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RESEARCH ARTICLE

Planktonic Foraminifera Biostratigraphy Of Taeno Limestone, Ambon, Maluku Province, Indonesia

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Abstract

The limestone became exposed to the surface because of an uplift event during the Quaternary period. This study aims to determine the age of limestone outcrops in the Taeno Traverse using planktonic foraminifera. This research located in Negeri Rumah Tiga, Teluk Ambon District, Ambon City. Field observations and laboratory analysis comprise the two steps of the study methodology. Employ the measuring section approach to gather detailed data in the field. There are 12 layers in the track, totaling 5.34 meters in thickness and 16.5 meters in length. Foraminifera samples prepared in the laboratory using H_2O_2 extraction and each sample's planktonic foraminifera taxa were identified. Nineteen samples were processed and confirmed to be fossilized planktonic foraminifera. A binocular stereo microscope with a 40x magnification used to analyze the data. The Taeno traverse is composed of calcarenite, a type of clastic limestone. The main characteristics include brownish-grey color, good sorting, sand particle size, open packing, and rounded-subrounded grain shape. Based on the identification results, 30 taxa of planktonic foraminifera fossils were found. The species with the highest abundance are *Globorotalia tumida tumida*, *Globorotalia menardii menardii*, *Neogloboquadrina incompta*, *Pulleniatina obliquiloculata*, *Orbulina universa*, *Globigerinoides tenellus*, and *Spaerodinella deshiscens*. According to the biodatum results, the Taeno Traverse is part of the *Globorotalia ttruncatulinoides truncatulinoides* zone with *Globigerinella calida calida*, *Globorotalia tosaensis tosaensis*, and *Globorotalia crassaformis crassaformis* sub-biozonation. This zone shows the age range of N21-N23, or equivalent to the Pleistocene.

Keywords: Ambon, Biostratigraphy, Limestone, Measuring section, Planktonic Foraminifera, Pleistocene

1. Introduction

Eastern Indonesia, like Ambon Island, has been formed from the complex tectonic (Pownall et al., 2016), interaction result of three plates, the Australian, Southeast Asian, and Pacific Ocean plates since the Late Oligocene (Hall, 2012; Linthout & Helmers, 1994; Menziel et al., 1997; Watkinson et al., 2012). Despite its complicated formation history, the stratigraphy of Ambon Island, as described by Tjokrosapoetro et al., 1993, is relatively simple (Menziel et al., 1997). The Coral Limestone Formation is the youngest lithology exposed on Ambon Island (Figure 1). Coral limestone made up of colonies of corals, algae, and bryozoans; it is white, hard, and porous, filled with calcite and coral fragments (Tjokrosapoetro et al., 1993, 1994). Mollusk and foraminifera fossils in this limestone formation indicate an Upper Pleistocene - Holocene age (Tjokrosapoetro et al., 1994).

Quaternary tectonics in Indonesia is conveniently grouped into four types (Katili & Tjia, 1969) (1) uplift and subsidence, (2) warping and folding, (3) horizontal displacements, and (4) volcano-tectonic deformations. According to Katili & Tjia (1969) coral reefs and reef terraces are common examples of young uplift in the Maluku, the north coast of West Irian, Sulawesi, the Lesser Sunda Islands, and the islands west of Sumatra. The presence of Quaternary limestones at elevations of up to 500 meters above sea level attests to Ambon Island's rapid uplift (Menziel et al., 1997). One of the best places to study limestone Ambon is in Taeno Traverse. Limestone research in Taeno is only conducted regionally. According to the regional geological map of Ambon sheet, Taeno limestone is part of the coral limestone formation (Tjokrosapoetro et al., 1993, 1994). As a result, this study focuses on the characteristics of Taeno limestone and determining age based on planktonic foraminifera content.

Planktonic foraminifera is widely acknowledged to be one of the most stratigraphically significant types of organisms with a high correlation potential (Peryt et al., 2022). Planktic foraminifera are single-celled eukaryotic organisms with passive floating lives that inhabit the photic zone of the marine environment (Boudgher-Fadel, 2015; Dowsett, 2007). Foraminifera boasts a high taxonomic diversity with a wide distribution throughout all marine, brackish, and infrequently freshwater environments (Rossbach et al., 2021; Siemensma et al., 2017). The foraminifera test consists of agglutinated and calcareous tests with single chamber (monothalamous) and multi-chamber (polythalamous) (Loeblich and Tappan, 1987 in Siemensma et al., 2017).

