DOI: 10.56794/VSSR.4(216).108-128

Prehistoric Archeological Sites in Krông Nô Volcanic Caves

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Received on 4 January 2023. Accepted on 25 May 2023.

Abstract: Excavations in the Krông Nô volcanic cave have given a standard stratigraphy of the prehistoric cultural process of the middle Holocene period, providing a lot of documentary information about the prehistoric human habitation patterns: through the remains of kitchen fire pit; strategies to exploit food sources through traces of hunting-gathering; cultural behavior of people through the technique of making and using tools; spiritual culture of people through funeral rites and other vestiges of activities. Through the geo-archaeological approach, we have gained more evidence about people's adaptability to the fluctuations of climate and the regional environment, the changes in the local landscape, and the flora and fauna ecosystem in broader context. The documents on the characteristics of tools, burials, flora, and fauna, and the dating system from 7,000 years BP to 4,000 years BP of the archaeological sites in the Krông Nô volcanic caves are uncommon in Vietnam, Southeast Asia, and over the world. Archaeological remains in the Krông Nô volcanic caves - an outstanding cultural heritage of Đắk Nông UNESCO Global Geopark (UGGp) - should be scientifically recognized and protected as a typical chain in the Central Highlands region, and have its heritage values promoted for sustainable tourism development.

Keywords: Krông Nô volcanic cave, prehistoric, Neolithic, archaeological site, Đắk Nông UGGp.

Subject classification: Archeology.

1. Introduction

Prehistoric archeology research in Vietnam has more than 100 years of history. However, the archeological sites in volcanic caves were first discovered and excavated only in the 22nd century. In the first excavation of the archeological sites in the Krông Nô volcanic cave system, a 1.8m thick and relatively intact stratigraphy was discovered, dating

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back to the middle Holocene, from 7,000 years to 4,500 years BP. The data acquired has provided important information about habitation patterns, food procurement activities, and cultural behavior through product-making activities and funeral rites. The geo-archeological evidence collected further elucidates the changes in climate and environment of volcanic fields, the changes in the local landscape, flora and fauna, and the human adaptation to the changes in nature at the time.

This study presents some outstanding cultural and historical values of the archeological sites in volcanic caves, their contributions to the study of the prehistoric culture of Vietnam and Southeast Asia, and the responsibility of today's generations in conserving and promoting the archeological sites in volcanic caves of Đắk Nông UNESCO Global Geopark, and contributing to sustainable socio-economic development in the Central Highlands.

2. Literature review

2.1. Over a century of discovery and research into Vietnam's prehistoric archaeology, archaeologists have excavated and studied hundreds of caves and rock shelters, all of which are Karst caves. In these types of monuments are found not only the remains of *Homo erectus* fossils, dating from the Early Pleistocene, but also the cultural sites of *Homo sapiens*, dating from the Late Pleistocene to the Holocene (Nguyễn Khắc Sử, 2006: 89-102).

The most active volcanic region in Vietnam is in the Central Highlands provinces. There were also hundreds of open-air archeological sites, dating from the Early Pleistocene to the Late Holocene, but all the organic remains have been destroyed (Nguyễn Khắc Sử, 2007). Therefore, the discovery of volcanic cave sites in the Central Highlands, where animal bones and human remains are still preserved, is a turning point in the history of Vietnamese Prehistoric Archaeology Research, because it has provided a lot of scientific information for the comprehensive study of the historical and cultural picture of the ancient inhabitants of Vietnam.

2.2. Volcanic cave, also known as lava tube, is of primary origin and formed by the volcanic eruptions of Pleistocene volcanoes in Krông Nô district, Đắk Nông province. The first caves were discovered by La Thế Phúc and his colleagues in 2007 and studied by the Geological Museum of Vietnam and Japan Caving Association (2011 - 2014), later taken over by the Vietnam National Museum of Nature and the Japan Caving Association (2015 - 2018) (La The Phuc, Hiroshi Tachihara, Tsutomu Honda, Truong Quang Quy, Luong Thi Tuat, 2015: 28-38). So far, 45 volcanic caves have been discovered in this area, of which 20 have been measured, studied in detail, and clarified in terms of the origin, formation mechanism, and geological, biological and archeological values (La The Phuc, Hiroshi Tachihara, Tsutomu Honda, Luong Thị Tuat, Bui Van Thom, Nguyen Hoang, Yuriko Chikano, Katsuji Yoshida, Nguyen Thanh Tung, Pham Ngoc Danh, Nguyen Ba Hung,

Pham Gia Minh Vu, Nguyen Thi Mai Hoa, Hoang Thị Bien, Truong Quang Quy, Nguyen Trung Minh, 2018).

Traces of prehistoric humans have been found in 10 of the 45 caves. Those caves are C1, C2, C3, C4, C4.1, C6 (Đắk Sor commune); C6' and C6.1 (Nam Đà commune); P1 and P2 (Buôn Choa'h commune), Krông Nô District, Đắk Nông province. All are archeological sites in volcanic caves located deep underground, also known as lava tubes. Lava rocks with vertical grooves and twisted lines representing the lava flow are on the two sides of the cave walls. The stratigraphy of the archeological sites in volcanic caves shows the natural preservation of manufacturing activities of stone tools and pottery; the remnants such as coal ash, stoves, graves and human remains; the remains of hunter-gatherer groups such as animal bones, shells or seeds left after human consumption (La The Phuc, Nguyen Khac Su, Vu Tien Duc, Luong Thi Tuat, Phan Thanh Toan, Nguyen Thanh Tung, Nguyen Trung Minh, 2017: 97-108; Nguyễn Khắc Sử, Lê Xuân Hưng, La Thế Phúc, 2019: 77-81).

Of the ten caves mentioned above, C6.1 and C6' caves were selected for exploration and excavation. In 2017, a $2m^2$ excavation pit was dug at C6.1 cave with a cultural layer of 0.8m. In 2018, according to Decision No. 52/QD-BVHTTDL, dated January 9, 2018, approved by the Minister of Culture, Sports and Tourism, the Ministry of Culture, Sports and Tourism of Đắk Nông province and the Vietnam National Museum of Nature are allowed to coordinate in excavating the sites of two caves C6-1 and C6' with each cave's area being $20m^2$, Nguyễn Khắc Sử being in charge of the excavation. The C6.1 cave was excavated during the years 2018 and 2019 with an area of $10,3m^2$; the excavation area of the C6' cave in 2018 was $13m^2$. These excavations are within the framework of State-level scientific project No.TN17/T06, chaired by the Institute of the Vietnam National Museum of Nature and administered by La Thế Phúc (Nguyen Khac Su (ed.), Nguyen Lan Cuong, Le Xuan Hung, Vu Tien Duc, La The Phuc, Luong Thi Tuat, Pham Thi Phuong Thao, Nguyen Thanh Vuong, 2019; Phan Thanh Toàn, Vũ Tiến Đức, Nguyễn Thanh Tùng, 2018: 46-50).

