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Occurrence of a suid mandible from the Pliocene Ueno Formation, Mie Prefecture, central Japan

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三重県の鮮新統上野累層からイノシシ科下顎骨化石の産出

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抄録：三重県伊賀市平田の足跡化石発掘調査地で調査終了の約4年後にイノシシ類の下顎骨化石が発見された．この化石は，この調査地から知られる唯一の哺乳類の化石骨である．この下顎骨は調査地の堆積物のうちB層から産出したもので，この層は古琵琶湖層群上野累層の上部にあたり，古地磁気法による年代尺度の入った古琵琶湖層群の標準層序と火山灰層を用いて対比することでき，その年代は約3.6 Maである．この下顎骨では左右の下顎体が保存され，それらは前方の下顎結合部でつながっていて，それぞれに3個の大臼歯が植立している．左右の下顎体は埋没後の垂直方向の圧力によって，それぞれが舌側に傾いている．下顎骨とそこに植立する臼歯の形態はイノシシ（*Sus scrofa*）の現生標本と似ているが，M_3が小さく単純なことなどの相違点も見られる．この下顎骨は，おそらくイノシシ亜科のイノシシ族，またはカワイノシシ族に属するものと思われる．

Abstract: A suid mandible was discovered from the excavation site for fossil footprints on the northern bank of the Hattori River at Hirata, Iga, Mie Prefecture, about four years after the finish of the excavation. It records the only mammal bone known from the site. The mandible occurred from Bed B in the sediments of the site which are included in the upper part of the Ueno Formation of the Kobiwako Group. This bed is correlative with the paleomagnetically-dated standard sequence of the group, and is dated to about 3.6 Ma. The mandible comprises left and right horizontal rami which are united anteriorly at the symphysis. Both of the rami have three molars, and are tilted lingually by post-burial vertical stress. The morphology of the mandible and molars is similar to that of the living specimens of the wild boar (*Sus scrofa*), but is also different in smaller and simpler M_3 and so on. The mandible probably belongs to the tribe Suini or Potamochoerini of the subfamily Suinae.

Key Words: Suidae; Mandible; Pliocene; Ueno Formation; Kobiwako Group; Japan.

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Mud and sand beds constituting the Ueno Formation of the Kobiwako Group are exposed on the riverbed of the Hattori River running from east to west through the eastern part of the Iga Basin, Mie Prefecture. The formation is of lacustrine origin, and of Pliocene age. In 1993, fossil footprints were found on the riverbed eroded by a rising of the water level by a heavy rainfall of a typhoon. In the next year, a research group was organized for excavating the footprints and for geological and paleontological studies related (Kumai, 1996). From August to November of the same year, the group excavated the northern bank of the Hattori River just downstream of Nakajima Dam at Hirata, Iga (Fig. 1). The excavation resulted in recognizing several footprint-bearing levels in sand and mud beds with a total thickness of only 1 m (Hashimoto, 1996). Among the levels, two were thoroughly excavated, and were called the first and second excavation surfaces in descending order. Many footprints of a proboscidean and crocodilian were found on these surfaces (Taruno, 1996a; Kamiya, 1996). The second excavation surface was left intact, after the excavation was finished. In addition to the fossil footprints, many fossils including molluscan shells, teeth of freshwater fishes and bones of a turtle were obtained (Matsuoka et al., 1996; Nakajima, 1996; Taruno, 1996b), but neither mammal bones nor teeth were found by the excavation.

In 1998, Mr. and Mrs. Ninomiya visited the excavation site of 1994, and discovered a mandible with teeth partly exposed on the second excavation surface which was weathered and somewhat eroded at that time. They dug it out from sediments, and preserved it in their home. In 1999, two of us (Matsuhashi and Kawamura) visited their home, observed the mandible, and were convinced that it belonged to the pig family (Suidae). It records the first occurrence of mammals from the site.

This mandible is important for understanding the Pliocene mammal fauna of Japan as well as morphological characters of Pliocene suids there, because mammal fossils are sparse, and suid fossils are especially rare in the Pliocene of Japan. The importance is also indicated by its occurrence from the well-dated sediments of the excavation site.