Planktonic foraminifera have contributed significantly to the fossil record of marine sediment and have been of

great ecologic, palaeoceanographic, and stratigraphic relevance since the Middle Cretaceous (Schiebel & Hemleben, 2005). In biostratigraphy, planktic foraminiferas offer crucial information (Schiebel & Hemleben, 2019), especially in identifying age and paleoenvironment (Fakhruddin & Kurniadi, 2019; Kurniasih et al., 2021), and employed since the 1960s to date marine sediments samples, during the Deep-Sea Drilling Program (DSDP) and the Ocean Drilling Program (ODP) (Schiebel & Hemleben, 2005). Biostratigraphy is concerned with identifying and organizing strata of rock based on their fossil content, intending to determine the age of rocks using fossils (Davies, 2022; Eide, 2005; Lucas, 2021).

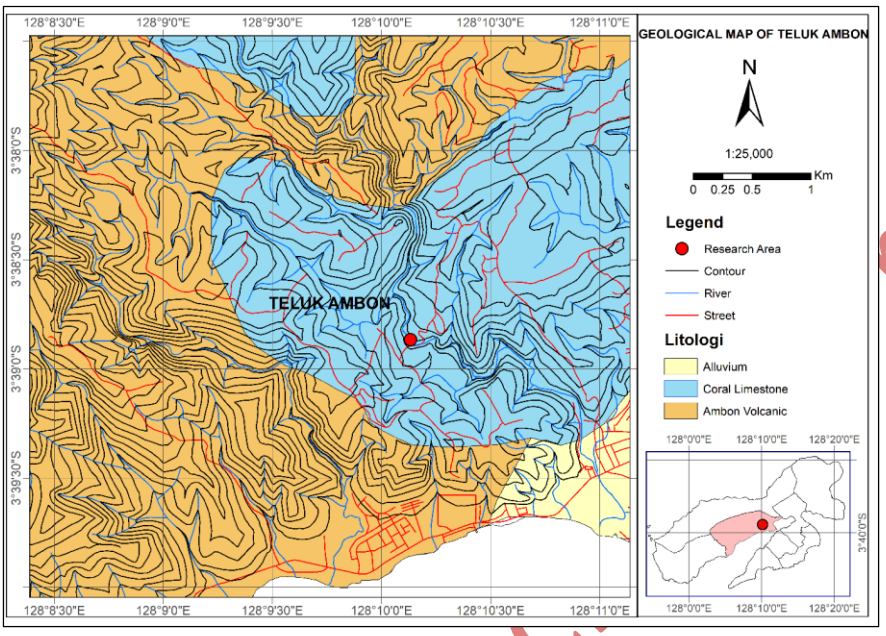

Fig 1. Regional geological map of Teluk Ambon area, Ambon City (modify from Tjokrosapoetro et. al., 1993).

Understanding the stratigraphic units that contribute to the reconstruction of Earth's history requires understanding the identification and characterization of bio-events. The biostratigraphical chronology of deep-sea sediments has been extensively ascertained by the use of many kinds of planktonic foraminifera (Margaritelli et al., 2022).

Many biostratigraphic studies have been carried out, such as the biostratigraphic of the Luth bed (Kurniasih et al., 2023), biostratigraphy analysis of Barbatos-1 exploration well in Tomori Block (Kurniasih et al., 2021), biostratigraphic analysis from well X in North Sumatera Basin (Syavitri et al., 2019), etc. Based on several previous researchers, shows that biostratigraphy using foraminifera proxies is an effective study in identifying the age. Therefore, this research has also used a biostratigraphic approach.

2. Materials and Method

Research area located in Negeri Rumah Tiga, Teluk Ambon District, Ambon City, Maluku, Indonesia with coordinates 03⁰ 38' 52" South Latitude and 128⁰ 10' 8" East Longitude (Figure 2). This research is divided into two stages, field observation and laboratory analysis. Field observations used the measure section method. This method allows detailed data collection including lithology data for each layer, sediment texture and structure, and contact between rock layers vertically and horizontally. Sampling was carried out in detail at each layer to prepare it for use in microfossil analysis. Nineteen sediment samples were taken in the limestone of Taeno Traverse, and the total thickness is 5.34 meters. Samples were taken randomly based on the thickness of each layer. If the layer is thick enough, three samples are taken at the bottom, middle, and top of each layer. The laboratory stage consists of two processes: sample preparation and planktonic foraminifera identification under microscope.

