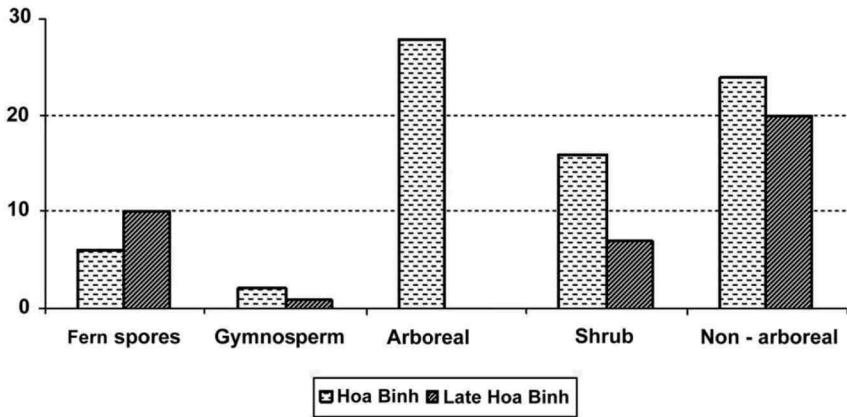


Fig.10: Comparison of the distribution of pollen and spore between the two cultural layers at Con Moong cave

Ban Thuy site (Vinh Loc district, Thanh Hoa province) (Fig.4; Tab.1) was first discovered in 1978 and test excavated in 2001 by the Institute of Archaeology. This site located in the low valley of about 0,8 to 1,0m above rice field, on the right side of Ma River. The site is covered of about 200m². Some part of this site is destroyed because of making road, houses or cultivation,...The stratigraphy is composed of numerous fresh snails and bivalves fragments. Six soil samples from two test excavation trenches were collected for pollen and spores analysis. Based upon stone tools and pottery typologies, Bui Vinh stated that the site belongs to Da But culture, which is dated to 5000 ± 95 BP (HNK-89) and 5560 ± 95 BP (HNK-90) (Bui 1991; 2001). The results from Ban Thuy show a high concentration of fern spores. This suggests that the area had high humidity during prehistoric times, with predominant shrubs, small trees and grass species. At 0.50 m depth,

there are rich concentrations of spores and pollen. At 0.80 m depth, the diversity of pollen and spore declines, but Poaceae pollen remains high (84 percent); possibly including paddy rice species (Nguyen and Pham 2003a)

Table 2: ^{14}C dates of the studied sites

No	Site name	Signed	Depth (cm)	Material	Analysis Lab.	Dating (yr BP)
1	Ban Thuy	BT01	100	Corbicula	HNK-90	5,560±95
2	Ban Thuy	BT01	40	Corbicula	HNK-89	5,000±95
3	Con Moong cave	CM 86-A 2	40-60	Charcoal	Bln. 3482	8,500±60
4	Con Moong cave	CM 86 - A 3	60-80	Charcoal	Bln. 3483	9,150±60
5	Con Moong cave	CM 86 A 4b	120-140	Charcoal	Bln. 3484	9,380±60
6	Con Moong cave	CM 86 - B 3aM1	200-240	Snail	Bln. 3488	11,830±70
7	Con Moong cave	CM 86 - B 3aM2	240-260	Snail	Bln. 3494	12,040±70
8	Con Moong cave	CM 86 - B 4aM2	280-300	Snail	Bln. 3495	12,150±70
9	Con Moong cave	CM 86 - B 5	350	Snail	Bln. 3496/I	12,920±90
10	Con Moong cave	08CM M15	50	Snail	HNK- 496	9,840±175
11	Con Moong cave	08CM M11	100	Snail	HNK-495	10,660±145
12	Con Moong cave	08CM M8	160	Snail	HNK-494	10,990±210
13	Con Moong cave	08CM M5	250	Snail	HNK-493	11,240±205
14	Con Moong cave	08CM M3	300	Snail	HNK-492	13,110±180
15	Con Moong cave	08CM M1	360	Snail	HNK-491	13,980±200
16	Phia Diem cave					4700 – 5000BP*
17	Phai Ve II cave					4700 – 5000BP*
18	To 2 cave					? – 3000BP**
19	Lan Mo cave					5000-3000BP**
20	Thach Lac					4000-3500BP***

Source: Nguyen 2005; Pham and Nguyen 2000; Nguyen 2009; Nguyen et al. 2012**, Nguyen et al. 1998*; Ha 1998*; Ha ed. 1998*** (* Because there are no radiocarbon dating, the age is estimate based on archaeological chronology was used). Bln: Berlin Radiocarbon Dating Lab; HNK: Radiocarbon Dating Lab, Institute of Archaeology Vietnam in Hanoi.