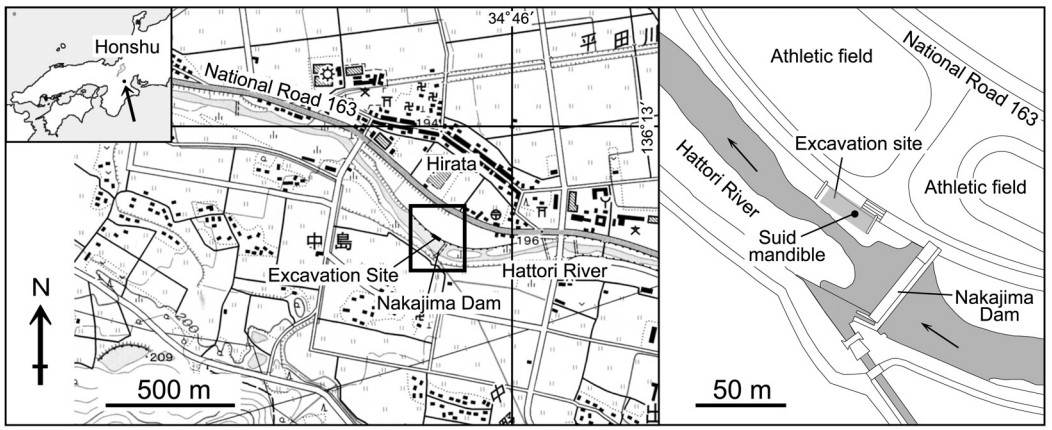

Fig. 1. Map showing the location of the excavation site for fossil footprints in 1994, and the exact position of the suid mandible discovered. The scale 1: 25,000 map sheet "Ueno" published by the Geographical Survey Instutute is used for the left map.

