Palaeoloxodon naumanni and its environment at the paleolithic site of Lake Nojiri, Nagano Prefecture, Central Japan

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SUMMARY: Tategahana Paleolithic Site is one of the unique sites situated at the west shore of Lake Nojiri, on the northern highlands of Nagano Prefecture, Japan. The Pleistocene lacustrine sediments named as the Nojiri-ko Formation yielded abundant fossils of extinct large animals associated with Paleolithic implements. Most of the vertebrate fossils from the Nojiri-ko Formation are *Palaeoloxodon naumanni* and *Sinomegacerous yabei* remains. Some of them are incomplete and have evidence of artificial treatment. A bone cleaver, some refitted bone flakes and chips, rib bones of *Palaeoloxodon naumanni* and stone flake tools were found in the horizon of the Middle Nojiri-ko Member I. As a result of pollen analyses, the sediments in and around Lake Nojiri were divided into nine pollen zones. The Nojiri-ko Formation dates range from OIS 4 to OIS 2.

1. Excavation

The first excavation was conducted in March 1962 on the site. After that, several times of the excavations have been carried out by about ten thousand people, composed initially of non-specialists including students, teachers, laborers, farmers, and so on under the leadership of scientists. In the fourteenth excavation, in 2000, about 560 people participated and collected more than 2200 pieces of fossils and archeological remains, Molluscan fossils, insect fossils and sediment samples for micro-fossil study. Tategahana sites have yielded abundant fossils and the prehistoric materials, but beds containing numerous elephant fossil appear to be restricted in distribution.

More than 6700 m^2 of the main find horizon have been excavated so far.

2. Geologycal setting

2.1 Stratigraphy

Lake Nojiri situated at lat. 36°49' N and long. 138°12' E and at an altitude of 645m above the sea level, with a water depth of 38.5 m and a size of ca. 4.5 km^2.

It is surrounded by four Pleistocene strato-volcanoes, namely Mt. Madarao, Mt. Iizuna, Mt. Kurohime and Mt. Myoko. Tateganaha Site lies on the west shore of the Lake Nojiri.

The Upper Pleistocene series distributed in and around Lake Nojiri is composed of lacustrine sediments with intercalation of wide-spread volcanic ash layers and there are divided into four formations, Biwazima-oki peat Formation, Kannoki Formation Nojiri-ko Formation and J-retu Formation from bottom to top.

The lacustrine deposits in much of the Tategahana Site can be divided into three groups which in ascending order are Lower, Middle and Upper Nojiriko Formation. Further each group is sub-divided into three units I, II, III on the basis of its lithology.

Nojiri-ko Formation consists of 100 to 500 cm of well-stratified sands and sandy silt, but contains thin pyroclastic deposits. Some the Lower Nojiri-ko Formation has ripple marks indicating shallow water condition.

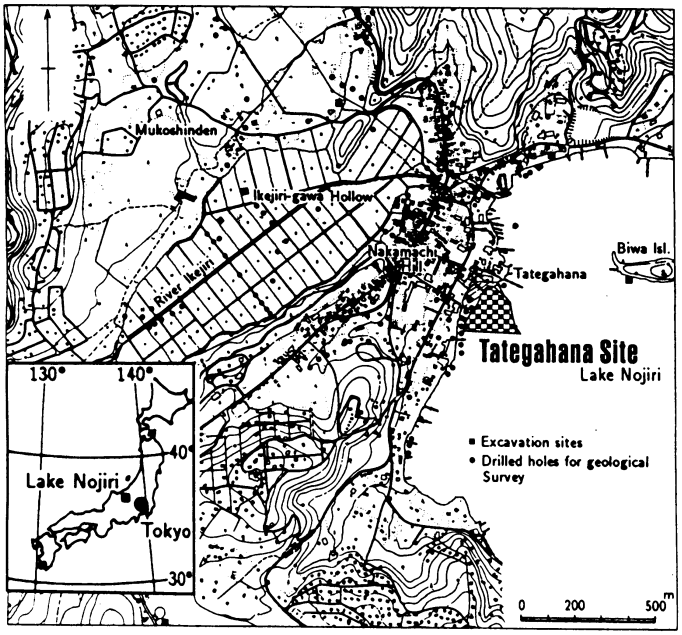


Fig.1 - Excavation sites around lake Nojiri.

2.2 Age

The age of Nojiri-ko Formation is bracketed between 11,000 and 49,000 years BP based on ^{14}C data. (Sawada *et al.* 1992, Nojiri-ko Excavation research Group 1993). The results are as follows:

J-retsu formation:
8000-11,000 BP

Upper Nojiri-ko Member II-III:
11,000-33,000 BP

Upper Nojiri-ko Member I:
33,000-39,000 BP

Middle Nojiri-ko Member:
39,000-41,000 BP

Lower Nojiri-ko Member III:
49,000-41,000 BP

Lower Nojiri-ko Member I-II:
49,000-53,000 BP

Kannoki Formations:
53,000-70,000 BP

The age of Kanaka Formation can be calculated using the sedimentation rates.