Thach Lac site is located at 18°02' 00" N; 105°57' 25" E in Thach Lac village (Thanh Ha district, Ha Tinh province); It is a shell midden site that is 1.9m above sea level (Fig.4; Tab.1). The site was investigated in 1962 and excavated in 1963 by Archaeological team and Ha Tinh Culture Bureau (Nguyen and Ha 1963). In 2002, the Vietnam National History Museum, Ha Tinh Provincial Museum in cooperation with the Academia Sinica, Taiwan conducted excavations. Nine soil samples were collected from the stratigraphic profile for pollen analysis. This is the only Neolithic site along the northern Central coast of Vietnam where pollen analytical research had been conducted. The stratigraphic sequence from the Thach Lac site contains of thick cultural layers, with high concentration of marine mollusks, mostly bivalves at the depths of 60-80 cm and 120-145 cm, but no pollen or spores were recovered. This is probably due to the stratigraphy that is composed of numerous shell fragments, giving it a loose structure in which pollen could be easily washed away.

Samples from the depth of 10-60 cm contained predominantly herb pollen, but at 90-120 cm depth, arboreal pollen dominates again. Thus, large trees primarily represent as the dominant plant species within the floral ecosystem at 90-120 cm depth. Fern spores of Polypodiaceae were found in a large quantity, which also indicates an area with relatively high humidity. Mangrove pollen was also found, and thus it can be said that the environment of this area was certainly marine influenced. Further geological research will be needed for further definite conclusions about sea level fluctuations and their effects on the landscape and environment of Ha Tinh province, and especially the area immediately surrounding this archaeological site (Nguyen et al. 2003).

DISCUSSION AND CONCLUSION

Results from samples of seven sites show comparatively low concentrations of pollen and spore overall. There is no reason why pollen should not be preserved in other tropical caves for example Maloney has been recovered pollen and phytolith from Gunung Mulu cave, and three other caves at Sarawak but unrecovered from other caves sites (Maloney 1994). It seems assumed because of the high humidity condition in the limestone caves in North Vietnam.

To reconstruct the vegetation and understand more about the ecology, the results from the palynological analyses were classified into five groups after Li Zhen (2006) (see Tab.3): Tropical plants are characterized by Magnoliaceae (*Magnolia* sp.), Moraceae (*Morus* sp.), Sapindaceae (*Sapindus* sp.) and Rubiaceae; while sub-tropical plants consist mainly of Fagaceae (*Castanopsis* sp.) and Hamamelidaceae (*Liquidambar* sp., *Hamamelis* sp.). Temperate plants include Pinaceae (*Pinus* sp.), Fagaceae (*Quercus* sp., *Castanea* sp.), Juglandaceae (*Juglans* sp.), Ulmaceae (*Ulmus* sp.), Aquifoliaceae (*Ilex* sp.) and herbs such as Compositae, Chenopodiaceae, Malvaceae, Leguminosae, Cyperaceae and Poaceae species. Fern spore is a primary species of the Pteridophyta family (*Lygodium* sp., *Polypodium* sp., *Microlepia* sp., *Stenochlaena* sp., *Cyathea* sp., *Acrostichum* sp.). The pollen recorded from these sites, such as: Poaceae, Malvaceae, Palmae, *Morus* sp. may relate to the plants that believed to have been taken cultivation in Southeast Asia (Maloney 1994). Based on this analysis, it is argued that the vegetation during the Neolithic period in northern Vietnam reflects both natural and cultural influences on the environment, possibly as a mosaic of grassland species, shrub trees and native forest.

The analysis of pollen and spores from each site, combined with archaeological and environmental data, may give a clearer picture of the cultural and environmental landscape of the late Paleolithic and Neolithic periods in this area.

Table 3: List of plant taxa recovered from all study sites.

