Pale environmental reconstruction on Toroan residential site in Madura Island: Phytolith-based analysis

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Abstract. The location of Madura Island is quite strategic as a trajectory of human migration, in the prehistoric neolithic era, because it was based on the island's location. Large islands such as Java, Kalimantan and Sulawesi, besides small islands also stretch around it. To reveal the ancient environment (paleoenvironmental) and how the use of the environment in the neolithic period can be known through phytolith research. Taking sediment samples has been carried out through excavations at Goa Toroan Site. Phytolith analysis that has been done through soil sampling method follows the sampling procedure carried out in Palynologi analysis. The phytolytic identification stage uses a reference to pre-existing plants. The results of this study have shown a picture of the ancient environment in Madura in general, especially in the Toroan Cave site, and the results of this analysis are also reinforced by archaeological findings revealed at the excavation on the site.

1. Introduction
Prehistoric Madura Island is still an enigma in the reconstruction effort, its role as a prehistoric human migration pathway for speakers of Austronesian Languages in the archipelago. Based on the results of research at several sites in Indonesia, Prehistoric Political Sites are scattered on the islands of Sumatra, Java, Flores, Kalimantan and Maluku. In Sumatra, Praneolytic sites are found like those on the Tiger Cave Site with dates of 14,825 BP and Gua Tiangko Panjang 10,259 BP. On Java, the sites of the Sewu Mountains have dates such as Gua Brahelo 11,940 ± 160 BP, Song Keplek 15,880 ± 540 BP. In Maluku the Praneolytic Site was found in the Golo Cave with the age of 31,260 BP and in Tanjung Pinang Basin with a date of 13,390 BP [1] When considering the geographical position of Madura Island which is between Sulawesi Island, Kalimantan and Java and surrounded by small islands, it is assumed that Madura Island has an important role in spreading culture or becoming a human migration pathway for Austronesian speakers.

The preliminary survey on Madura Island succeeded in finding two potential sites, namely the Delubang Cave Site in Sumenep Regency and the Toroan Cave Site in Sampang Regency (See Figure 1). Some archaeological remains are found around the site such as pottery, shellfish, bone tools, leftovers from shells and bones. Based on the results of the survey it was used as a recommendation for excavation. This excavation action produces several variations in the findings of archaeological remains. Archaeological remains found from the two sites include a large number of pottery fragments, varied shells such as shells, jewelry and food scraps and fauna bones identified as tools as well as the remainder of past human consumption. On the basis of these archaeological findings, the
two sites are categorized as potential sites to be further investigated in their proofs as cave dwellings in the past.

**Figure 1.** Administrative Map of Sampang Regency and the location of the Toroan site.

The choice of location settled by the past community is certainly based on various considerations, one of which is the feasibility of the physical environment, in this case, the availability of adequate environmental resources to support life.

Various analyzes that can be done to reveal the ancient environment (paleoenvironmental) include analysis of pollen, phytolith/phytolite, spores, and starch [2]. Pollen analysis aims to reconstruct vegetation and climate landscapes. In addition, analysis of pollen also aims to reveal the relationship between humans and the surrounding vegetation environment in the past [3].

Various studies have been conducted to find out the past environment, reconstruction of the environment where prehistoric humans lived, such as in the Kidang Cave Site in Blora Regency, Song Gilap Site, Wonogiri Regency [5][6]. Phytolith is a plant microfossil formed from silica. Fitlite is mostly produced by plants, especially types of grass [4] and other types of plants. If pollen is produced by plants in adulthood, then phytolite is produced by plants since the age of six weeks. Thus it is assumed that Phytolith analysis is better able to detect the presence of certain plants early [2].

The presence of phytolite is aided by age, environment, and the amount of water around it. When plants live, silica is transported from the soil and deposited on the stem, leaf, and inflorescence cells [5]. Then when the plants die, lose the protoplasm, the plant's organic cells rot and leave the silica microfossils. Molds of plant cells make Phytolith have various shapes and sizes. The shape and size are the references in identifying phytolith. The environmental conditions of vegetation obtained from the Phytolith analysis will be supporting data in reconstructing the human way of life supporting the Toroan Cave site.

The use of Phytolith analysis in Archeology is not only to uncover ancient environments, but it is also useful to know subsistence patterns, needs, and utilization of living plants around residential areas. In addition, through phytolite, it can be seen that there is human intervention/domestication in the management of plants that have undergone gradual changes in a long period of time [6].