3. VERTEBRATE FOSSILS

3.1 Vertebrate taxa

The mammalian and avian fossils obtained from the Nojiri-ko Formation consisted of the following species *Palaeoloxodon naumanni, Sinomega-ceros yabei, Cervus* sp. cf. *C. nippon, Ursus arctos, Lepus* sp., *Microtus* sp., *Anser fabalis, Phalacrocorax* sp. cf. *carbo, Phasianus soemmerringii*. The majority of the vertebrate fossils are made up of two species. Fossils of *Palaeoloxodon naumanni* make 89.4% and *Sinomegaceros yabei* make 10.2% of total identified specimens.

Fossils of *Palaeoloxodon naumanni* and *Sinomegaceros yabei* have been obtained ranging from the lowermost part of the Lower Nojiri-ko Member III to the Upper Nojiri-ko Member I. Most fossils of rare species were found from the Middle Nojiri-ko Member. Fifty nine percent of the vertebrate fossils have been obtained from the upper part of the Lower Nojiri-ko Member III, although most of them were bone fragment. No articulated bones were

found from the Nojiri-ko Formation. Bones from the Nojiri-ko Formation were mostly incomplete and found with some concentrations in every part of the excavated area (Ono, 2001).

3.2 The mode of occurrence of the Middle Nojiri-ko Member I

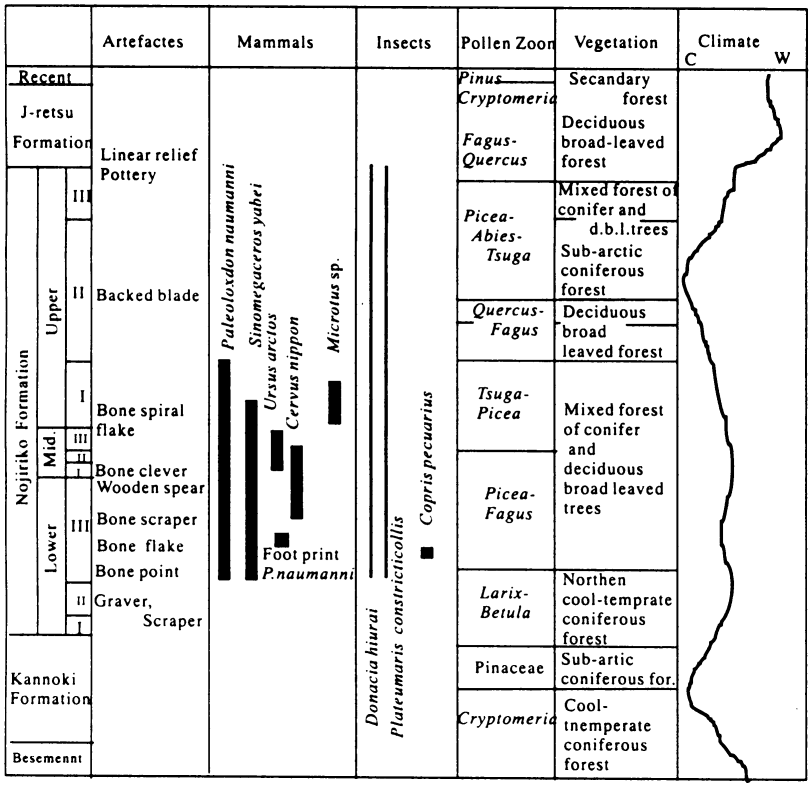
Three clusters or concentrations of bones of *Palaeoloxodon naumanni* associated with artifact are recognized in the excavated area of the Middle Nojiri-ko Member I. The skull cluster area yielded an incomplete skull, including fragments of skull, an upper M3, a radius, a wooden remain, and a boulder. The rib cluster area yielded 23 ribs (almost belong to a same individual), vertebrae, a stylohyoid, a bone cleaver, some refitted bone flakes and a bone flake core. The forelimb cluster area yielded a scapula, an ulna, carpals and metacarpals (almost belong to a same individual). It is probable that fossil assemblages of skull, ribs, and forelimbs in the range of 40 m square belong to the same individual. The arrangement of fossil assemblages is almost parallel to the recent shoreline (NE-SW) and it is presumed that the shoreline of that age coincides with the recent shoreline.

Mammalian bones and fragments should have been scattered by hydro-dynamic transport to some extent.

