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Geology and quaternary environments of the Tategahana Paleolithic site in Nojiri-ko (Lake Nojiri), Nagano, central Japan

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ABSTRACT

Excavation of the Tategahana Paleolithic site at Nojiri-ko (Lake Nojiri), central Japan, began in 1962, and the 21st excavation was performed in 2014. The Upper Pleistocene to Holocene fluvio-lacustrine Nojiri-ko Formation is distributed in and around Nojiri-ko. Fossils such as those of Naumann's elephant (*Palaeoloxodon naumanni*) and Yabe's giant deer (*Sinomegaceros yabei*), representing the ice age in Japan, have been excavated there in large quantities; at least 46 Naumann's elephants have been found. The fossils have been excavated in strata dating to 37.9–60.4 ka, comparable to MIS 3. Analysis of fossil pollen assemblages indicates that the vegetation at the time was a mixture of coniferous and broad-leaved trees. Bone instruments and spiral flakes made from elephant and deer bones, and stone tools created from stone, not found in the peripheral region, have been excavated from the Nojiri-ko Formation, and concentrated clusters of different types of fossilized elephant bones have been found.

The top horizon containing elephant remains is 37.9 ka old, and thus older than MIS 2 (the Last Glacial Maximum), making it unlikely that Naumann's elephant disappeared from Nojiri-ko only because of climatic cooling. Findings strongly suggest that the occurrence of these large mammal fossils is the result of human activity. The Tategahana Paleolithic site provides important insights into the transitional phase from Asian Paleanthropine to *Homo sapiens* in Japan.

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1. Introduction

Nojiri-ko (Lake Nojiri) is located in the northern part of the Fossa Magna region of central Japan (36°49'N, 138°13'E). The water level of Nojiri-ko is at an altitude of 657 m above sea level, with the deepest point at 38.5 m, and it covers an area of 4.5 km². Nojiri-ko is the second-largest lake in the Nagano Prefecture. The Myoko, Kurohime, and Iizuna volcanoes are situated to the west and the Madarao volcano to the east of Nojiri-ko.

In 1948, the owner of a lakeside inn found a fossil molar of a Naumann's elephant (*Palaeoloxodon naumanni*) on the western shore of Nojiri-ko. At that time, the stratigraphic horizon of the fossil was unclear. The first Nojiri-ko excavation was performed in March 1962 at the site where the molar was found in order to fix the stratigraphic horizon of the fossil. Lacustrine sediments are

distributed on the bottom and around the lake, grading laterally into terrestrial sediments consisting chiefly of volcanic ash. Subsequent excavations and geological surveys revealed that the lacustrine sediments of Nojiri-ko and its surrounding area bear fossils and belong to a late Pleistocene series, now named the Nojiri-ko Formation. More than 20 fossils were collected during the first excavation, including the femur of a Naumann's elephant and the upper jaw of a Yabe's giant deer (*Sinomegaceros yabei*).

In the third excavation, conducted in 1964, two stone flakes were found, which drew the researchers' attention toward the relationship between Paleolithic humans, the Naumann's elephant and the giant deer. The fifth excavation was conducted in March 1973, involving 1100 participants from across Japan. A research body was organized under the name of the Nojiri-ko Excavation Research Group, composed of both specialists and non-specialists and including members of the public such as primary school children, university students, teachers, and housewives. This excavation yielded artifacts such as retouched bone flakes and tools, together with many fossils. Bones of Naumann's elephant and giant deer were often found *en masse* (Nojiriko Excavation Research

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Group, 1975). From the sixth excavation (1975) to the ninth Fossil Mammal Research Group for Nojiri-ko Excavation (1984), a large number of elephant fossils were found on the lake floor 30 m from the current shoreline. During this time, advances made in the study of pollen, plant, and diatom fossils and entomolites enabled researchers to visualize in high resolution the transition of the paleo-environment of the site.

Currently the Nojiri-ko Excavation Research Group biannually carries out excavations at the western shore of Nojiri-ko, called the Tategahana Paleolithic site, with the aim of investigating the relationship between the paleo-environment and Paleolithic humans (Nojiriko Excavation Research Group, 1997, 2011). Since 1997, a major aim has been to unearth evidence of a possible kill-butcher site. In the 20th excavation, conducted in 2014, which involved about 200 people, more than 750 pieces of fossils and archaeological remains were discovered and sediment samples for microfossil study were collected.

2. Geology

2.1. Lake Nojiri-ko and surrounding areas

The area around Nojiri-ko is underlain chiefly by Miocene to Lower Pleistocene sediments such as marine and fluvial deposits, volcanic rocks, and intrusive rocks; Quaternary volcanic products from the Madarao, Iizuna, Kurohime, and Myoko volcanoes; and Lower Pleistocene to Holocene sediments such as alluvial fan deposits, debris flow deposits, and lake and fluvial deposits (Fig. 1).