The primary objective of the excavations is to collect data to build the profile of the cultural heritage in Đắk Nông Global Geopark, supplement prehistoric research materials, collect specimens for Đắk Nông Museum, exhibit on-site displays in association with tourism, and contribute to the socio-economic development of Đắk Nông province.

3. Methodology

For the first time when excavating volcanic cave relics in Vietnam, archaeologists have used modern archeological excavation methods. When excavating according to grid coordinates, each mesh is $1m^2$. The excavation pit is 10.3m wide, including coordinates b,c,d (horizontally), 1,2,3 (vertical) and depth, each layer is 8cm deep, including 23 layers, in the entire terrain 185cm thick layer.

During the excavation, samples were collected according to coordinates, applied natural scientific methods in the study of minerals, animal bones, mollusks, pollen spores, ancient magnetism, human remains, ^{14}C age (radiocarbon) and stratigraphic structure.

The relics of the tomb, the stove, as well as the stone, bone, and pottery items are measured, photographed, qualitatively and quantitatively studied, characterized, and their relationship determined in space and time. The topic uses an integrated research method to determine the nature and age of the monument, as well as outlining the prehistoric cultural appearance of the residents who used to live here in a broader relationship.

4. Results and discoveries

4.1. Excavation results of Krông Nô volcanic caves

4.1.1. C6-1 Cave

The cave is located at 12030’47.6” Latitude and 107054’06.2” Longitude, with a height of 346m above sea level (*Figure* 1). The cave’s entrance is exposed due to the falling of the arch’s weakest part, resembling a skylight. Three cave entrances leading to the lava tube are in different directions and located at the skylight’s bottom. C6-1 cave has two connecting entrances since the lava tube curves in a C shape, with a total length of 293.7m.

Figure 1: Cave C6-1 Excavated in 2018 and 2019

Source: Photo by Lê Xuân Hùng.

The prehistoric archeological sites are located at the mouth of the cave. The cave's entrance is semi-annular, 15.0m wide, and 3.2m high. The cave floor is flat, wide, airy, and slopes inward. The structure of the cave arch is relatively stable and convenient to commute. The cave is next to the Đray Sáp waterfall, near the Serepok River, with a good flow of water, raw materials for tool making process, and a great source of aquatic animals meeting humans' needs. The cave is surrounded by temperate broadleaf forests rich in flora and fauna, benefiting hunting and gathering activities.

The excavation at C6-1 cave was conducted in an area of 10.3m^2; the 1.85m stratigraphy indicates 13 ages, dating from 6,090±25 years BP (Calibrated date: 6,954 years BP) to 4,680±20 years BP (Calibrated date: 5,391 years BP). In the excavation pit, archeologists have found 14 stoves, 7 graves where the bodies were placed in a flexed position with the legs bent, and remnants after meals of ancient people, including 76,425 pieces of animal bones and over 100,000 pieces of mollusk shells. Other items obtained are 3,967 stone artifacts, 66 bone artifacts, 10 jewelry artifacts made out of sea snail shells, 1 bronze arrow, and 1,276 pieces of pottery. C6.1 cave is the residence, burial and tool-making site of the prehistoric inhabitants of the Neolithic period and the latest known archeological site in volcanic caves in Vietnam.

4.1.2. C6'Cave

The cave has coordinates of 12030'55.4" N and 107054'04.4" E; it is 424m high above sea level and about 250m southeast of the C6-1 cave. Its shape resembles a 15m wide and over 100m long tube; the ceiling is 13m from the ground. Cave sediments are soil and basalt rock clustered into three circle-like piles; two of which were excavated in 2018. Cluster 1's code is 18.C6'.F1, its base size is 3m x 3.5m with a height of 0.6m; Cluster 2's code is 18.C6'.F2, with a base area of 2.5-3m (Vũ Tiến Đức, Phạm Thị Phương Thảo, Lương Thị Tuất, 2019: 97-99). (*Figure 2*).

The two excavation pits share the same stratigraphy from top to bottom, including the top layer - a natural basalt layer with the size of rocks over 20cm; the second layer is a dark brown soil layer containing some fragments of animal bones. One layer under is a dark brown soil layer lying on the cave floor with small stones < 5cm. Surrounding each cluster are basalt stones arranged in an arc.

Fourteen fragments of deer bones, bat skulls and land snails were found in cluster 18.C6'.F1. Twenty pieces of deer bones and teeth were obtained from cluster 18.C6'.F2. The age of this excavation pit dates back to 4,160±20 years BP, with the adjusted figure being 4,707 years BP, resembling the age of the latest layer in the C6.1 cave. Excavators believe the clusters are hunter's stone structures to make a fire, in which there are teeth and bone remains of wild animals hunted and discarded. These hunters were temporary residents of the same period as the dwellers of the C6.1 cave.

Figure 2: Location of F1 and F2 Stoves in C6’ Cave

a. Cluster 18.C6’.F1

b. Cluster 18.C6’.F2

Source: Photo by Nguyễn Lân Cường.

4.2. Discussion

4.2.1. Archeological sites in volcanic caves - a specific type of archeology in Vietnam’s prehistory

Over 100 years of research in prehistoric archeology in Vietnam, we have acknowledged some types of archeological sites such as hills, river beds, karst caves, and midden (*kjokokenmodding* in Indonesian). The discovery of archeological sites in lava tube caves in 2017 in Krông Nô (Đắk Nông province) has added another type of prehistoric site to the prehistoric archeological map of Vietnam. The archeological sites in volcanic caves distinguish them from those in karst caves in terms of formation mechanism, stratigraphic characteristics, and geo-archeological values. Karst caves were formed in limestone blocks; due to water flow, the limestone was eroded, creating caves on the ground. There are two types of archeological sites in karst caves: One is the cave inhabited by primitive people, forming the cultural layer in the cave; the second is the cave containing the sediments of the Pleistocene, in which there are human and animal fossils clinging to the wall or ceiling, sometimes falling to the cave floor. Meanwhile, volcanic caves were formed due to volcanic eruptions, creating deep underground lava tubes. Archeological sites in this type of cave were formed after the structure of the lava tube was stabilized; a part of the lava tube fell, exposing the cave entrance. Humans started to reside and leave traces inside. No sediment is clinging to these caves’ walls and ceilings compared to karst caves.