This research is intended to reconstruct the ancient environment of the Toroan Site on Madura Island to contribute to the dynamics of prehistoric culture in Indonesia, especially the Neolithic era.
2. Method

Astronomically the Toroan site is between 113° 19’28.6” BT and 06° 53’35.0” LS with a height of 37 masl. Toroan Cave is in a karst cluster of the Madura Formation. The location of the Cave is one km from the beach. The surrounding environment is dominated by shrubs. There are several banana trees, perennials such as mango trees, there are also cactus and plants typical of karst vegetation.

The method of data collection is done by archeological excavation by opening 6 test boxes with a distance of 10 cm per spit. Determination of the excavation box was carried out after conducting a survey and finding several potential locations, supporting that Gua Toroan was a site of former prehistoric human dwellings.

Four soil samples were taken from the excavation box of the Cave site. Taking phytolite samples at the Toroan Site was done by selecting the deepest excavation box, the TP 2 excavation box. The soil sampling method followed the sampling procedure carried out in the Palynology analysis. As in the method of taking soil samples for pollen extraction, contamination must be avoided. The soil sample data taken is as follows:

| Sample Code | Spit | Depth of surface (cm) |
|-------------|------|-----------------------|
| S5          | 2    | 20                    |
| S6          | 5    | 50                    |
| S7          | 8    | 80                    |
| S8          | 12   | 120                   |

The laboratory extraction process is like the method used by Bowdery (1998) and which has been modified by Anggraeni [7]. The extraction phase begins by cleaning the soil from the clay using 10% sodium hexametaphosphate (Calgon) solution. The next step is to use 15% Hydrochloric acid (HCl) to remove lime and use 15% Hydrogen peroxide (H$_2$O$_2$) to remove organic material. After clean soil samples from clay, lime and organic material, then the final step is to use sodium polytungstate (NPTH) solution with a specific weight of 2.28 sg to separate phytolite from other materials. In this last stage the phytolite will separate and float. The extracted Phytolith is then ready to be observed and identified using a microscope with 400x magnification. The phytolytic identification phase uses reference to pre-existing plants. The author uses the morphological classification conducted by The Grass Phylogeny Working Group (GPWG) (2001) for grasses, Rovner [8] for plants not grass and also Piperno [4] Naming morphology of phytolith using ICPN (International Code for Phytolith Nomenclature 1.0) in 2005 [9].

3. Climate and Vegetation of Madura Island

Madura Island has relatively different climatic and environmental conditions. Volcanoes are not found on the mainland of Madura Island that belongs dried land. This area has a lot of rain in places where the altitude is low in places with low slopes and less rain.

The west and east monsoon winds influence the wet tropical climate on Madura Island and Java Island. the transition season is also known on this island, because of the season and dry season [10].

The dry climate and calcareous soil produce a unique plant for Madura Island. Arifin Surya Dwipa Irsyam, and friends provide a special research for Madura vegetation because, botanical research in this region is still small, causing information on Flora Madura has not been complete since Flora of Java was published fifty years ago. One tribe of flowering plants that can adapt to the Madurese environment is Rutaceae [11].

Plants that grow together consist of various types in one place, vegetation that can describe the environment where the plants live. The flora and fauna on Madura Island are stable. Different
circumstances with larger islands such as Sumatra, Kalimantan, Sulawesi and Papua, wealth in the form of fauna and flora resources varies greatly. Climate and soil type factors play an important role in the diversity of flora and fauna vegetation in one place.

Although Madura Island has a dry place but has a unique grass which is a type of puzzle or commonly referred to as beard grass Fimbrystylis adenolepis (type). In addition, also found plants that grow evenly, namely algae (Utricularia baouleensis) (See Figure 1), the shape of the stem grows upright and is often found in rice fields. Information about the flora and fauna that are endemic on Madura Island based on fossil findings, it is unfortunate that in some places it is not found anymore, because the place does not support conservation of the remains of flora and fauna [12].

In addition to climate and vegetation, the influence of ecosystems on the environment can be seen in the environment. Ideal and balanced ecosystems will support producing a variety of plants that have a variety, otherwise ecosystems that are not ideal and unbalanced will show a varied environment. Not only does flora experience such things, but fauna also influences, including the availability of food ingredients and their level of variation [12].

