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PROBLEMATICA OF THE BEACON SANDSTONE AT BEACON HEIGHT WEST, ANTARCTICA

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ABSTRACT

Worm borings, wave-ripple marks and other Problematica from the Beacon Sandstone are described and discussed. They include a new form of ripple mark. An enigmatical form of Problematica is described under the provisional name *Beaconites antarcticus* "gen." et "sp." nov.

INTRODUCTION

(H.J.H. and I.G.S.)

The type locality of the Beacon Sandstone is, by tautology, the twin peaks named Beacon Heights on the south side of the upper Taylor Glacier in Victoria Land (Ferrar, 1907). As described in a separate paper elsewhere in this number, a section at Beacon Height West was examined by the writers in the course of work by the New Zealand Geological and Survey Antarctic Expedition 1959–60. The petrography of samples from the mountain is described by Shaw (1962), and the geology of the district surrounding the mountain has been described by Ferrar (1907), McKelvey and Webb (1959), and Hamilton and Hayes (1960).

Only a portion of the lower part of the Beacon Sandstone is exposed in the sections on Beacon Heights, and it is probably of Early Carboniferous age. Many of the sandstone beds contain "Problematica" such as worm borings, or display prominent ripple marks and other surface markings. For this class of Problematica the term *ichnofossils* has been used by Seilacher (1953), as pointed out to the writers by Professor R. T. Prider. Some of these features were photographed, and a few were sampled within the practicable limits of load-carrying on the climb. A selection of photographs of the more enigmatical ichnofossils was shown and discussed at the Perth meeting of ANZAAS in 1959. Later, Professor Vialov requested a set of photographs, which were sent to him with the following notes.

1A, 1B (Fig. 1 of this paper)	Face view and side view of a loose block (specimen P23074 in the New Zealand Geological Survey collections), found 550 ft below the summit of Beacon Height West. The nature of the markings is not understood at all; they seem to be too regular and too angular to be ripple-marks or sun-cracks.
2 (Fig. 5)	Weathered face of Beacon Sandstone near the foot of the mountain on its north side. The structures resemble stylolites, and are common on the lower slopes of the mountain.
3 (Fig. 6)	As for photograph 2, but a different outcrop.
4 (Fig. 7)	Outcrop on the lower northern slopes of Beacon Height West. Almost certainly seem to be worm borings.
5A, 5B	Sample P23073 from a height of 300 ft (approx. 100 m.) above the Taylor Glacier on lower north slope of mountain. Seem almost certainly to be worm borings.
6 (Fig. 8)	Block of Beacon Sandstone on north slope of Beacon Height West showing worm borings (?) on a bedding plane (in the background there is another block with laminated bedding).
7 (Fig. 9)	Organic trails or borings on bedding planes. Very common about 1,000 ft (330 m) above the Taylor Glacier on the north slope of the mountain. These are the most puzzling of the markings. We called them "pseudo-gastropods" because they resemble superficially gastropod casts.
8	Block about 550 ft below the summit of the mountain on its western side. One type of "pimply" bedding-plane surface, perhaps(?) in some way related to rain-drops.
9 (Fig. 11)	Another type of "pimply" markings, similar to those of photograph 8, but superposed on a ?ripple-marked bedding plane.

THE BEACON SANDSTONE AND OTHER SEDIMENTS OF EAST ANTARCTICA

The Beacon Sandstone, first described and named by Ferrar (1907), is now known to form the higher parts of the mountains of the Victoria Land Horst (David and Priestley, 1914) from the vicinity of Wood Bay to at least as far south as the Queen Maud Range described by Gould (1935), but it has been eroded from the ranges between Wood Bay and the Admiralty Mountains. Lithological correlatives, which have been grouped together as the Beacon System (Harrington, 1958), have been found in King George V Land (Mawson, 1940), Mac-Robertson Land (Crohn, 1959) and Coats Land.

Until recently it was supposed that the relatively unindurated sediments of the Beacon System represented the chief sedimentary cover of the foundation

of the East Antarctic Platform, but another set of sediments exposed in the Amundsen and Sandow mountains has been described (Ravich and Voronov, 1958) and named the Sandow Series (Vialov, 1959). The first sample of sedimentary rocks from this region was obtained by Mawson's Australasian Antarctic Expedition of 1911–14 and was described by Nockolds (1940). The Sandow Series is tentatively assigned to the Upper Proterozoic or the Lower Paleozoic because it has suffered rather higher metamorphism than the Beacon sediments. It is regarded as forming the first stage of the sedimentary cover of the East Antarctic Platform, with the Beacon System forming a second stage. The metasediments of Robertson Bay to the west of Cape Adare (Rastall and Priestley, 1921) were included in the Moubray Group of northern Victoria Land (Harrington, 1958; Harrington *in* Hamilton, 1958, pp. 14–15), but are now being called the Robertson Bay Group (H. J. Harrington, pers. comm.). Widespread comparable sediments found by New Zealand geologists *in situ* and in moraines further south in Victoria Land may be grouped also with the first stage of the sedimentary cover.

More recently the discovery of fragments of sedimentary rocks containing Cretaceous or Tertiary marine faunas among moraine debris in the McMurdo Sound district (Cranwell, Harrington, and Speden, 1960) indicates the existence of a third stage in the sedimentary cover of the East Antarctic Platform. Evidently, even Cretaceous or Tertiary marine deposits are buried beneath the ice cover, at least in the Ross Sea region, and this discovery greatly alters ideas on the paleogeography and history of geological development of the Antarctic.