Organic remains such as human bones and animal teeth are relatively intact in karst caves since there are very high levels of CaO. CaO is formed by rainwater eroding limestone, creating calcium carbonate that penetrates the tiny holes in the bones and hardens them. Due to volcanic eruptions, the pH in the red basalt soil is high, so most of

the bones are destroyed in a short time. However, the C6.1 cave is in a volcanic region where human and animal bones are preserved quite well.

In 2018, a group of geologists from Hà Nội University of Natural Sciences analyzed the chemical composition of C6.1 cave stratigraphic sediments using X-XRF 1800 Shimadzu fluorescence and the mineral composition using the Siemens X-ray Diffractometer, model D5005. By processing the mineral phases with BGMN - Rietveld software, they found that the chemical composition of sediments in layers at different depths does not fluctuate much. The most significant element is CaO with a high content (50.51-60.10%) and SiO2= 8.70 -13.03%; sub-components such as Al_2O_3, FeO^*, P_2O_5, MgO have contents of less than 5% and do not change much between layers. In this cave, the mineral composition is mainly carbonate, in which calcite is the mineral phase with the highest content, followed by aragonite, calcium silicate, dolomite, witherite, and cerussite. The high ratio of these minerals is a key factor in preserving human and animal bones, as well as shells of mollusks that were not destroyed in volcanic caves (Tạ Hòa Phương, Nguyễn Thùy Dương, Nguyễn Thị Ánh Nguyệt, Phan Thanh Toàn, 2018).

In 2021, Nguyễn Ngọc Trường, studying the composition of sediments in the C6-1 cave, noted that the calcium oxide (CaO) content at this place is very high, 39.54% to 45.57%. As a result, organic matter was likely to be preserved in the cultural layer. Lime CaO, an anthropogenic mineral, is formed by human use of carbonate rocks (limestone), biochemical carbonate rocks, or mollusk shells heated at a temperature of 800 (Nguyễn Ngọc Trường, La Thế Phúc, Nguyễn Trung Minh, Bùi Quang Anh, Lương Thi Tuất, Đặng Thi Hải Yến, 2021: 38-48).

However, limestone is absent in the highlands of Đắk Nông. We believe that the origin of CaO in the C6.1 cave can only be from the shells of mollusks collected by humans in nearby rivers and streams and brought into the cave as food; the shells were burned and left at the cave. Statistics show that the ratio of CaO between the layers of 7,000 years to 4,500 years is hardly different, indicating that the exploitation of terrestrial mollusks is a tradition of local prehistoric inhabitants. Determining the reasons why human and animal remains are preserved in Krông Nô volcanic caves has a significant and practical value, opening the prospect of finding more ancient human and animal fossils, developing the mechanism of long-term conservation of human and animal remains in the cave when building on-site museums in the Đắk Nông Global Geopark volcanic cave system.

4.2.2. C6.1 cave - A standard archeological stratigraphy of volcanic caves in the Central Highlands

The stratigraphy of the excavation pit in the C6.1 cave is 1.85m thick, including eight successive layers of sediment from top to bottom:

- Layer 1 (top) is 35cm thick; the soil is non-cohesive, gray to dark gray, with few roots. Eight stoves, grinding axes, grinding tables, pestles, bone needles, crushing tables,

ceramics, and a grave where the body was placed in a flexed position with legs bent were found in this layer.

- Layer 2 is 30cm thick, with smooth, gray-white to light gray soil; they found one stove, a great number of mollusk shells, animal teeth, stone tools, bones and pottery.

- Layer 3 is 25cm thick; the soil is smooth, non-cohesive, and dark brown; many basalt stones are arranged almost in a circle, in which there are many ash coals and burnt bones. The structure looks like a trash pit.

- Layer 4 is 45cm thick; the soil is smooth, solid, and ash-gray, with some milky kaolin lumps, many mollusk shells and animal bones. There are graves with codes M 1, M2, M3, M4, M5, M6, and M7. The bodies in graves were buried in a flexed position with the legs bent. Artifacts obtained are flaking tools, blade-sharpening axes, anvil stones, flakes, raw materials, bone tools, and mollusk shell jewelry.

- Layer 5 is 25cm thick; the soil is solid and light brown, with F12, stone tools and a few bone tools; the number of mollusk shells is less than that of the upper layers; there is no evidence of grinding tools.

Table 1: Results of C14 Dating of the C6-1 Cave in Krông Nô (Đắk Nông)

No.	Sample code	Sample location (cm)	Material	Dating back - BP	Calibrated date
1	18.C6-1.C4.L1.2	16	Charcoal	4.680±20	5.391BP
2	17.C6-1.D3.L3	32	Charcoal	5.070±20	5.815BP
3	17.C6-1.D3.L.6	43	Charcoal	5.110±20	5.815BP
4	17.C6-1.D3.L.7	56	Charcoal	5.225 ±20	5.965BP
5	17.C6-1.D3.L.8	63	Charcoal	5.230±20	5.966BP
6	18.C6-1.C2.L4.3	58	Charcoal	5.760±25	6.560BP
7	18.C6-1.D4.L4.5	99	Charcoal	5.780±25	6.686BP
8	18.C6-1.D2.L4.7	125	Charcoal	6.030±25	6.876BP
9	18.C6-1.C2.L4.9	126	Charcoal	5.850±25	6.672BP
10	18.C6-1.D4.L4.10	138	Charcoal	5.945±25	6.768BP
11	18.C6-1.C4.L4.12	154	Charcoal	5.945±25	6.768BP
12	18.C6-1.D4.L4.13	175	Charcoal	5.970±25	6.800BP
13	18.C6-1.C3.L4.16	183	Charcoal	6.090±25	6.954BP

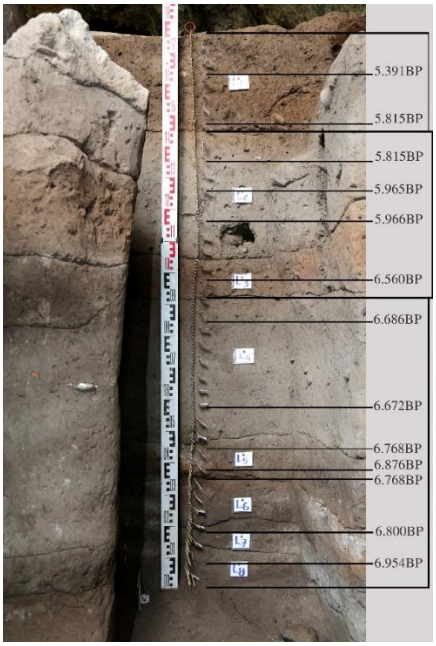
- Each of the three layers (6, 7 and 8) has an average thickness of 10cm to 15cm, with alternating gray-white or gray-brown basalt layers of soil; burning marks of F13 and F14

stoves with milky kaolin lumps are occasionally found. The soil in these three layers is compacted with a few stone artifacts, flaking tools, animal bones and few crumbling mollusk shells.