4. Analysis
Excavation at Gua Toroan Site opened 6 boxes of excavation boxes, one of which was the box TP2 which was most in the excavation selected to take the sample. Sampling at Toroan Site after excavation was carried out, taking four soil samples in different spits, based on depth (spit). The results of the Phytolith analysis of the four soil samples, identifiable phytolite derived from the types of grasses (poaceae) and phytolite types that can be found in various types of plants such as tree species, shrubs, herbs and grass (see table 1).
Table 2. Accumulation of Phytolith findings at the Toroan Cave site.

| SITE | NO SAMPLE | POACEAE | TREE/SHRUB/HERB/POACEAE | Other |
|------|-----------|---------|------------------------|-------|
|      |           | bilobate| polylobate | angular | fan | cross | saddle | rondel | elongate ornamented | rectangular | globular | square | Tracheid | accular hair cell | epidermal cell | unidentified | TOTAL | nematode |
| Toroan | S5 | 1 | 1 | | | | | | | | | | | | | | |
|          | S6 | 1 | | | | | | | | | | | | | | | | |
|          | S7 | 9 | 1 | 1 | | 3 | | | | | | | | | | | 19 | | |
|          | S8 | 5 | 1 | | | 3 | 1 | 1 | | | | | | | | | 13 | 1 | |

On this site, four soil samples were differentiated by spit. Of the four soil samples, there were no large quantities of phytolite. Two samples did not have phytolite. From samples no S7 and S8, identifiable phytolites are from grasses (poaceae) and phytolites which can be found in various plant species such as tree species, shrubs, herbs and grass (see table 1).

Figure 3. Phytolite (Poaceae).

It is a phytolite that is lined up in short double sphere (Bilobate) epidermal cells (figure 3) including the Poaceae class found on spit 8 (80 cm deep).
The shape of a rectangular Phytolith (Rectangular) has a smooth surface (Figure 4). Can be found in various types of plants, found on spit 8 (depth of 80 cm).

Some Phytolith found cannot be identified with certainty, because the possibility of appearing in Epidermal cells, Elongate ornamented, has not been identified with certainty because it can appear in several types of plants. For phytolytes the epidermal cell is found to be black, leaving a trail of fire.

Environmental conditions and vegetation Toraan Cave sites in particular and Madura Island in general are still having the same as environmental conditions and vegetation while still inhabited in the neolithic era.
5. Discussion
Phytolith which can be identified from the four samples, comes from the types of grasses (Poaceae) and the type of Phytolith that can be found in various types of plants such as trees, shrubs, herbs, and grasses. The Poacea species dominates almost all types of Phytolith that can be observed from the Toroan site. The presence of grass-type Phytolith indicates past environmental conditions around the Toroan Site consisting of grass-type vegetation. The data supports the condition of the site's vegetation since long ago which was dominated by deciduous grasses, and interspersed by several shrubs and trees.

The yield of Phytolith in each test sample has been able to give a picture of past vegetation and environment since 4770 years ago. None of the Phytoliths found that did not indicate the type of plant cultivated, such as bananas, rice or breadfruit. From the findings of Phytolith, it is also described as an ancient environment, the Toroan Cave Site is a dry savanna region. The site of Toroan Cave is about 580 meters from the coastline, and from the river is about 2 km from the river. The use of aquatic biota and terrestrial fauna can be seen from the findings in each spit in the excavation box on the Toroan Site. This utilization is not only a nutrient material but as a tool used for daily needs to fulfill nutrition.

Generally, in prehistoric archeology research, especially neolithic, besides aiming to find out the ancient environment at a site under study, other objectives also want to get the results of research related to the use of the environment, especially plants as nutritional ingredients, or other necessities.

The use of caves and niches has gradually become more optimal. This happened at the beginning of Pleistocene to the Holocene period, which was the culmination of cave exploitation and niche not only as a residence, but also as a workshop and burial. Pottery findings at several cave sites at that time, can be considered a marker of Neolithic culture. The Toroan Cave site is used as a residential cave but from the results of surveys and excavations there are no indication of the workshop for stone tools in particular, but for shells and bone tools it is possible that the workshop is carried out around the cave, because some shellfish and bone residues are possible as a trace of the manufacturing process carried out on the site. The bone tools and clams do not show as agricultural tools.

Utilization of marine and land products is really done to the maximum. The findings of shells of various types both from freshwater and those from shallow seas, while the findings of deep sea fish bones and teeth of sharks show that they have used the results of the deep sea. As for the utilization of environmental vegetation around archaeological findings from excavations do not support this.

6. Conclusion
Based on the findings of archaeological remains if it is associated with the results of Phytolith analysis, the conclusions that can be taken by the residents of Gua Toroan Site are using game animals and the use of aquatic biota. This can be seen from the many findings of fauna bones and the remnants of the use of aquatic biota. Whereas the conclusion of the Phytolith analysis gives results that show that prehistoric humans inhabiting the Toroan Cave site have inhabited since the environment was still quite dry to a fairly humid environment. They burn tubers and fauna for consumption. If it is associated with the number of shells found in the rest of the excavation, in the next period they might then exploit the sea and the river considering the distance of the Toroan Cave site to the beach and river is quite close.

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