Lithic tool and flakes have been excavated with bone materials from Nojiri-ko Formation. In the Middle Nojiri-ko Member I, a bone cleaver, flake and chips were also found at the concentration.

Archaeological contexts suggest that the place once functioned as kill-butchering site. (Nojiri-ko Excavation Research Group, 1994; Ono, 2001).

Tab.1 - Synthetic diagram on the results by Nojiri-Ko Excavation. Adapted From Nojiri-Ko Excavation Research Group,1994.



3.3 Age profile for Palaeoloxodon naumanni

A total of 66 molars (upper 31, lower 35) were available for age determination. Laws (1966) method was applied to those fossil molars. Estimated ages were presented in African elephant years (AEY) after Haynes (1991). The result is as follows; 0-12 AEY, 4.5%; 13-24 AEY, 17%; 25-36AEY, 39%; 37-48AEY, 10.5%, 49-60 AEY, 29%. The prime-age adults pre-dominate, seniles come to the second and calves and juveniles are conspicuously rare. This resulted from time-averaged selective mortality.

3.4 Morphological features of Palaeoloxodon naumanni

The cranium of *Palaeoloxodon naumanni* has a moderately raised parieto-frontal crest and considerably inclined incisive alveoli, which are characteristic of the genus *Palaeoloxodon* (Inuzuka 1977). The stylohyoid bone has a distinct but stout process at the dorsal border of the base of the posterior ramus (Inuzuka *et al.* 1975). It is the unique character to *P. naumanni*. The tusks are considerably strong curved and twisted in males, not straight as in *P. antiquus*.

The longest tusk was 2.4 m in length.

According to Takahashi *et al.* (1991), the characteristic features of upper M3 are: dental lamella formula 18 1/2 1/2 20; width of tooth crown, mean 82.7 mm, observed range (OR) 68-93 mm, SD 7.34; enamel thickness, mean 2.61 mm, OR 1.6-3.1 mm SD 0.29; lamella frequency, mean 6.2, OR 5-8, SD 0.58. the lower M3 1/2 19; width of tooth crown, mean 77.9 mm, OR 58-96 mom's 10.37; enamel thickness, mean 2.73 mm, OR 1.8-3.5 mm SD 0.43; lamella frequency, mean 5.2, OR 4-7, SD 0.80. The molars of Nojiri-ko specimens are larger than the specimens from other localities such as Seto Inland Sea. The loxodont sinus is developed in lower molars, but not so developed in upper molars.

The shoulder height of *P. naumanni* from Lake Nojiri estimated upon femur length is 2.7 to 2.8 m. Including other localities in Japan, shoulder height is estimated to be 2.4- 2.8 m (male) and 1.9 m (female).

4. Paleoenvironment

The sediment sequences are characterized by cool-temperate element. The fossil assemblages of pollen and macroscopic remains from the Nojiri-ko Formation are composed mainly of elements of the subarctic coniferous forest tree.

The pollen found in the Nojiri-ko formation showed a great variety. Dominant conifers are *Picea, Tsuga, Abies* and *Haploxyon*, deciduous broad-leafed tree *Juglans, Betula, Alnus, Fagus, Quercus, Ulmus*. Seeds and cones of *Pinus koraiensis, Larix leptolepis, Tsuga diversifolia, Cornus controversa* and *Juglans sieboldiana* are also found in the Nojiri-ko formation.

The sediments distributed in and around Lake Nojiri are divided pollen stratigraphically into nine zones. (Palynological Research Group for Nojiri-ko Excavation 1993). From this Group, extremely cold climate was recognized at two horizons. The lower horizon is Kannoki Formation and corresponds to oxygen isotope stage 4.

The upper horizon is the upper part of the Upper Nojiriko Member II and the lower part of the Upper Nojiri-ko Member II, and corresponds to the oxygen isotope stage 2 The vertebrate fossil and artificial material horizon are correlative with oxygen isotope stage 3.

Molluscan fossils of the Nojiri-ko Formation are *Inversidens japanensis*, *Anodonta* sp., *Semisulcospira* sp.

Insect fossils such as *Copris pecuarius* were found from the Nojiri-ko Formation, suggesting continuous inhabitation of herbivorous animals of medium to large size.

Many foot prints of *Palaeoloxodon naumanni* and *Sinomegacerous yabei* were found from the Nojiri-ko Formation.

These fossils indicates that Tategahana site was on the shoreline of paleo-Lake Nojiri, close to the forest.

5. Conclusion

Data from the mode of occurrence and the age profile for *Palaeoloxodon naumanni*, as well as paleoenvironment data, indicate that Tate-

gahana Sits is kill-butchering site. The horizon of the vertebrate fossil and artificial material was restricted to oxygen isotope stage 3.

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