There are 13 ages in this stratigraphy, analyzed at the Radiocarbon Laboratory of the Institute of Geography RAS (Russia) and the IGAN Laboratory of the Center for Applied Isotope Research, University of Georgia (USA) (*Table 1*).

The stratigraphy of the C6-1 cave shows that humans had a continuous residence for nearly 3,000 years, from 7,000 to 4,500 years BP. The first residence dates back to 6,090 ±25 years BP; the adjusted figure is 6,954 years BP. The latest age dates back to 4,680 ±20 years BP, but it is not the last layer of the archeological site. The prediction is that the end of the cave habitation was around 4,000 years BP (Nguyễn Khắc Sử, Nguyễn Lân Cường, La Thế Phúc, Nguyễn Trung Minh, Lương Thị Tuất, Lê Xuân Hưng, Vũ Tiến Đức, 2020: 16-30) (*Figure 3*).

Figure 3: Stratigraphy and Ages of C6-1 Cave



Source: Nguyễn Khắc Sử, 2018.

The period from 7,000 to 4,000 years BP matches the residence of the inhabitants of the Middle Neolithic period in Vietnam; typical are the Cái Bèo culture (Quảng Ninh - Hải Phòng), the Đa Bút culture (Thanh Hóa - Ninh Bình), Quỳnh Văn culture (Nghệ An - Hà Tĩnh), groups of archeological sites in Bàu Dũ (Quảng Nam) and Thôn Tám – Làng Gà - Buôn Kiều (Central Highlands) (Nguyễn Khắc Sử, 2016).

4.2.3. C6-1 cave - a historical source outlining the prehistoric culture of Krông Nô

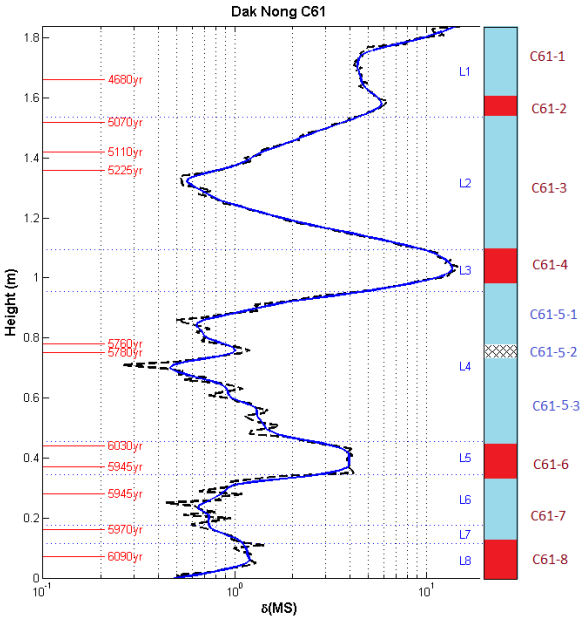
Climate, environment, and landscape of Krông Nô in the Holocene period: Analysis of 19 pollen spores samples in C6.1 cave stratigraphy shows that tropical plants play a dominant role, with little temperate and subtropical pollen. The pollen of herbaceous plants accounts for 74%; fern spores with 12%; pollen from woody plants with 8% and 6% for unspecified elements (Nguyễn Thi Mai Hương, Phạm Văn Hải, Phan Thanh Toàn, 2020: 45-48). The paleoclimate in this area changes from early to late stage according to the depth of culture layers. At the earliest layer, 156cm - 185cm (from 6,954 to 6,900 years BP), fern spores, mainly *Polypodiaceae*, make up the majority (65%); 30% of herbaceous plant pollen including *Poaceae* and *Pilea* sp., and 5% of the pollen of woody plants (only pollen of *Rubiaceae*). It is the beginning of the middle Neolithic period of C6.1 cave; the climate was cool, slightly dry, warm and humid. In the middle Neolithic period, with the cultural layer's depth from 155cm to 46cm (5,900BP to 5,300 years BP), the herbaceous plant pollen remains its portion of 60%, including *Pilea* sp., *Poaceae*, *Vilebrunea* sp; fern spores make up 20%, woody plant pollens make up 20%, including *Myrica* sp., *Carex* sp., *Magnoliaceae*, which are typical for warm and humid yet cool climate (with the *Sequoia* sp. pollen of temperate species). The latest layer, at a depth of 45cm, presents the Late Neolithic habitation (from 5,200 BP to 4,300 years BP). Herbaceous plants account for 80%, such as *Pilea* sp., *Poaceae*, and *Vilebrunea* sp.; ferns spores account for approximately 20%, including Polypodiaceae, *Lygidium* sp., *Cyathea* sp., with pollen of *Sequoia* sp. flowers, reflecting a cool, humid, and tropical climate. Overall, the inhabitants of the C6.1 cave belong to the tropical monsoon period, with alternating warm/humid and cool weather, open forest, and low forest cover related to human luminescence activities.

From the analysis data of 185 ancient samples using magnetic susceptibility in 185cm thick stratigraphy at the C6-1 cave, Lưu Thị Phương Lan has divided the stratigraphy into four cold periods (blue): C6.1-1, C6.1-3, C6.1-5, C6.1-7 and four warm periods (red): C6.1-2, C6.1-4, C6.1-6, C6.1-8. The cold period of C6.1-5 is classified in more detail: there is a short warmer period (C6.1-5-2) between the two colder periods (C6.1-5-1 and C6.1-5-3). During the period from 6,900 to 5,391 BP year, there are two overlapping weather cycles in cave C6-1, a cycle of 475 years and another of 317 years (Lưu Thị Phương Lan, nnk, 2018). (*Figure 4*).