Tropical arboreal plants	Sub-tropical arboreal plants	Temperate arboreal plants	Herbs	Fern spores
<i>Aralia</i> sp. <i>Morus</i> sp. <i>Carya</i> sp. <i>Melia</i> sp. <i>Sapindus</i> sp. Palmae Rubiaceae <i>Platycarya</i> sp. Ericaceae Rhamnaceae <i>Euphorbia</i> sp. <i>Rhus</i> sp. <i>Magnolia</i> sp. <i>Pterocarya</i> sp. Magnoliaceae	<i>Castanopsis</i> sp. <i>Liquidambar</i> sp. <i>Hamamelis</i> sp.	<i>Alnus</i> sp. <i>Castanea</i> sp. <i>Ilex</i> sp. <i>Ulmus</i> sp. <i>Myrica</i> sp. <i>Sequoia</i> sp. Taxodiaceae <i>Quercus</i> sp. <i>Betula</i> sp. <i>Juglans</i> sp. <i>Metasequoia</i> sp. <i>Pinus</i> sp. <i>Engelhardtia</i> sp.	<i>Chenopodium</i> sp. Chenopodiaceae Compositae <i>Polygonum</i> sp. Liliaceae Leguminosae Labiatae <i>Digitaria</i> sp. <i>Flagellaria</i> sp. Malvaceae Poaceae <i>Cyperus</i> sp. <i>Pilea</i> sp.	Polypodiaceae <i>Lygodium</i> sp. <i>Coniogramme</i> sp. <i>Microlepia</i> sp. <i>Cibotium</i> sp. <i>Coniopteris</i> sp. <i>Dicksonia</i> sp. <i>Selaginella</i> sp. <i>Osmunda</i> sp. <i>Lycopodium</i> sp. <i>Pteris</i> sp. <i>Gleichenia</i> sp. <i>Cyathea</i> sp. <i>Polypodium</i> sp. <i>Salvinia</i> sp. <i>Acrostichum</i> sp.

The direct evidence of vegetation changes derived from palynological and macrofossil analyses presented here shows that Neolithic people were familiar with several cereal food crops and domestication (see Tab. 3). Among the pollen assemblages identified, it is important to note the ubiquity of Leguminosae pollen, as well as Chenopodiaceae, Rubiaceae, Compositae, and most importantly Poaceae in virtually all samples, some of which having a diameter larger than 30µm and thus possibly related to the domestic cereals (Zheng 2009). This information is very valuable in its own way. However, in order to interpret which types of plants were grown by human, and whether or not rice was domesticated, it would be necessary to analyze more samples including macrofossils. The fragments of fruits and seeds have been recovered at Con Moong cave (Thanh Hoa province), Xom Trai and Cho cave (Hoa Binh province) such as *Gnetum montanum*, *Linstora cochinchinensis*, *Elaeocarpus sylvestris*, *Phyllanthus emblica* L., *Thea* sp., *Canarium* sp., *Cucumis* sp., *Lagenaria* sp., *Areca* sp., *Livistona* sp., *Prunus* sp. may related to the food of the past. Some of them are still use recently by Muong people in North Vietnam (Nguyen and Vu 1987; Gyong Ah Lee, pers.comm., 2007).

From the Hoabinhian-Bacsonian transitional of Con Moong cave, archaeologists have recovered a large number of stone tools, mainly made from quartz, andezit, andezit—porfia,...all in level 6 or higher follow Mohs scale of mineral hardness. Depend on the size and shape, it can be use for cut timber, clearance grass, hunting, or digging soil (Nguyen et al. 2011). Ran (2011) stated that: “the connection between (re) appearance of bifacial tools and the transition from nomadic hunting—gathering to settle agriculture is not incidental. Bifacial tool develop as a solution to a practical problem; they play an important role in the life if early settlers. The Neolithic axes were an essential and significant tool, used for most important daily activities and agriculture is not suitable without axes”. Syntheses of stone

tools from Hoa Binh culture to post Hoa Binh cultures, like Bac Son, Da But, Quynh Van, Ha Giang culture in Vietnam (Tab. 4) it can be seen a huge number and diversity of tool types that have been interpreted as for activities related to initial cultivation (Ha ed. 1998).

Table 4: Archaeological artifacts showing technological transitions.