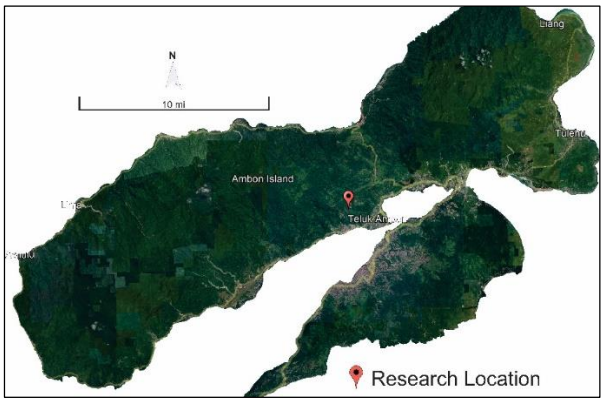

Fig 2. Research area in Taeno, Ambon City

2.1 Sample Preparation

The samples were prepared with an H_2O_2 solution and sieved to obtain clean samples. The preparation stages are as follows:

a. The dry sample is crushed to facilitate easy reaction with the chemical solution, weighed 100 grams, and then placed in a glass beaker for storage.
b. Every sample covered with a 30% H_2O_2 solution and allowed to stand for fifteen minutes, or until the gas bubbles disappeared indicating the reaction had ended.

c. The samples were cleaned with a mesh 60 while running water to remove the mud particles.
d. The used mesh is carefully cleaned to prevent contaminating with other samples.
e. The sample is put in an aluminum foil-covered cup and baked at 45⁰-60⁰C until completely dry.
f. Samples are kept in vials with labels.
g. The sample is prepared for picking, separating individual fossils from sediment debris. However, to get the best observation results, repeat steps b–e if the sample is still dirty when observing it.

2.2 Identification of Planktonic Foraminifera

The next step is to select each taxon from the sediment material and store it on a fossil plate. A Binocular Stereo microscope with a 40x magnification is used in this procedure. The semiquantitative methodology is applied. Each individual was recognized by the name of its species, and a calculation was made of its abundance. Identification of planktonic foraminifera fossils refers to Bolli et. al. (1985) and Postuma (1971). Foraminifera, both planktonic and benthonic, were found in approximately 300 individuals per sample. The collected data are displayed in a microfossil distribution diagram to understand biozonation and lithological age. Blow Zonation (1969) in (Bolli et al., 1985) used to determine the age. According to Blow Zonation (1969), the Paleogene (Paleocene-Oligocene) and Neogene (Miocene-Pleistocene) biozones comprised the two sections of the Cenozoic biozonation. Overall, the biozonation used in this work is based on that of Blow (1969), which identified 23 primary Neogene biozones with N1 to N23 notation and 22 primary Paleogene biozones with P1 to P22 notation.

3. Results

3.1 Lithology Data

The lithology of Taeno Traverse is made up of clastic limestone that ranges in size from silt to coarse sand (Figure 3). The track measures roughly 16.5 meters in length and 5.34 meters in thickness at the outcrop. The outcrop is brownish-colored, well-sorted, open-packed calcarenite limestone (Figure 4). Cross stratification, planar stratification, and dune geometry are examples of discernible sedimentary features. The upper layer has a position measurement (strike/dip) of N 38⁰E/17⁰, whereas the bottom layer is N27⁰E/20⁰.

3.2 Planktonic Foraminifera Data

Nineteen samples were observed under a stereo microscope to determine the composition and abundance of foraminifera fossils. All samples have an abundance of foraminifera, especially planktonic foraminifera. Planktonic foraminifera are classified into 30 taxa according to the results of the foraminifera determination. In practically every sample, *Globorotalia tumida tumida*, *Globorotalia menardii menardii*, *Pulleniatina obliquiloculata*, *Orbulina universa*, *Globigerinoides tenellus*, *Sphaerodinella dehiscens*, *Globigerinoides ruber*, and *Neogloboquadrina incompta* were the most prevalent planktonic foraminifera. Some examples of foraminifera species found in the research area are shown in Figure 5. The abundance of foraminifera also showed the paleoenvironmental condition. According to (Bhonsale & Saraswat, 2012; Jayan et al., 2021; Nishi et al., 2000, the abundance of foraminifera during the Quarternary such as *Globorotalia menardii* (Bhonsale & Saraswat, 2012; Nishi et al., 2000), *Globigerinoides ruber* (Jayan et al., 2021), relates to glacial-interglacial conditions.