The fauna composition of the C6.1 cave is presented with 76,425 animal bones and thousands of shells of mollusks, hunted and gathered by humans, brought into the cave as food, and left in the cave. Most of them are modern animals, typical for the tropical monsoon climate. They are monkeys (*Macaca* sp.), orangutans (*Pongo* sp), sambars (*Rusa unicolor*), Indian hog deers (*Axis porcinus*), wild boars (*Sus scrofa*), wild buffaloes /bison; tigers (*Panthera tigris*), hog badgers (*Artonyx collaris*), Asian small-clawed otters (*Aonyx cinerea*), bears (Ursidae), civets (*Viverridae*), jackals (*Canidae*), rhinoceros (*Rhinoceros* sp.); turtles/softshell turtles account for a large number; Birds and fish account for a majority of, gathering mainly in the upper layers. Megabats (*Pteropodidae*) and the Old World leaf-nosed bats (*Hipposideridae*) make up a certain proportion, suggesting that the

cave was accompanied by human habitation. The most significant are mollusks, such as snails with a gill and an operculum (*Sinotaia aeruginosa*) (85.4%). In comparison, freshwater mussels (*Oxynaia micheloti*) (9.77%) and a species of freshwater clam (*Corbicula fluminae*) were found only in the upper layers, representing the period of heavy rain, abundant water resources, and the rapid growth of freshwater mollusks (Nguyễn Anh Tuấn, Vũ Tiến Đức, Nguyễn Thành Vương, 2019: 85-89). The collection of large volumes of mollusk shells and the CaO ratios in the basal soil layers suggest the tradition of mollusk collection in the Hòa Bình culture of Neolithic inhabitants in the Central Highlands.

Figure 4: Magnetic Domains



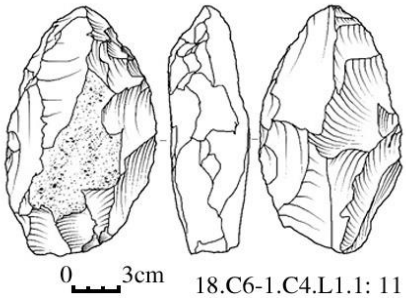
Source: Lưu Thị Phương Lan, 2019.

Tool and pottery manufacturing: the C6.1 cave dwellers crafted stone tools at the residence. The artifacts obtained are 3,788 scrap pieces (flakes) and raw stone, in which there are only 179 stone tools, including 25 oval axes, 4 short axes, 2 iron-shaped tools, 1 disc-shaped tool, 1 blade sharpening ax, 28 rough chopping tools, 14 slicing tools, 2 sharp cutting tools, 13 flaking tools, 13 grinding tables, 23 anvil stones, 3 stone slabs, 11 incomplete axes, 5 stone nodes, 33 ax shards, and 1 quartz crystal.

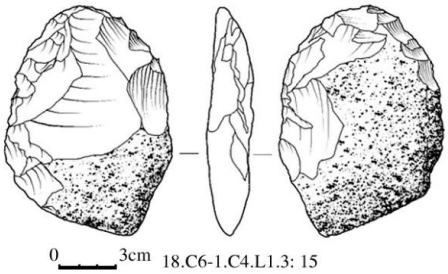
The highlight feature of residents living in volcanic caves is exploiting local materials such as basalt, chert or stream pebbles to make tools that have a quite similar shape to those of Hòa Bình culture (Hoanhinhian), such as oval axes, short axes, disc-shaped scrapers, and iron-shaped tools. The difference is that this area's tools are smaller, primarily double-sided and

finely adjusted (*Figure* 5). This sign indicates the preservation of the tool-making tradition of the prehistoric inhabitants in the Central Highlands (Nguyen Khac Su, 2021: 26-42).

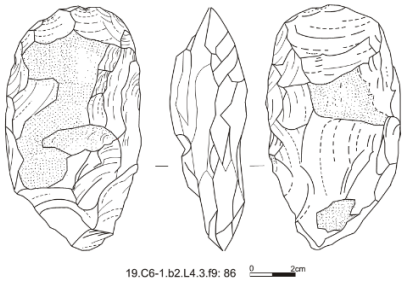
Figure 5: Typical Stone Tools in C6-1 Cave



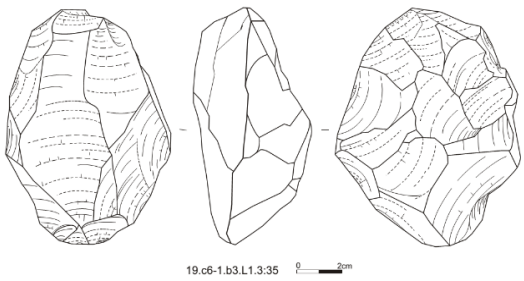
a. Oval axes



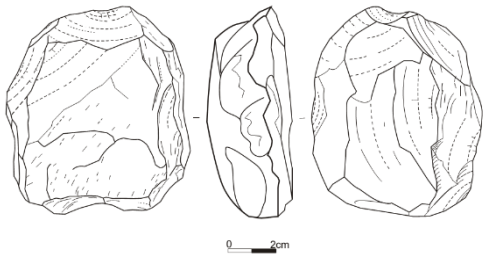
b. Oval axes



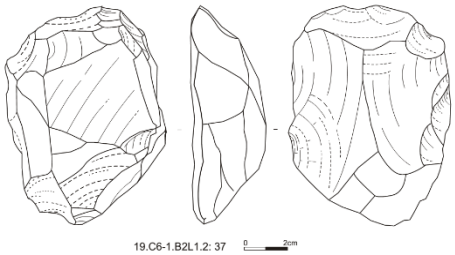
c. Oval axes



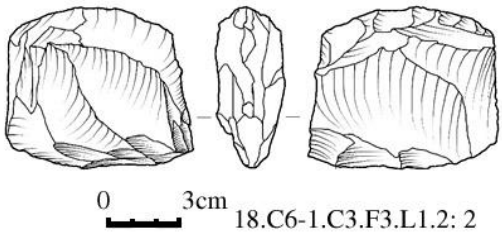
d. Oval axes



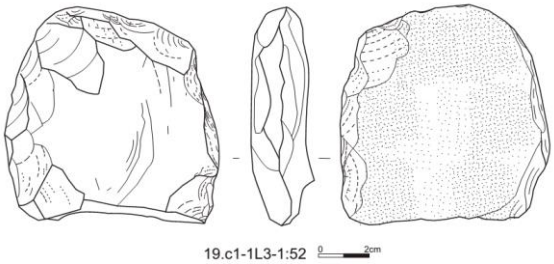
e. Disc-shaped scrapers



g. Disc-shaped scrapers



h. Short axes



i. Short axes

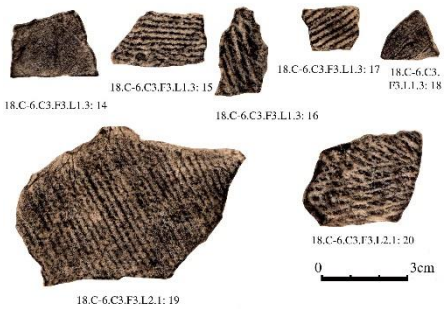
Source: Nguyen Khac Su, 2019.

