A Fossil Tubular Structure from Wakayama Prefecture, Southwest Japan

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Introduction and Acknowlegments

It is well known that burrow and tubular structures of worm and of other origin occur in the shallow seas of the Japanese Islands (Okuda and Iizuka, 1949, p. 1310–1348) and also in the geologic column (Shrock and Twenhofel, 1953, p. 516–520), and many kinds of tubular structures have been described by Howell and Häntzschel (Howell, 1962, p. 144–177; Häntzschel, 1962, p. 177–222), yet there seem to be some that have not been described to date. Pipy structures can also be made by inorganic processes (Hatai and Iwai, 1960), but in the present case only those made by organic processes will be considerd. The newly obtained tubular specimens seem to belong to the undescribed ones and form the scope of the present article. The specimens were found in the Shimosato sandstone and siltstone member of the Koguchi Formation distributed near the tip of the Kii Peninsula, Wakayama Prefecture. The stratigraphic position of the Shimosato sandstone and siltstone member of the Koguchi Formation in the geological column of the tip area of the Kii Peninsula is shown in Fig. 1, according to the stratigraphical studies of A. Mizuno (1957).

Recent deposits
..... unconformity .....
Pleistocene deposits
..... unconformity .....
Kumano acidic igneous rocks (Post-Middle Miocene)
..... unconformity .....
Kumano Group (Middle Miocene)
{ Mitsuno Formation
{ Koguchi Formation { Shikiya siltstone member
{ Shimosato sandstone and siltstone member
..... unconformity .....
Kinan Group (Eocene ?)

Fig. 1. Stratigraphic sequence of the stratal units distributed in the Arafune area, Higashi-Muro-gun, Wakayama Prefecture (after A. Mizuno, 1977).

The tubular specimens upon which the present article is based were found distributed on the plane of a grayish colored tuffaceous siltstone of Miocene age in the area of Arafune, Tawara, Higashi-Muro-gun, Wakayama Prefecture, near the tip of the Kii Peninsula. These tubular specimens are mostly parallel with the bedding plane, but some are partly embedded in the silty sediments in oblique position. The specimens are from straight, slightly curved to more or less sigmoidal in extension, and some are probably rather complete although

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somewhat deformed by subsequent agencies, and many that are mere fragments probably of larger tubes are distributed sporadically over the surface of the siltstone.

From the general orientation of the tubular structures it is judged they were deposited after death in the direction of current flow and that the current may have flowed from the smaller end towards the larger. From the occurrence of fragments of probably larger tubular structures, it is thought that the original tubes, that is to say the material making them, may have been fragile or rather weak. It is also suggested that the current action may have been not so strog or strong enough to destroy all of the specimens before their burial.

Before entering into the description of the newly obtained specimens, the writer expresses his thanks to Mr. Yukio Sako of Kushimoto-Cho, Wakayama Prefecture, who discovered, collected and forwarded the tubular specimens to the writer for study. Deep appreciation is expressed to Dr. Kotora Hatai, Professor Emeritus of the Tohoku University, for kindly helping the writer with the present article.

The Tubular Structures

The tubular structures are all, except a few, incomplete, being deformed by subsequent agencies and detached, parallel with the surface of the slabs or bedding plane and distributed at random but with vague orientation. The structures measure from 2 to 9 mm in diameter in the preserved condition and one is 15 mm in diameter in somewhat deformed condition but may have been about only 10 mm in diameter if restored. In length the structures are found to attain 70 mm in maximum and exposed preserved condition. Most are straight or almost so, but some are roughly sigmoidal and crossing (one specimen) another. One specimen that is oblique to the surface of the slab, exposes the wall of the tubular structure which is almost 0.5 mm in thickness and encloses homogeneous fine grained sediment, another that is parallel with the surface does not show a distinct wall, but it exposes fine grained sediment at its inner part. A distinct or more or less vague wall can be seen in several of the specimens, all of which have the same kind of surface sculpture. In extension the tubular structures apparently become narrower, probably towards the posterior part, and this evidently points to the organic origin of them.

The surface sculpture of these tubular specimens consists of small, about 1.5 mm or less in length and less than 0.5 mm in width, pustules or granules, more or less elongate oval to elongate roundly quadrate or roughly rounded in shape, distributed over the surface. The granules are rather closely set together, but with interstices separating one from the other of about one half of the width of the granules the general arrangement seems to be rather concentric or banded. The granules or pustules are arranged longitudinally or parallel with the lenght of the tubes, appearing as if narrow pellet-like structures spread longitudinally in more or less linear orientation over the surface. In some of the specimens the surface sculpture appears as small ovoidal granules, arranged in latitudinal to somewhat longitudinal shape and in banded orientation due to subsequent shearing (displacement). In other specimens that have been crushed laterally by subsequent agencies the ovoidal granules are arranged more or less wth random orientation.