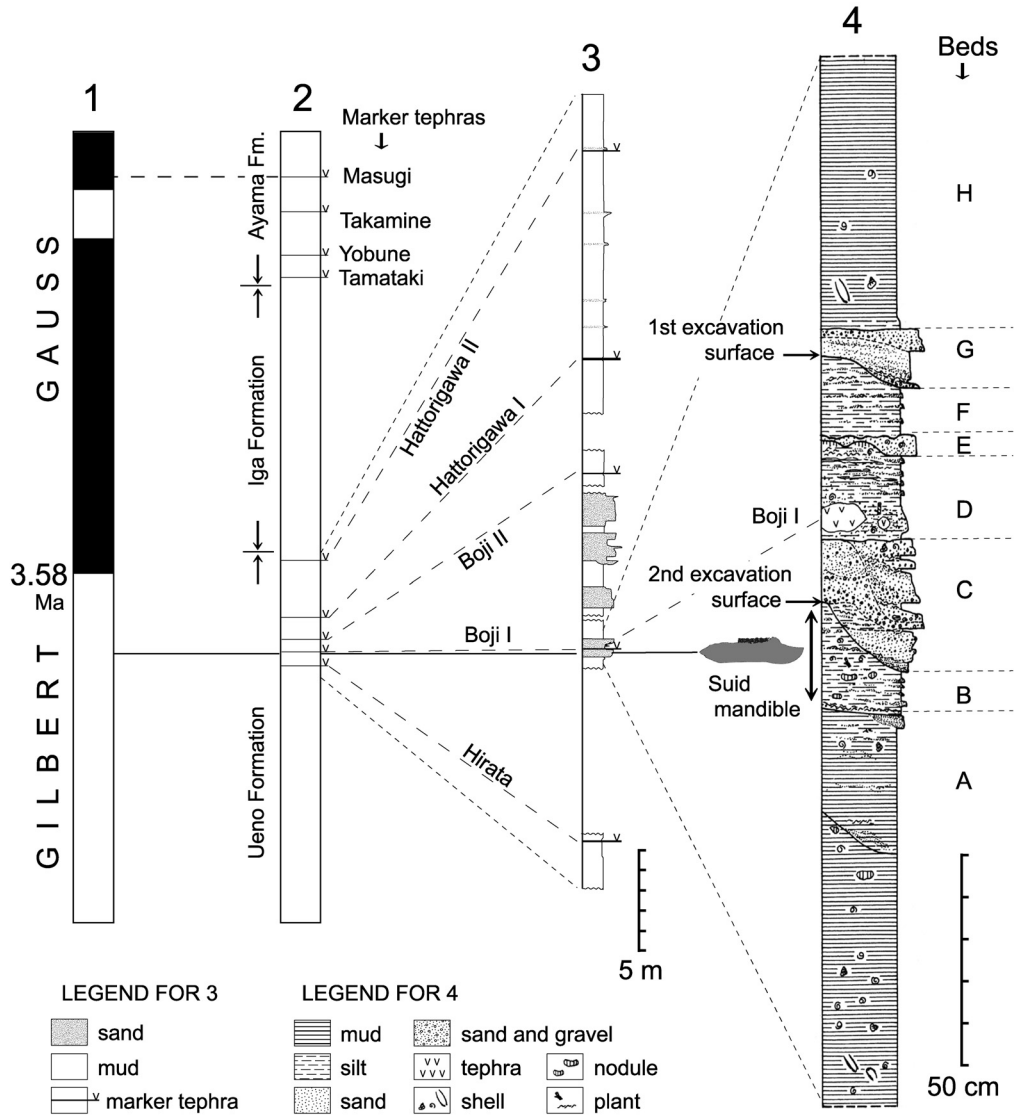

Fig 2. Stratigraphic and chronological positions of the suid mandible. 1,2: Paleomagnetic polarity and generalized columnar section of the lower part of the Kobiwako Group modified from Yoshikawa and Yamasaki (1998), 3: Columnar section of the Ueno Formation of the group along the Hattori River, modified from Hashimoto (1996), 4: Detailed column of the sediments at the excavation site for fossil footprints after Hashimoto (1996), showing the horizon of the suid mandible.

Taking the importance of the mandible into consideration, we describe its stratigraphic setting, chronological position, storage, state of preservation and morphological characters with taxonomic comments herein, but its systematic description will be given in a separate paper. Additionally, Matsuhashi (2009) outlines a history of the research since its discovery.

I. Stratigraphy and Chronology

Kawabe (1989) presented a detailed description of the stratigraphy of the Kobiwako Group in and around the Iga Basin. He recognized many marker tephras in the section along the Hattori River. Among them, the Hirata, Boji (Booji) I, Boji (Booji) II, Hattorigawa I and Hattorigawa II Volcanic Ash Layers are intercalated in the upper part of the Ueno Formation of the group (2 and 3 in Fig. 2).

Hashimoto (1996) described the stratigraphic sequence of the sediments exposed at the excavation site, and divided the sediments into eight beds (Beds A to H in ascending order; 4 in Fig. 2). Among them, Bed D intercalates the Boji I Volcanic Ash Layer. Hashimoto (1996) designated the first and second excavation surfaces as the boundery between Beds F and G and that between Beds B and C, respectively. As mentioned above, the mandible was found on the weathered and somewhat eroded second excavation surface, and its main part was buried in the sediments underneath. Thus the mandible was undoubtedly embeded in Bed B. According to Hashimoto (1996), Bed B is 10 to 25 cm in thickness, and consists of interbedding of thin layers of fine sand and bluish grey silt. Such lithofacies is well coincident with the sediments adhering to the mandible. This also supports its occurrence from Bed B.

The sediments of the excavation site can be correlated with the paleomagnetically-dated standard sequence of the Kobiwako Goup (1 and 2 in Fig. 2) using marker tephras. Yoshikawa and Yamasaki (1998) placed the boundary between the Gauss and Gilbert Chrons at a horizon between the Hattorigawa I and II Volcanic Ash Layers. Beds B just below the Boji I Volcanic Ash Layer is placed about 14 m below the Hattorigawa I Volcanic Ash Layer. Thus Bed B is somewhat earlier than the Gauss / Gilbert boundary, which is dated to 3.58 Ma (Cande and Kent, 1995). On the other hand, Uchiyama (1996) stated that the sediments of the excavation site were probably correlated with the Gauss / Gilbert boundary on the basis of his own paleomagnetic measurements. At any rate, the age of Bed B is considered to be about 3.6 Ma (Fig. 2).