The other artifacts obtained from the cave are 66 bone tools with sharp tips as awls, formed by polishing technique; they function as sewing needles or fishing spears; 10 shells of sea snails (Cypreae sp.) with pierced backs and threaded to make jewelry. The ancient people in the cave used pottery after 5,225 ±20 years BP; 1,276 pieces of pots, bowls, and plates with decorative patterns, such as twisted rope, dashed lines, dot-dash, and dotted lines. All were made from fine-grained sand clay and fine-grained ceramics (*Figure* 6). The only bronze item is a two-pronged arrow with a short nock; it was cast in a small double gill found in Layer 1 (the latest layer).

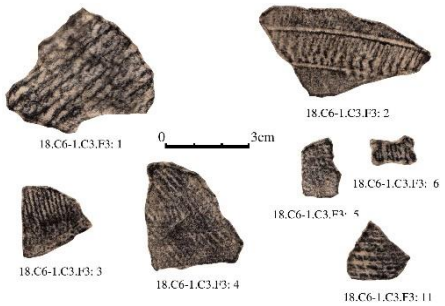
Figure 6: Bone Tools, Mollusks, and Pottery in the C6-1 Cave

a. Bone tools with sharp tips

b. Sea snail jewelry *(Cypreae* sp.*)*



c.Pottery



d. Pottery

Source: Nguyễn Khắc Sử, 2019.

Hunting-gathering is the main activity of the prehistoric inhabitants of the C6.1 cave. Among the 76,425 animal bones found, there is no evidence of domesticated animals. Hunting and gathering activities increased from the earliest to the latest stage, as demonstrated by an increase in animal bones and mollusk shells from bottom to top. The

animals hunted and gathered by the local inhabitants are modern species that still exist in the Đray Sáp forest surrounding the cave.

With the number of animal bones identified, turtles have the most numerous, accounting for 27.1%, followed by fish with 24.6%, bats with 17.1%, deer with 7.71%, and monkeys with 5.14%. These species groups are in all layers, while other mammals are in smaller numbers. Some animals hunted by C6-1 cave dwellers are monkeys (*Macaca* sp.), orangutans (*Pongo* sp), sambars (*Rusa unicolor*), Indian hog deers (*Axis porcinus*), wild boars (*Sus scrofa*), wild buffaloes /bison; tigers (*Panthera tigris*), hog badgers (*Artonyx collaris*), Asian small-clawed otters (*Aonyx cinerea*), bears (*Ursidae*), civets (*Viverridae*), jackals (*Canidae*), rhinoceros (*Rhinoceros* sp.); turtles/softshell turtles account for a large number and are considered a common source of food of the ancient people.

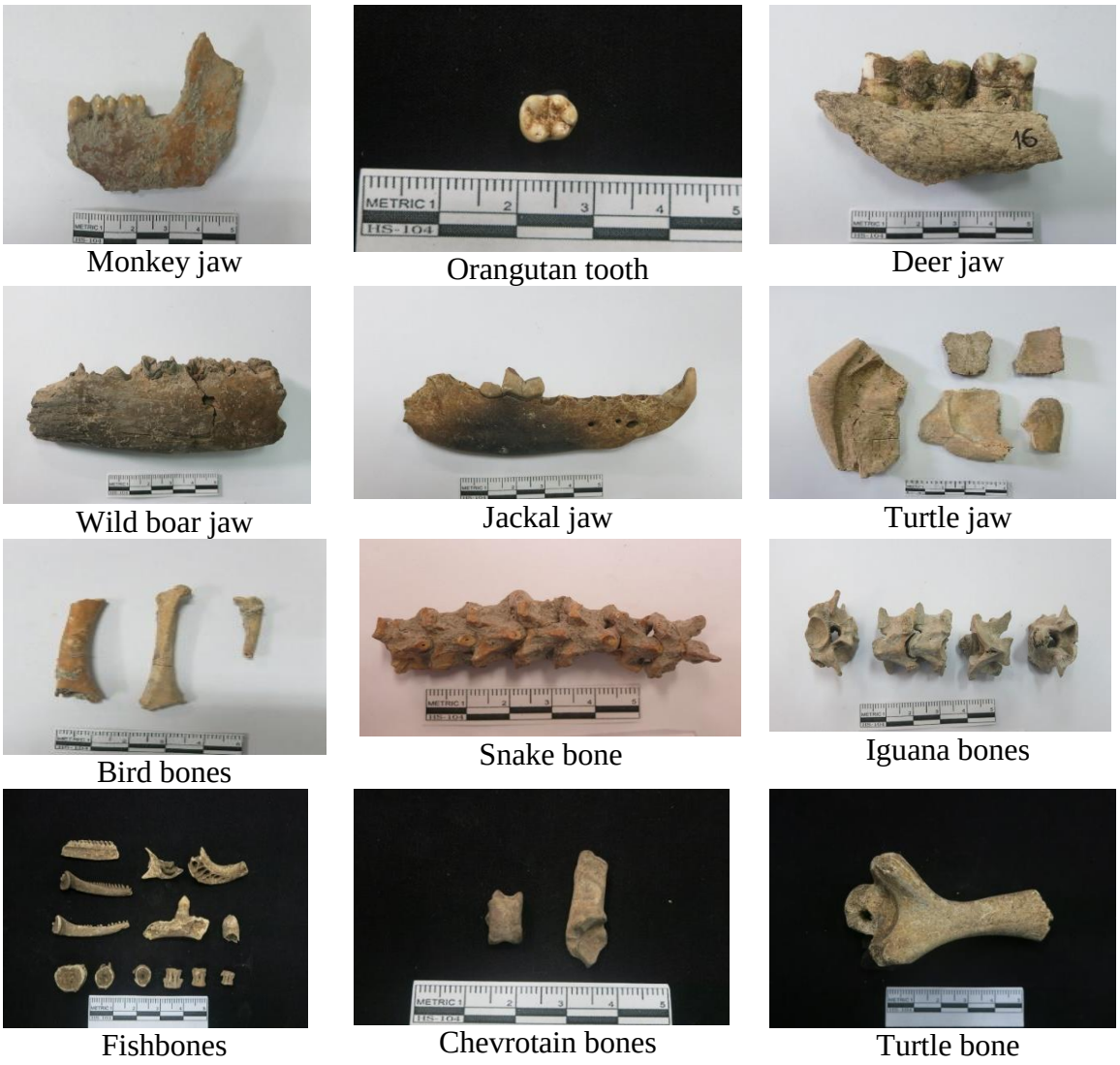
Only a few bone remains of an animal are found in the cave; the bones of a complete animal are rarely seen. It indicates that individuals hunted small animals while bigger groups went for larger mammals; many people got involved, so the game was shared by many people. Therefore, the bones found are not from a whole animal. Mollusc shells are a frequent object collected by humans, increasing over time from the earliest to the latest stage. The majority is a species of freshwater snail with a gill and an operculum (*Sinotaia aeruginosa*) (85.4%), while freshwater mussels (*Oxynaia micheloti*) account for 9.77%; a species of freshwater clam (*Corbicula fluminae*) embodies the fluctuations of the hot and humid environment with increasing rainfall and abundant water resources, allowing the rapid growth of freshwater mollusks. It also reflects the tradition of eating snails in caves of Hòa Bình culture's inhabitants in Southeast Asia prehistory (*Figure 7*).