Stone tools	Pebbles	Choppers	Polished Axes and adzes	Other	Environment
Culture					
Hoa Binh	421	3915	125	Stone hoe	Karst limestone
Bac Son	121	402	355 (partly)	Stone hoe	Karst limestone
Da But			36	Stone hoe	Coastal plain
Quynh Van	328	253	3		Coastal plain
Ha Giang			381	Stone hoe	Karst limestone
Mai Pha			97		Karst limestone

Source: Ha (ed.) 1998: 166, 169, 173, 192, 204, 250, 255-6

Although there remain significant gaps and unresolved issues in the paleo-environment of North Vietnam, this discussion and interim synthesis of existing data only serve as a highlight topic for further research i.e. more testing for the pollen analysts as far as tracing agricultural origins is concerned.

The evidence for early cultivation at this stage illuminate the preconditions required for more intensive cultivation and domestication apparent at the sites of the subsequent Phung Nguyen period, corresponding to the Late Neolithic/Early Bronze Age. Rice husks and burnt rice grains were encountered under the Dong Dau cultural layers at the Dong Dau and Thanh Den sites in Vinh Phuc province (Ha ed. 1999). Together with further refinement of stone tool assemblages relating to cultivation, including polished axes and knives (e.g., the Trang Kanh site, Hai Phong province and Go Hen sites, Hanoi); and sickles (e.g. the Go Bong site, Phu Tho province). The rich and diverse pottery assemblages indicate economic stability, suggesting that settled agriculturalists inhabited the Red River region by the later period, from Phung Nguyen culture (Ha ed.1999).

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越南北部的新石器時代植被：早期農耕活動的跡象

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越南的新石器時代文化橫跨更新世到全新世，約在距今12000年前到4000年前之間。這個文化直接延續在（Hoabinhian）和平文化之後，以獨特多樣的石器工具聞名，除了分佈在越南也散佈於整個東南亞。海平面變化對於越南北部新石器時代考古遺址的分布有著巨大的影響，新石器時代早期的考古遺址大多分佈在山區海拔25公尺附近或是更高的位置，晚期的遺址則是在平原與海岸地帶，尤其經常出現在植物相能夠適應酷熱、潮濕氣候型態的區域。和平或後和平文化的進展對於後續新石器考古文化的形成與發展建構了不可或缺的有利條件。

一般相信新石器時代的人群是狩獵採集者，然而，由與繩紋陶、小型板岩製石刀一起出土的石器（例如磨製石斧、石鏃、石鋤與石刀等）的間接證據，指示著這些器物具有農業上的用途。早期農耕活動的議題雖然引起當代學者的興趣，不過卻因欠缺古環境的相關內涵，目前瞭解有限。為了對這個議題有進一步的理解，本文採用孢粉分析方法來重建過去的植被狀況，並建立早期農業活動的指標。本研究採集越南北部7個新石器時代遺址考古地層的沈積物進行孢粉分析。

分析結果顯示當時屬於草地、灌木與天然林交錯分布的植物生態體系，自然與人文對於環境的影響顯然同時並存。在洞穴遺址中，蕨類孢子比其他植物群落出現更高的比例，指示著過去潮濕的環境條件，而在平原區的遺址，則是以樹種與非樹種花粉佔有優勢地位。此外，本文所鑑定出來的禾本科、錦葵科、菊科與豆科等花粉種屬與當時的栽培作物密切相關，這些種類的花粉普遍出現在新石器時代遺址以及上部地層中，可能與人工培育品種有關，說明著越南北部的新石器時代人群很可能已經開始栽培作物。這樣的研究結果不僅修正了過去所建立的植物系統，也對這個區域新石器時代的文化與環境地景，建構出一個更為清楚的圖像。

透過孢粉分析與考古學證據的結合，我們推斷過去的植被改變與新石器時代人群的早期農耕活動有關。雖然對於越南北部的古環境仍存在一些明顯的空缺與未解的議題，本文目前也只能透過討論和現階段資料的整合，突顯出未來研究將要關注的主題，也就是以更多、更全面的孢粉分析工作來追溯農業起源。

我們主張藉由孢粉學研究，能夠釐清越南北部屬於新石器時代晚期／青銅器時代早期的Phung Nguyen階段，之所以能夠發展出更廣泛的農業與馴養活動所需的先決條件，提供越南北部新石器時代至青銅器時代有關古代植被的具體解釋。

關鍵詞：孢粉學、農耕、新石器時代、越南北部

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