II. Storage and state of preservation

The mandible is now stored in the private exhibition room of Mrs. C. Ninomiya's home (3-1911 Agatagaoka, Yokkaichi, Mie Prefecture). Its plastic casts were made for our research, and are stored in the Osaka Museum of Natural History, in the Department of Earth Sciences, Aichi University of Education, and as a private collection of Y. Matsuhashi, respectively (Matsuhashi, 2009).

The mandible comprises left and right horizontal rami which are united anteriorly at the symphysis (Fig. 3). The anterior part of the symphysis is lost. Both of the ascending rami are also lost. The horizontal rami bear three molars each (M_1 to M_3). Among the molars, the anterior half

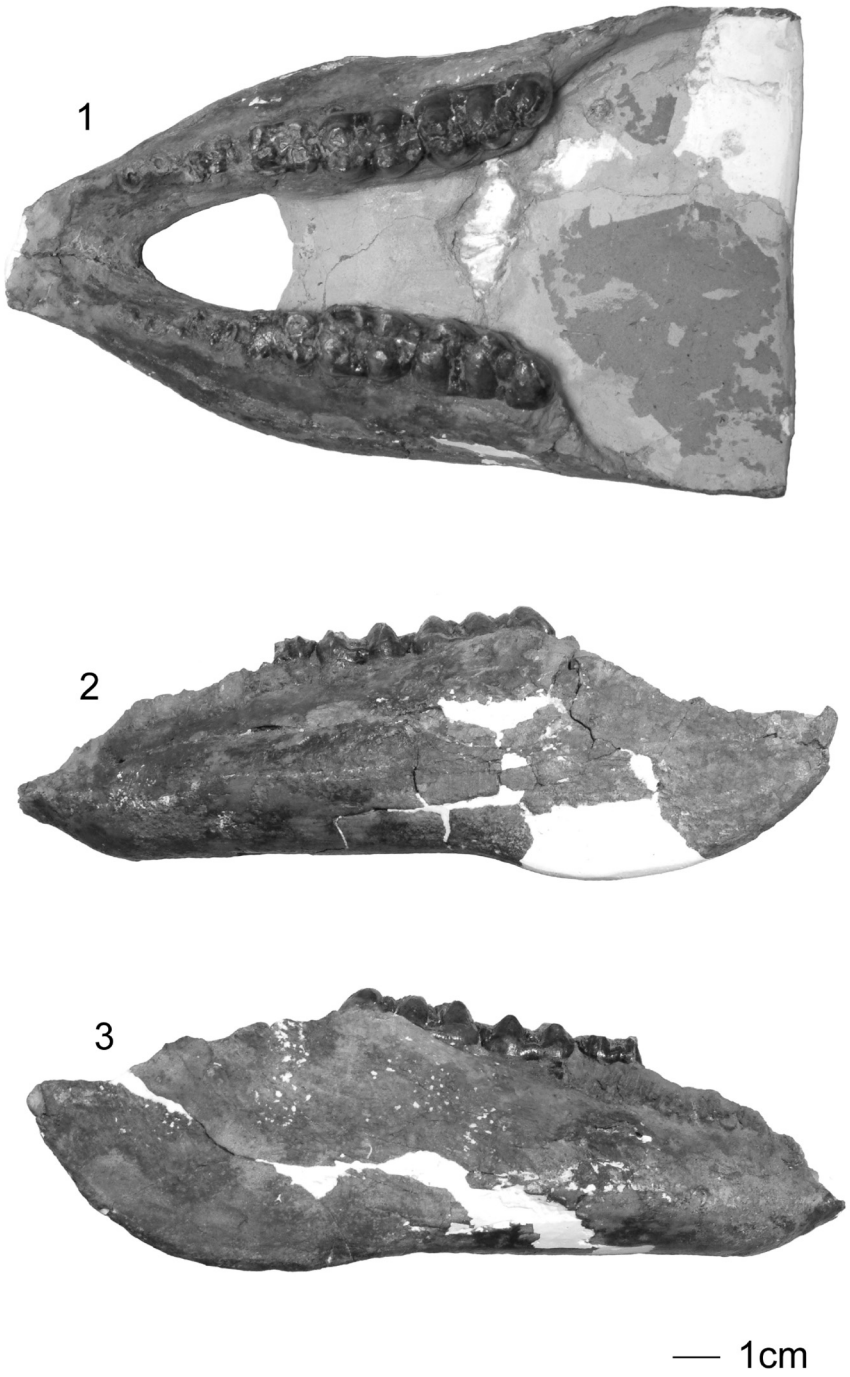

Fig. 3. Suid mandible, probably assingned to the tribe Suini or Potamochoerini of the subfamily Suinae.
1: Dorsal view
2: Buccal view of the left horizontal ramus
3: Buccal view of the right horizontal ramus

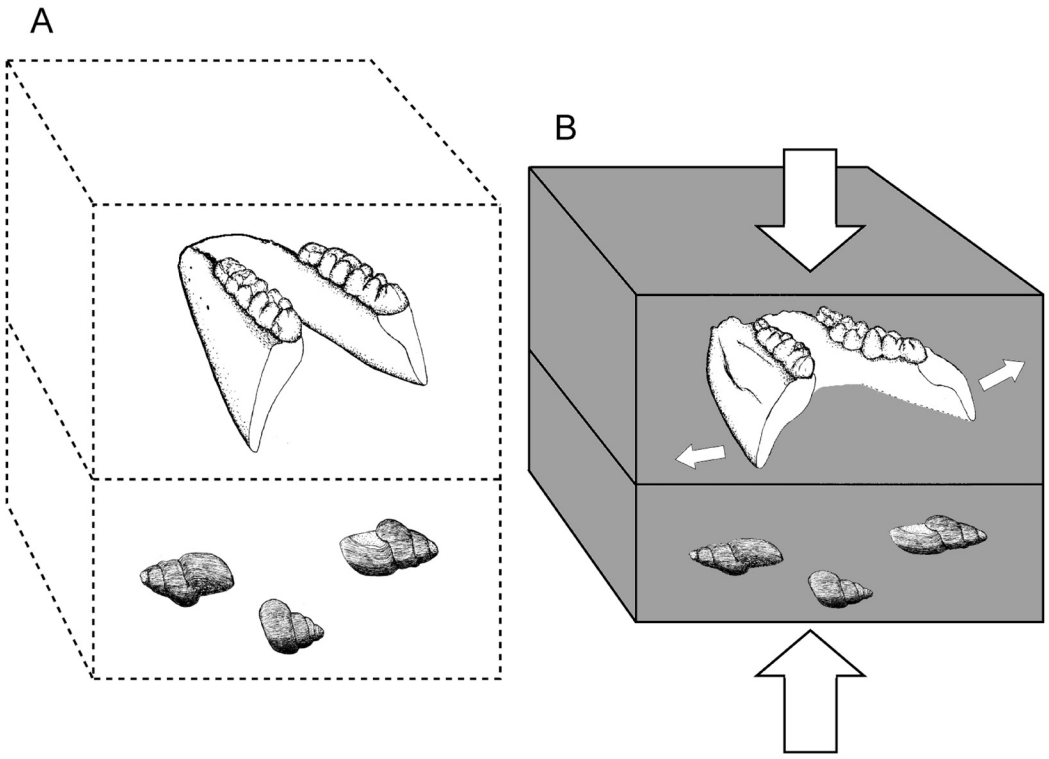

Fig. 4. Schematic diagram showing the post-burial deformation of the mandible and molluscan shells in the sediments by vertical stress. A: original state, B: deformation by the stress.

of left M_1 and the anterior end of right M_1 are lost, while M_2 and M_3 are well preserved. The horizontal rami and molars are brown and black in color, respectively.