In the spiritual life, the ancient people of the C6.1 cave knew how to beautify themselves with jewelry. The jewelry used was made from the shells of sea snails (Cypreae sp.) with an oval body, a narrow and long mouth, and a profoundly concave inward with a smooth and white shell. The shell was pierced on the back to make a chain worn as a necklace. Some of these shells were dyed with ocher and buried with the dead. To get these snails, the dwellers of C6-1 must trade with inhabitants living by the sea. The closest sea is the South Central Sea of Vietnam, over 100km from the cave. The use of sea snail shells such as jewelry and burial items was widespread in the Hòa Bình culture in North Vietnam thousands of years ago (Hoàng Xuân Chinh, 1998).

The culture of handling death: The inhabitants of volcanic caves buried the dead in a flexed position with their legs bent at their residence, next to the fire. Seven graves were discovered in the excavation pit. Human remains in these graves have been preserved relatively intact. Grave 1 is in a layer dating to 5,780 BP (the adjusted figure is 6,686 BP); the dead body is a man about 25 to 35 years old. Based on the length of the limb bones,

this person is believed to be about 1.84m to 1.85m tall. In terms of the composition of anthropology, the skull is similar to the *Melanesian* and the *Indonesian*, which is common in Hòa Bình culture (*Figure 8*.1a.1b.1c). The body in Grave 2 at a depth of 68cm, dating to 5,230±20 BP, is a baby about four years old buried in the sitting position with legs flexed closely to the chest. The skull bone is thin, broken into more than 100 pieces. These pieces are reattached to form a skull, but its ethnicity is unknown. The baby has a wide nasal cavity, a low-slanted eye socket, and large teeth, commonly seen in the black race (*Figure 8.2a, 2b, 2c*) (Nguyễn Lân Cường, 2019: 33-52).

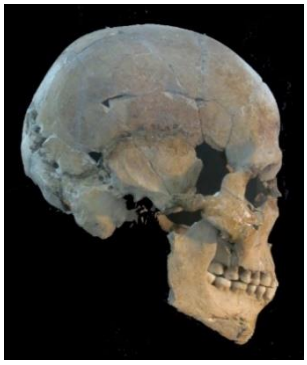
Figure 7: Animal Remains in the C6-1 Cave



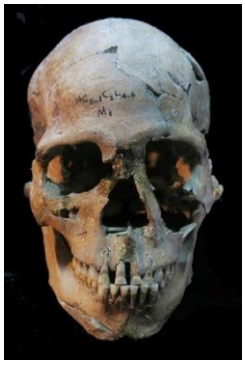
Source: Nguyễn Anh Tuấn & Trần Thị Minh, 2020.

Figure 8: Grave 1, Grave 2 and Skulls in the C6-1 Cave

1a. Grave 1. A grave where the body was placed in a flexed position with the legs bent.



1b. Lateral view M 1



1c. Frontal view M 1

2a. Grave 2

2b. Frontal view M 2

2c. Lateral view M 2

Source: Photo by Nguyễn Lân Cường, 2019.

The other graves have been processed and conserved in the excavation pit for later research. Some graves are surrounded by stone barriers; others are buried with stone artifacts and jewelry. In addition, fragments of human bones and teeth are scattered in the cultural layers in the excavation pit. The burial process and anthropological composition initially indicate that the inhabitants in this area are related to the Hòa Bình culture people in North Vietnam in the Neolithic period after Hòa Bình (Nguyễn Khắc Sử (chief author), Nguyễn Lân Cường, Lê Xuân Hưng, Vũ Tiến Đức, La Thế Phúc, Lương Thị Tuất, Phạm Thị Phương Thảo, Nguyễn Thành Vương, 2019).

Stoves and community structures: In the excavation pit of cave C6-1, 14 stoves distributed at different depths were discovered and coded from F1 to F14. A stove is usually formed by soil piling up; the soil used is black or dark black, round or oval; a thick layer of ash coal is placed in the middle, with a thin outer layer; a large stove has a diameter of 0.6m; smaller stoves have a diameter of 0.4m. There are stoves with basalt

stones piled around, in which there are ash coals, animal bones, burnt mollusk shells, and a few scraps and pieces of pottery. A stove is a place to cook food, get warm, gather all community members, and fight wild animals and harmful insects to protect people. Most stoves in cave C6-1 are small, possibly owned by households with two generations, including husband and wife and their children.

In the C6' cave, two large stoves of overnight hunters were found, dating back to the latest stage of the C6-1 cave. It is more likely that the owners of these hunting campfires are residents of the nearby C6-1 cave. Therefore, there was a division of labor in the community, such as tool makers, hunters and gatherers of herbs and mollusks. It is possible that there was a division of labor by sex and age in a clan commune.

5. Conclusion

5.1. For the first time, Vietnamese archeologists learned about a type of archeological site in volcanic caves, added to the prehistoric archeological site distribution map of Vietnam. Volcanic caves have preserved a relatively intact stratigraphy, reflecting the historical process from 7,000 to 4,000 years BP and clarifying the stages from the earliest to the latest based on cultural layers (Nguyễn Khắc Sử, Nguyễn Lân Cường, La Thế Phúc, Nguyễn Trung Minh, Lương Thị Tuất, Lê Xuân Hưng, Vũ Tiến Đức, 2020: 16-30).

