Akihiko SUZUKI[1] and Takafumi ENYA[2]：Pleistocene evidence of *Gastrochaenolites orbicularis* Kelly and Bromley in southwestern Hokkaido, northern Japan

鈴木明彦[1]・圓谷昂史[2]：西南北海道の更新統から産出した岩石穿孔性生痕化石 *Gastrochaenolites*

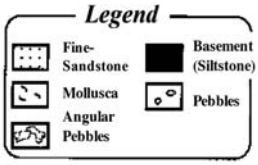
Introduction Rocky shore habitats often have well-preserved geological records that interface with reconstructions of paleoecological, paleogeographic and paleoenvironmental changes. Hard bottom environments often bear rock-boring trace fossils produced by boring organisms, such as bivalves, gastropods, brachiopods, barnacles, polychaete annelids, sponges and bryozoans. Members of ichnogenus *Gastrochaenolites*, which occur in the Ordovician to Holocene marine strata（Ekdale et al. 2002; Taylor and Wilson 2003）, have primarily been observed in rocky substrates that likely represent shallow marine facies（Bromley 1992, 1994）, and club-shaped borings can mainly be attributed to boring bivalves（Kelly and Bromley 1984）.

In August 2018, rock-boring bivalves and beach cobbles bearing the ichnogenus *Gastrochaenolites* were collected from the Setana Formation, Kuromatsunai Town, southwestern Hokkaido（Fig. 1）. Here, we briefly describe the characteristics, distribution and taxonomic significance of *Gastrochaenolites* and the associated rock-boring bivalves.

Fig.1 Map showing location of Kuromatsunai area, southwestern Hokkaido. X: Sample collection location.

Study area The shallow marine facies that are rich in rock-boring biota were primarily deposited during the Pleistocene in Hokkaido（Suzuki and Akamatsu 1994）. The Setana Formation in the Kuromatsunai area contains well-preserved molluscs dating to approximately 0.95 to 0.83 Ma based on microbiostratigraphy using planktonic foraminifera and nannofossils（Nojo and Suzuki 1999）.

In the Soibetsugawa section of the Kuromatsunai area, the basal part of the Setana Formation unconformably overlies a basement comprised of a conglomerate of Pliocene siltstone deposits（Fig. 2）. Many wave grooves and tidal pools are apparent on the basement surface. Boring bivalves are dominant in conglomerate clasts and are absent from the basement layer. The rock-boring bivalve, *Nettastomella*（Fig. 3）, and the clavate borer, Gastrochaenolites, are dominant in clastic sediments. Additionally, rocky substrate molluscs, such as mussels, limpets, and chitons, are also recognized. These molluscs are considered to be semi-autochthonous in origin.



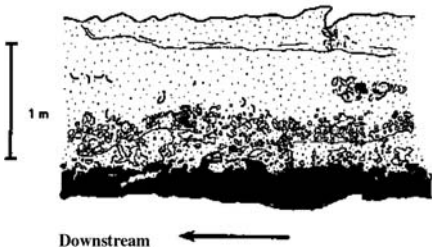


Fig.2 Modes of occurrence of rock-boring bivalves and their borings at the unconformity surface of Setana Formation, Kuromatsunai area.

Materials and methods Mudstone cobbles with boring trace fossils and associated rock-boring bivalves were collected. Samples were examined by a hand lens and stereomicroscope, and images were captured using a digital camera（Olympus Tough Tg-5, Olympus Corp., Japan）. Trace fossils in cobbles were identified based on comparisons with descriptions in the ichnological literature（Bromley 1994, 2004; Donovan 2011, 2013）, and the descriptive terminology of borings following Kelly and Bromley（1984）is used.

Systematic ichnology

Ichnogenus *Gastrochaenolites* Leymerie, 1842

Type ichnospecies: Gastrochaenolites lapidicus Kelly and Bromley, 1984

Other species: See Donovan（2011）.

Diagnosis: "Clavate borings in lithic substrates. The aperture region of the boring is narrower than the main chamber and may be circular, oval, or dumbbell shaped. The aperture may be separated from the main chamber by a neck region, which in some cases may be widely flared. The main chamber may vary from sub-spherical to elongate, having a parabolic to rounded truncated base and a circular to oval cross section, modified in some forms by longitudinal ridges or grooves to produce an almond- or heart-shaped section."（following Kelly and Bromley, 1984）

Remarks: Gastrochaenolites borings are excavated principally by endolithic bivalves, but also by recent coralliophilid gastropods（Bromley 2004）.