The Tategahana excavation site (Fig. 2) and surrounding areas such as the central part of Nojiri-ko, including the NJ88 Drilling Site, Ikejirigawa Lowland, and Nakamachi Hill, are in ascending order underlain by basement layers (debris flow deposits and volcanic rocks of the Middle to Late Pleistocene), the Biwajima-oki

Formation (massive peaty silt belonging to the Late Pleistocene), the Ikejirigawa debris avalanche deposit (Late Pleistocene), and the Nojiri-ko Formation (lacustrine deposits belonging to the Late Pleistocene to Holocene) (Fig. 2). Many tephra beds are intercalated with the Biwajima-oki and Nojiri-ko formations and have been employed as a key to determine detailed stratigraphies (Geology Research Group for Nojiri-ko Excavation, 1980, 1984a; 1984b, 1990). Many tephra beds in these formations are derived from the Kurohime and Myoko volcanoes (Geology Research Group for Nojiri-ko Excavation, 1984b) (Fig. 1).

The Kamiyama and Nojiri Loam formations (an eolian deposit and heterotopic facies respectively contemporaneous with the Biwajima-oki and Nojiri-ko formations) are distributed on the tops and slopes of the hills around Nojiri-ko (Fig. 2).

2.2. Lithostratigraphy and age of the Nojiri-ko formation

The Nojiri-ko Formation, which at the Tategahana excavation site consists of lacustrine deposits, is in ascending order divided on the basis of its lithofacies into the Kannoki Silt Member, the Umibata Sand and Silt Member, the Tategahana Sand Member, and the Fuyoko Sand and Silt Member (Geology Research Group for Nojiri-ko Excavation, 2004) (Fig. 2). Each member is subdivided into two to seven units on the basis of its lithofacies. The Kannoki Silt Member is divided into K1 and K2, the Umibata Sand and Silt Member into U1 to U3, the Tategahana Sand Member into T1 to T7, and the Fuyoko Sand and Silt Member into F1 to F4. Units U2 to T7 in the Nojiri-ko Formation bear many fossils, including those of Naumann's elephant and Yabe's giant deer (Kondo et al., 2007).

The depositional age of each of the members of the Nojiri-ko Formation has been estimated by using seven time-marker tephra beds (Kuronaka: K-Ah; Nuka I: AT; BW1466: TKN0301; Kigoma: DKP; Kibiokoshi: Tt-E; Togenuka: Aso-4; and Kotsubu-bio:

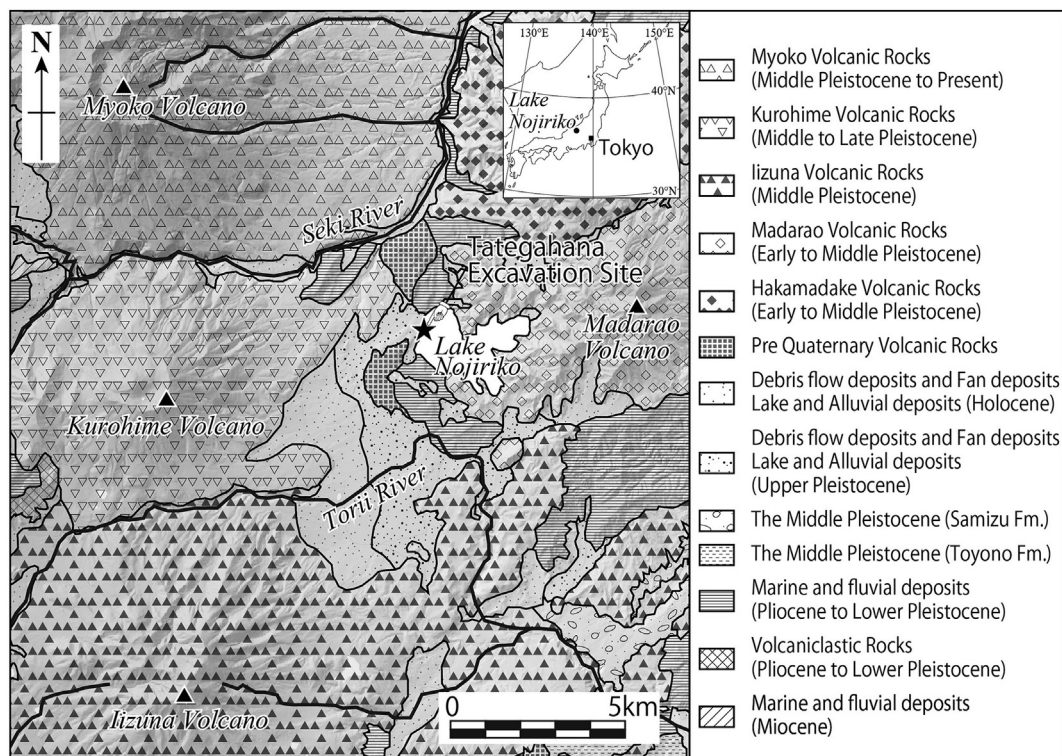


Fig. 1. Geological map of the area surrounding Lake Nojiri-ko. Modified from Sakai et al. (1996).

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