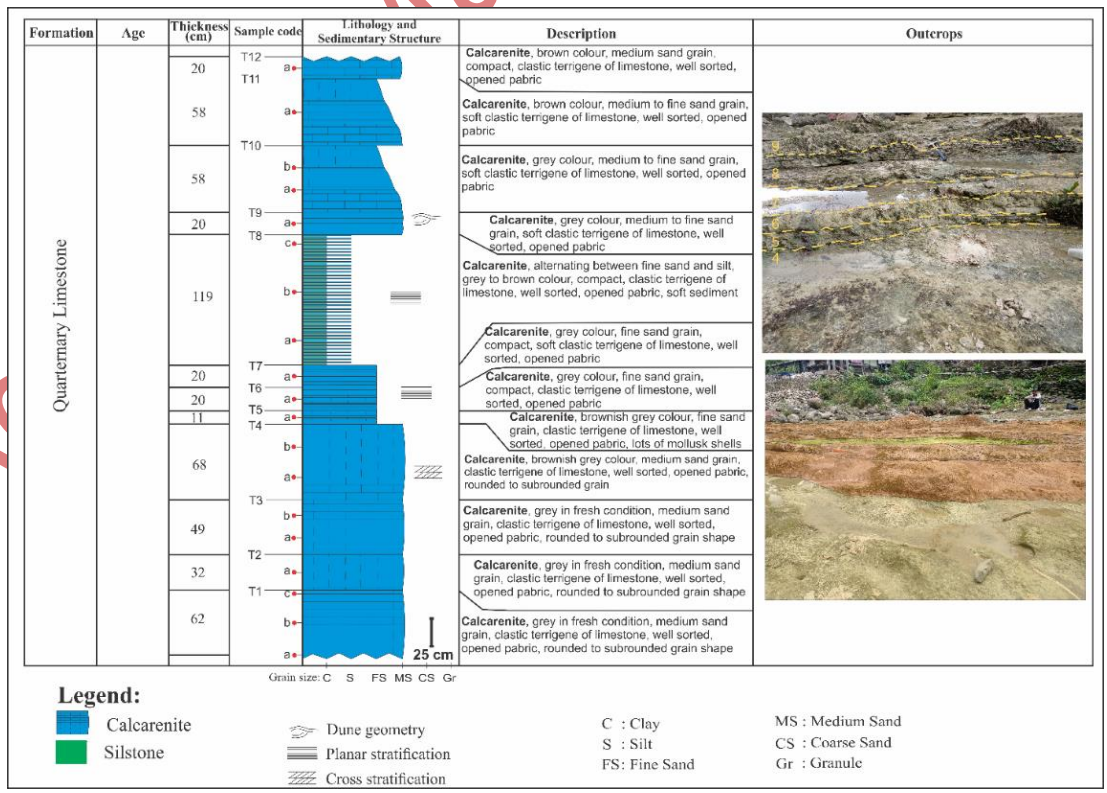

Fig 3. Stratigraphic columns and rock outcrops on the Taeno traverse

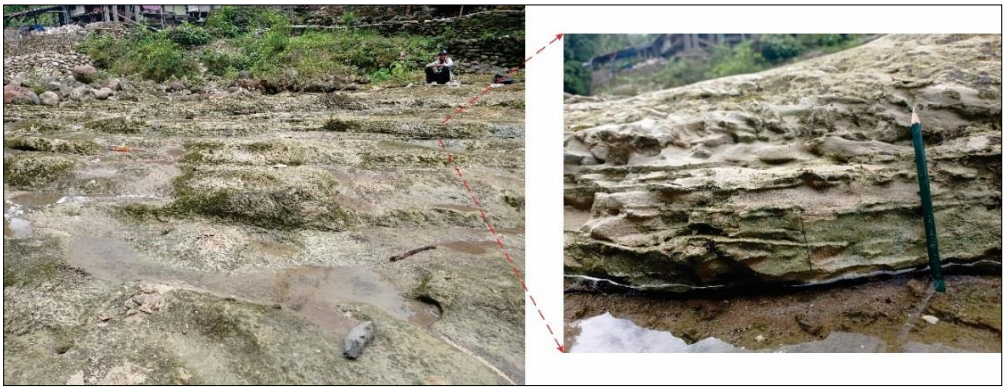

Fig 3 The Taeno Traverse exhibits outcrops of calcarenite limestone.