***Gastrochaenolites orbicularis* Kelly and Bromley, 1984**

Specimens: Three mudstone cobbles bearing the boring trace fossils. One is almost complete and has been cast in latex.

Locality and horizon: Soibetsu, Kuromatsunai Town, southwestern Hokkaido. Basal part of the Setana Formation（Early Pleistocene）.

Description: Smooth Gastrochaenolites, circular in cross-section throughout; main chamber orbicular; neck region elongated in type specimen but may be short（Fig. 4, 5）.

Remarks: The orbicular main chamber and circular cross-section to the

Fig.3 Rock-boring bivalve, *Nettastomella japonica*（Yokoyama）, from Setana Formation.

neck distinguish this species from other similar ones. Borings of this type are produced by *Jouannetia*. There may be an inconspicuous thin lining.

Gastrochaenolites turbinatus is "acutely conical" with its widest diameter occurring close to its base (Kelly and Bromley 1984). *Gastrochaenolites ornatus* can be distinguished from *G. orbicularis* by having a less globular main chamber and a base with a circular, sculpted bioglyph (Kelly and Bromley 1984). Based on the above description, the *Gastrochaenolites* borings of Soibetsu samples are identified as belonging to *G. orbicularis*.

Discussion Preservation of specimens at the study site was generally good, and several club-shaped borings were recognized as belonging to ichnogenus *Gastrochaenolites*. Among the collected samples, there were many clasts of *Gastrochaenolites* borings, and few were associated with rock-boring clams. The recent borings of *Nettastomella* were similar to *G. orbicularis*, bearing an orbicular chamber (Kelly and Bromley 1984). The clavate borings described here were identified as *G. orbicularis* according to the taxonomy of Kelly and Bromley (1984).

The paleoecological characteristics of the molluscan and ichnofossil assemblages in the study section reflect changes in the sedimentary environment during sea-level transgression during the Pleistocene. Wave-cut platforms bearing wave grooves and tide pools were created during the initial period of the transgression. Subsequently, *N. japonica* and *G. orbicularis assemblages* found in the conglomerate during the late transgression reflect the semi-autochthonous occurrence of these taxa on unstable substrates.

Acknowledgments We thank Takamasa Iwabuchi of Hokkaido University of Education for assistance with boring rock preparation. This study was supported by a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science ((C)19K03107).

要約：2018年 8 月，西南北海道黒松内町の更新統瀬棚層から，穿孔性二枚貝ヨコヤマスズガイ *Netastomella japonica* を含む泥岩の礫を採集した。これらの礫は，当時の岩礁海岸を構成する海浜礫に由来するものである．礫に含まれるヨコヤマスズガイの貝殻を取り除き、岩石穿孔性生痕を検討した結果，*Gastrochanolites orbicularis* Kelly and Bromley に同定された．

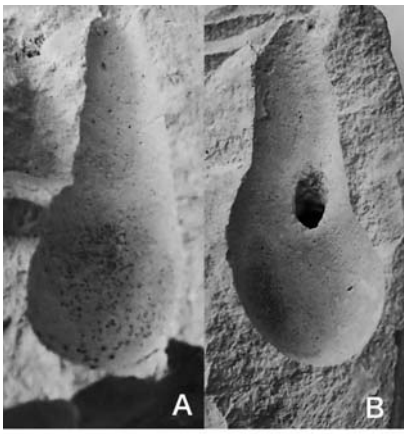


Fig.4 Club-shaped boring ichnofossil, *G. orbicularis* Kelly and Bromley, from Setana Formation. Boring in mudstone; the specimen was broken to retrieve the bivalve shell.

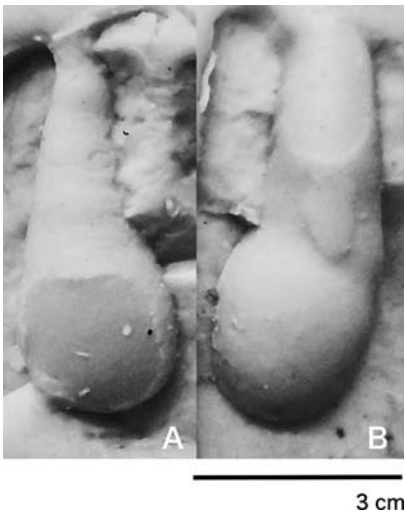


Fig.5 Club-shaped boring ichnofossil, *G. orbicularis* Kelly and Bromley, from Setana Formation. Latex cast of the same specimen.

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(Received Apr. 5, 2020; accepted June 15, 2020)

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