The early stage, from the 3rd to 8th cultural layers (7,000 to 5,500 years BP), demonstrated a humid tropical climate alternated by cooler periods; humans resided, made tools, and buried the dead in caves. People at this stage used the grinding technique, but it was not typical; they encountered only one blade sharpening ax. Local inhabitants quarried local stream pebbles such as quartz, quartzite, schist-silica, chert or basalt. The raw materials then got hewn and slightly modified to create oval axes, sharpening axes, disc-shaped graters, short axes with chopped handles, and thin flakes similar to those of Hòa Bình culture; the primary technique is the bifacial technique. Besides, ancient people made and used small, sharp bone tools that smoothed the whole body. During this time, people hunted animals, such as rhinos, tigers, buffaloes, bison, deer, wild boars, iguanas, turtles, softshell turtles, crabs, fish and mollusks, such as mussels, snails, worms, and freshwater mussels; there is no evidence of domesticated animals. The early inhabitants maintained the tradition of burying the dead in caves with their bodies placed in a flexed position with the legs bent, resembling Melanesian and Indonesian ethnic characteristics found in the Hòa Bình people.

In the late stage, from 5,500 years to 4,000 years BP, people resided in caves, but some chose to live outdoors, around Đray Sáp waterfall - Gia Long, where cultural relics have been found. The cave people perfected tools for hedging and sharpening; the shape was

more stable; there were many punches, grinding tables used in food processing, and sharp bone tools, especially tools made of opal and pottery. A few opal tools and crude pottery obtained indicate that the inhabitants of this period had contact with groups of people of the Late Neolithic in the area where stone ax and opal quadrilateral manufacturer was.

In this layer, there is only one grave (Grave 4); the body was placed in a flexed position with legs bent and head facing the northwest; four small basalt stones (stalagmite) were placed under the skull; the soil at the bottom of the grave is grey and smooth; burial items are snails and stone tools. Similar to the early stage, a few fragments of different individuals' remains are scattered throughout the culture layer of this stage. The inhabitants hunted small animals, such as bats, snakes, iguanas, fish, birds, tortoises, scaly reptiles, porcupines, mice, chevrotains, monkeys, langurs, orangutans, etc., and freshwater mollusks such as snails with a gill and an operculum, freshwater mussels, and freshwater clams.

5.2. Geo-archeological documents recorded indicate the adaptation of humans to changes in the environment of the volcanically active area on Krông Nô. Such compatibility is reflected in the exploitation of tool-making materials, bifacial and blade sharpening techniques, and the preservation of tool shapes of Hòa Bình culture people, such as oval axes, short axes, and disc-shaped scrapers. The volcanic stone tool industry in this area belongs to the Post-hoabinhian. In the tropical environment of the red soil highlands, the inhabitants retained the tradition of living in caves, collecting mollusks, and hunting various species. However, they hunted a few individuals of each species to prevent species extinction, bringing ecological balance and allowing the human community to settle permanently in the cave. During the funeral, the inhabitants of the Krông Nô volcanic caves performed the tradition of burying the dead in their residences with the dead bodies in a flexed position with the legs bent or in a sitting position with legs flexed closely to the chest. Their graves were sprinkled with ocher; their bodies were buried with stone tools and sea snail shells of *Cypreae* sp, resembling Hòa Bình culture. In terms of ethnic composition, people of this period belonged to the *Indonesian*, originating from the Hòa Bình culture in North Vietnam.

5.3. The archeological documentation of the C6-1 cave is reliable in terms of the Central Highlands prehistory from the Middle Neolithic to the Late Neolithic. The typical cultural relics of the Middle Neolithic in the Central Highlands are Krông Nô volcanic caves, the relics of Làng Gà (Gia Lai province), Buôn Kiều (Đắk Lắk province), Thôn Tám (Đắk Nông province), Gia Canh (Đồng Nai province) and Eo Bồng (Phú Yên province). These relics are in the same line as other Neolithic cultures in Vietnam, such as the Cái Bèo Culture (Quảng Ninh province – Hải Phòng city), Đa Bút Culture (Thanh Hóa - Ninh Bình provinces), Quỳnh Văn Culture (Nghệ An - Hà Tinh provinces) (6,000-3,500 years BP) and Bàu Dũ archeological site (Quảng Nam province) (Nguyễn Khắc Sử, 2021: 78-92).

In the Neolithic era in Vietnam, most of the inhabitants after the Hòa Bình Culture developed in the delta-coastal area, while some developed in the red soil plateau mentioned above. The inhabitants of the Central Highlands in the Neolithic period developed into the Late Neolithic period, typically the Lung Leng Culture (Kon Tum province), the Biển Hồ Culture (Gia Lai province), the Buôn Triết Culture (Đắk Lắk province) and groups of residents of Thôn Bốn (Lâm Đồng province), Chu K'tur (Đắk Lắk province), H'lang (Gia Lai province) (Nguyễn Khắc Sử, 2007). With the emergence of post-Neolithic cultures, the Hòa Bình Cultural tradition in the Central Highlands began to be broken. People did not see dwellers in caves, buried bodies in a flexed position with the legs bent, or Hòa Bình-style tools, but instead, the formation of ax and quadrangle or full-body grinding mills.

5.4. The presence of archeological sites in the volcanic caves of Krông Nô clearly indicates an intact chronicle with outstanding environmental changes and human adaptation in the past; it is a typical example of the tradition of living in caves and using natural resources, representing the process of interaction between humans and the environment under the influence of changes in nature and society in the Central Highlands.

The archeological evidence in volcanic caves in this area provides essential information about lost environments, the evolutionary history and diversity of nature, and human adaptation to environmental changes. The prominent findings on the characteristics of fauna and flora concerning the archeological evidence of the Central Highlands volcanic region are not common in Vietnam and Southeast Asia. In this case, the prehistoric archeology of the Krông Nô volcanic Cave system should be scientifically recognized as typical in the region. The prehistoric culture of the Krông Nô volcanic Cave system is an invaluable archived document in terms of geology, biodiversity, cultural history of the past in Đắk Nông Global Geopark and a new resource contributing to socio-economic development in the Central Highlands.

Acknowledgments: All documents from the excavation of cave C6-1 were carried out by the topic: "*Study on the value of cave heritage, propose to build an on-site conservation museum in the Central Highlands, for example volcanic caves of Krông Nô, Đắk Nông Province*", which belongs to a state-level scientific project, the Central Highlands Program 2016-2020, code TN17/T06, chaired by Vietnam Natural Museum. Dr. La Thế Phúc is the chairman. Participants in the excavation included Nguyễn Khắc Sử (chair), Nguyễn Lân Cường, Lê Xuân Hưng, Vũ Tiến Đức, La Thế Phúc, Lương Thị Tuất, Pham Thị Phương Thảo, Nguyễn Thành Vương, Phan Thanh Toàn, Nguyễn Thanh Tùng. We thank them for their help and support while conducting the field work.

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