Fig 4. Numerous fossilized foraminifera were discovered in the research area (a) *Globorotalia pseudobulloides*, (b) *Neogloboquadrina impacta*, (c) *Beella digitata*, (d) *Globorotalia menardii menardii*, (e) *Globigerinella obesa*, (f) *Globigerinoides elongatus*, (g) *Globigerina sacculifera*, (h) *Sphaerodinellopsis seminulina*, (i) *Trilobatus quadrilobatus*, (j) *Globorotalia tumida tumida, (k) Globorotalia tosaensis tosaensis, (l) Globorotalia truncatulinoides truncatulinoides, (m) Globigerinella calida calida, (n) Sphaerodinella dehiscens, (o) Pulleniatina obliquiloculata, and (p) Globorotalia flexuosa.*

4. Discussion

4.1 Biostratigraphy of Planktonic Foraminifera

The results of the data identification of planktonic species served as the basis for the foraminifera biozonation in this study. Other than that, Blow Zone (1969) serves as the foundation for creating this biozonation. The acronyms FO (first occurrence) and LO (last occurrence) are used to describe withdrawal date limitations. According to the biodatum drawing results, the research region is part of the *Globorotalia truncatulinoides truncatulinoides* zone (Figure 6), which has an age range of N21–N23, equivalent to the Pleistocene age (Figure 6). *Globigerinella calida calida*, *Globorotalia crassaformis crassaformis*, and *Globorotalia tosaensis tosaensis* make up the sub-biozonation division.

a. Biozonation of *Globorotalia tosaensis tosaensis*
   The first occurrence of *Globorotalia tosaensis tosaensis* is what distinguishes this biozonation. Zone N21, in Blow Zone (1969), is the equivalent of this biozonation. Sample T1b, located in the middle of the first layer, was the first to be identified *Globorotalia tosaensis tosaensis* (Figure 6). Along with *Globigerinoides tennelus* and *Globorotalia truncatulinoides truncatulinoides*, *Globorotalia tosaensis tosaensis* was discovered to be present in this biozonation. Apart from that, *Globorotalia menardii menardii*, *Globorotalia*

tumida tumida, *Globigerinoides ruber*, and *Globigerinoides elongatus* were the species that were most frequently discovered in this lower layer.

b. Biozonation of *Globorotalia crassaformis crassaformis*
According to this biozonation, *Globorotalia crassaformis crassaformis* was initially the first occurrence. Based on Blow Zone (1969), this biozonation is comparable to Zone N22. Table 3 These taxa were first present in the fifth layer, sample T5-a (Figure 6). In addition to Globortalia crassaformis crassaformis, two further taxa were newly identified: *Globorotalia hirsuta* and *Globorotalia flexuosa*. *Orbulina universa*, *Sphaerodinella dehiscens*, *Globigerinoides ruber*, *Globorotalia menardii menardii*, *Globorotalia tumida tumida*, and *Globorotalia truncatulinoides truncatulinoides* are among the other species that are prevalent in this layer.

c. Biozonation of *Globigerinella calida calida*
This biozonation shows the presence of *Globigerinella calida calida*, equivalent to zone N23 based on Blow Zone (1969). This subzone is still classified as Pleistocene based on the subzone divisions found in Blow Zone (1969). The top layer of the research data, layer 12 (sample T12-a) (Figure 6), contains the determination of this subzone. *Trilobatus immaturus*, *Globoquadrina detertrei*, *Globorotalia ungulata*, and *Neogloboquadrina atlantica* are among the other taxa that are prevalent in that strata.