The central to posterior parts of the horizontal rami are tilted lingually at the angles of 20° to 30° by post-burial vertical stress (Fig. 4). Molluscan shells in the sediments of the excavation site are mostly deformed probably by the same stress. Owing to such deformation, the rami look thick in dorsal view (Fig. 3), but in fact they are not thicker than those of the living specimens of the wild boar (*Sus scrofa*) from Honshu.

III. Morphology and taxonomic comments

The morphology of the mandible and molars is generally similar to that of the living specimens of the wild boar. Their sizes also fall within the range of variation recognized in the living specimens. The molars on the mandible have lingual main cusps higher than buccal ones. This feature is also recognized in those of the living specimens. The enamel thickness observed on the well-abraded occlusal surfaces of M_1 on the mandible is nearly the same as that of the living specimens. But the following differences are also observed between them: The size of M_2 relative to M_1 and M_3 is larger than that of the living specimens. The talonid of M_3 is smaller and simpler than that

of the living specimens, and comprises a small anterocentral cusp and a large posterior main cusp.

Pickford (1988a, 1993) provided a subfamiliar taxonomy of the Suidae. Recently Harris and Liu (2007) revised the taxonomy and proposed a different scheme with diagnostic characters of each subfamily. They recognized a primitive genus group without subfamiliar determination, Listriodontinae, Kubanochoerinae, Tetraconodontinae, Namachoerinae, Cainochoerinae, Schizochoerinae and Suinae. Among them, we tentatively exclude the primitive genus group, Listriodontinae, Kubanochoerinae, Namochoerinae and Schizochoerinae from the present discussion, because of their earlier geological ages (Miocene and / or earlier). Among the remaining subfamily, Tetraconodontinae has thick enamel in its molars, and very large P_4 (Pickford, 1988a; Harris and Liu, 2007). In the molars of the present mandible, the enamel is thinner and nearly as thick as that of the living wild boar specimens, and P_4 is probably smaller judging from the size of the alveolar sockets on the mandible. Cainochoerinae has no diastema and four main cusps in M_3 (Pickford, 1988b; Harris and Liu, 2007), but the present mandible seems to have a diastema on each side judging from the preserved part of the symphysis, and five main cusps in M_3. The remaining subfamily, Suinae, bears the mandibular and dental morphology well coincident with that of the present mandible, and thus it is probably allocated to this subfamily. This allocation is also suggested by its similarity to the wild boar, a representative species of this subfamily, as mentioned above.

McKenna and Bell (1997) revised the tribal taxonomy of Suinae, and recognized five tribes such as Suini, Potamochoerini, Hippohyini, Phacochoerini and Babyrousini. Among them, Hippohyini and Phacochoerini seem to have more hypsodont molars than those of the present mandible judging from the description of Pickford (1988a). The monogeneric tribe Babyrousini differs from the mandible in having longer diastema and smaller M_2. Consequently, the mandible probably belongs to Suini or Potamochoerini. In China, two genera of Suini ("*Dicoryphochoerus*" and *Sus*) and two genera of Potamochoerini (*Propotamochoerus* and *Potamochoerus*) have been recorded from the Pliocene and Pleistocene (Pearson, 1928; Han, 1987; Chen, 2004 etc.). In addition to these, *Chleuastochoerus* that was included in Suini by Pickford (1993) is known from the Pliocene of China, although it was excluded from Suinae by McKenna and Bell (1997). More comprehensive and detailed comparisons and discussion for the subfamiliar or generic taxonomy will be given in the separate paper.

IV. Conclusions

The suid mandible from the excavation site is dated to about 3.6 Ma by the tephrostratigraphic correlation with the paleomagnetically-dated standard sequence of the Kobiwako Group. It preserves the left and right horizontal rami with the three molars on each side, but is deformed by the post-burial vertical stress. It is probably assigned to the tribe Suini or Potamochoerini of the subfamily Suinae in sense of McKenna and Bell (1997) on the basis of its mandibular and dental morphology.

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