The tubular structures were probably vertical or somewhat oblique to the sea bottom surface in living state and only partly buried in the bottom sediments as in *Pectinaria* (Yonge, 1949, p. 218). From the description given above, it seems that the original structure of the present specimens was a narrow, tubular form with abundant ovoidal granules, closely set, distributed banded-longitudinally over the surface, and each of the granules or granular structures were separated from one another by interstices measuring a little less than about half the width of the granules. The tube wall was probably, as measured, about or a little less than 0.5 mm in width. All of the specimens were distributed by current action, after death, to be buried in the silty sediments, parallel with the surface of deposition.

Remarks and Affinities

Among the tubular structures recognized in literature, the genus *Ophiomorpha* (Häntzschel, 1952 ; Chamberlain and Baer, 1973 ; Dike, 1972 ; Cheng, 1972) that has been recorded from the Cretaceous to Tertiary strata of many parts of the world, shows some resemblance with the present specimens in having tubular shape and coarse granular surface sculpture. But in *Ophiomorpha*, the tubes are generally vertical to the plane of deposition, although sometimes parallel with the bedding (Cheng, 1972 ; Chamberlain and Baer, 1973). Howevere, in all cases the surface sculpture of *Ophiomorpha* is rougher and generally larger than in the present specimens and, furthermore, the present specimens are elongate triangular in shape, whereas *Ophiomorpha* is not so. *Stegerwaldichnium* that was illustrated and described by Häntzschel (1962, p. 218, fig. 2) from the Upper Triassic of Germany, shows a remote resemblance with the present specimens, but it can be distinguished by the different type of surface sculpture. The surface sculpture of the present specimens resembles that of *Granularia* (Häntzschel, 1962, p. 194, fig. 123-1) from the Tertiary of Italy, but it can be distinguished therefrom by the ovoidal granules being distributed more regularly, and also by the different shape of the whole specimen. The worm tubes illustrated by Howell (1962, figs. 96-102) are all different from the present tubular specimens, but it seems that, like the dead tubes of *Pectinaria* which are found in the present seas on sandy bottoms in a position parallel with the sea bottom, the present fossil ones from Wakayama Prefecture are also thought to have had a similar fate. Also from that a few of the fossil specimens were found in a position oblique to the surface of deposition, it may be possible that they lived half buried in the sea bottom like *Pectinaria*. The small conoidal shelles described and illustrated by Fisher (1962, p. 98-143, figs. 50-84) all differ from the present tubular structures in details of shape, sculpture and size, as well as geological age of occurrence.

In being arranged parallel with the bedding plane, the present specimens show remote resemblance with *Thalassinoides* from the Upper Jurassic of southern England (Fürsich, 1972), but differ therefrom in the surface sculpture and in shape of the structures.

From the literature available to the writer and also from observations on tidal flats in Uranouchi Bay, Shikoku and other places, it seems that there are no known tubular structures with which the present ones can be identified, although more or less similar ones exist as mentioned above. At a glance the present tubular specimens may be mistaken

for the pellet-cords described as *Sakoites yukioia* Katto from the same area and geological formation as the present ones, especially when they are more or less worn, but the present fossil specimens are tubular, whereas the specimens of *Sakoites* are not. The details of sculpture, arrangement of the surface granular sculpture, size and shape of the present specimens are different from those of *Sakoites*. Since specimens identical with the present tubular ones are unknown so far as literature is concerned, it seems advisable to propose a new name to distinguish them from those that have been published. At this place the name of *Keyia kiiensis* n. gen.n.sp., is proposed for the present tubular specimens. The name is taken from the old provincial name Kii, and the species name from that of the Peninsula.

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PLATE I

Explanation to Plate

(Almost in natural size)

Figs. Different views of the tubular structures. Fig. 1. The tubular structure is partly overlain by the partly destroyed pellet-cord, but the main part clearly shows the lumpy, nodular or irregular surface sculpture, tapering nature of the tubular structure although compressed along the middle. The pellets of the pellet-cord can be seen in the lower and upper parts of the photograph.

Fig. 2. View of the tubular structure seen from above. The wall can be noticed.

Fig. 3. Different views of the more or less destroyed tubular structures. The tapering, irregular surface sculpture and widths of the structures are well displayed.

Fig. 4. Lateral view of a tubular structure showing the surface sculpture.

Fig. 5. Another specimen showing the surface sculpture in lateral view. Notice the lumpy, irregular and nodular sculpture. When compressed the tubular structures always form a bead-banded structure appearing as if overlapping the one in front that is to say the younger one.

Locality:- All are from the vicinity of Arafune, Tawara, Higashi-Muro-gun, Wakayama Prefecture. Early Cenozoic in age.

J. Katto: Tubular Structure from Wakayama Prefecture. Pl. 1.