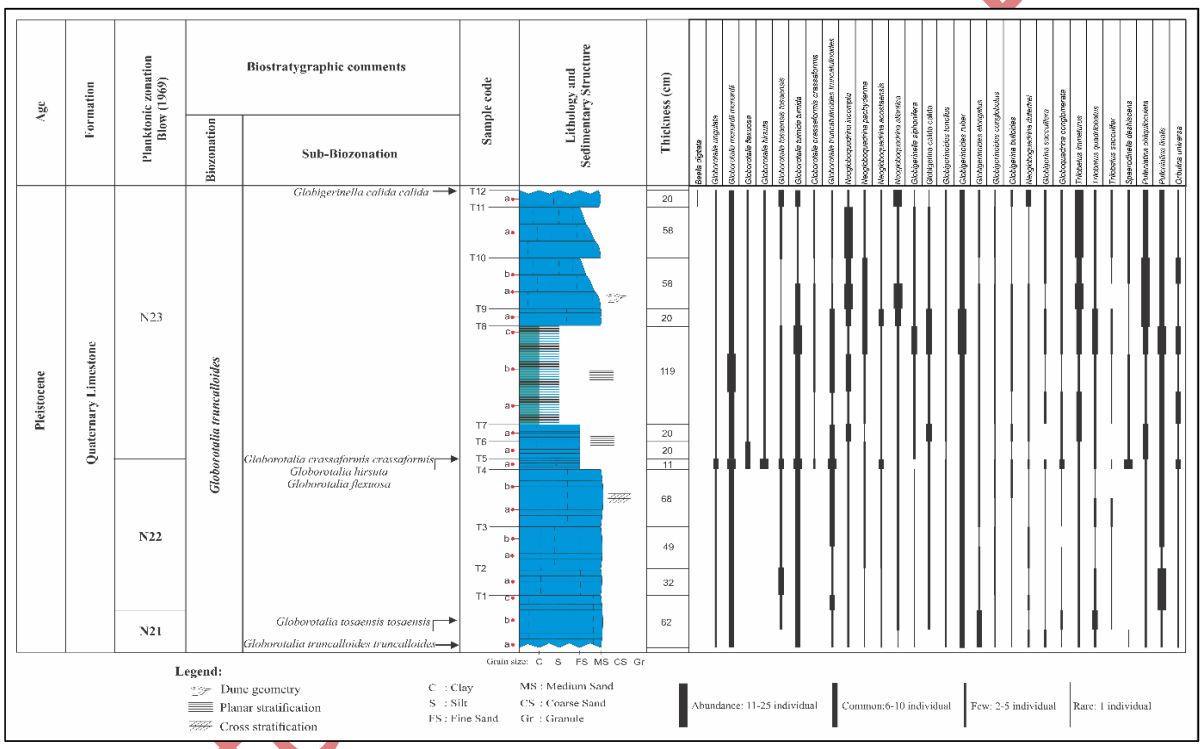

Fig 5. Biostratigraphic ranges of planktonic foraminifera taxa in Taeno Traverse, consisting of three biozonations, N21, N22, and N23, indicate Pleistocene age.

6. Conclusion

Based on the biostratigraphic analysis, the biozonation of planktonic foraminifera of Taeno Traverse consists of *Globorotalia truncatulinoides truncatulinoides.* The N21–N23 zone, which denotes the Pleistocene age, includes this biozone. The biozonation standards from Blow (1969) are applied in this biozonation. FO *Globorotalia tosaensis tosaensis* and FO *Globorotalia crassaformis crassaformis* make up the biodatum that is utilised. In addition, there are three sub-biozonations that make up this biozonation, *Globigerinella calida calida*, *Globorotalia crassaformis crassaformis*, and *Globorotalia tosaensis tosaensis*. The sub-zonations of Globorotalia tosaensis tosaensis represent the N21 (Early Pleistocene)., Globorotalia crassaformis crassaformis sub-zonation represents the N22 (Late Pleistocene), and the sub-zonation of *Globigerinella calida calida* represents N23 zones (Late Pleistocene). Based on the subzone divides discovered in Blow Zone (1969), Globigerinella calida calida subzone is still considered Pleistocene. These findings constitute the initial investigation of the Taeno limestone's biostratigraphy. Consequently, the age and zonation of planktonic foraminifera in the Taeno limestone are revealed by this study. The Pleistocene is the age of the Taeno limestone.

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