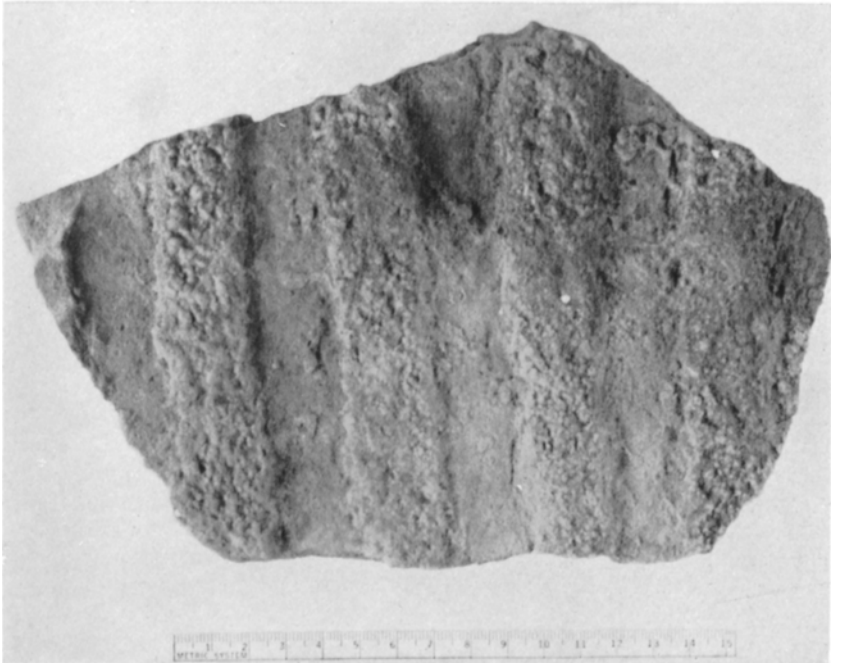
On the evidence of Devonian Placodermi (Woodward, 1921) and of coal layers and the Gondwanian flora (Edwards, 1928; Crohn, 1959), the age of the Beacon Sandstone is estimated to range from Devonian to Permian and possibly later. Floras and a marine fauna discovered in recent seasons in the Victoria Land Horst by United States and New Zealand geologists are not yet described (Harrington and Speden, pers. comm.; Long, 1960).

Partly because of the comparative rarity of paleontological data it is desirable to pay special attention to marks and "Problematica" within the Beacon System. The following descriptions are of a set of photographs of examples found at Beacon Height West (see notes above). I am grateful to R. F. Hecker (Moscow) for helpful opinions about several of the photographs.

DESCRIPTION OF PHOTOGRAPHS

Photographs 1A and 1B. These are face and side views of a loose block of sandstone measuring 18 × 14 cm (Fig. 1). It shows parallel protruding ridges or bands with straight edges separated by troughs. The surfaces of the ridges and troughs are almost flat; the height of their side-walls is about 5 mm, and the width about 2·7 cm (up to 3 cm). The distance between the ridges is about 1·8 to 2·3 cm, and the length of ridges preserved on the sample is up to 14 cm.

The minor features of the ridges and troughs are different; the surfaces of the troughs are more even than the ridges, which are finely stippled (tuberculated) recalling the markings showing on photographs 8 and 9 (Fig. 11).

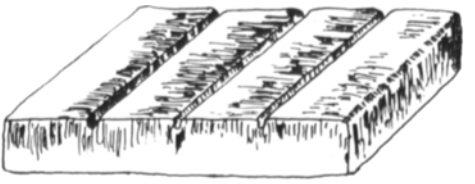


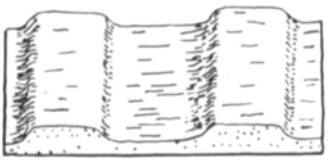
S.N. Beatus, photo

FIG. 1—Face view of sandstone block showing parallel ridges and troughs. P23074, Beacon Sandstone, Beacon Height West, Antarctica.

Marks of this type are seldom, or almost never, described in the literature. Sediments showing similar flattened ridges separated by parallel troughs were described and figured by Vialov (1955, fig. 3) in an account of the Silurian flysch from the Turkestan Range in Middle Asia, but in this example the ridges are extremely wide as compared with the low channels, which have an appearance similar to drag-marks (Fig. 2). The writer has observed the wide variety of ripple marks in the molasse sediments of the lower Miocene Dobrotov beds of the Pre-Carpathian foredeep, and they have been described and figured by his postgraduate student T. A. Denissova (1959). One of the Pre-Carpathian specimens, judging from a figure in Denissova (1959, fig. 1b), copied and reproduced here (Fig. 3), does not differ from the Antarctic specimen.

In the literature there are frequent indications that the flattening by erosion of the crests of ripple marks may be essentially contemporaneous with their formation. For instance, a case is illustrated by Shrock (1948, figs. 72f and 78c, pp. 114 and 118), but in this example the cross section of the troughs is regularly rounded, whereas in the Antarctic specimen the troughs are flattened and have sharply angular bends at their junctions with the ridges. A rare kind of ripple-mark (Fig. 4), which has wide flat troughs separated by low ridges with narrow crests, has been described by Denissova (1959, fig. 1c). On the basis of observations on the Pre-Carpathian Dobrotov beds,





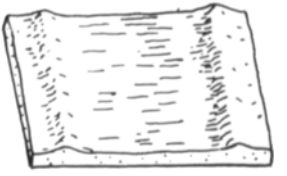


FIG. 2 (above)—Broad parallel ridges and narrow troughs on a specimen from the Silurian flysch, Turkestan Range, Middle Asia (*from* Vialov, 1955, fig. 3).

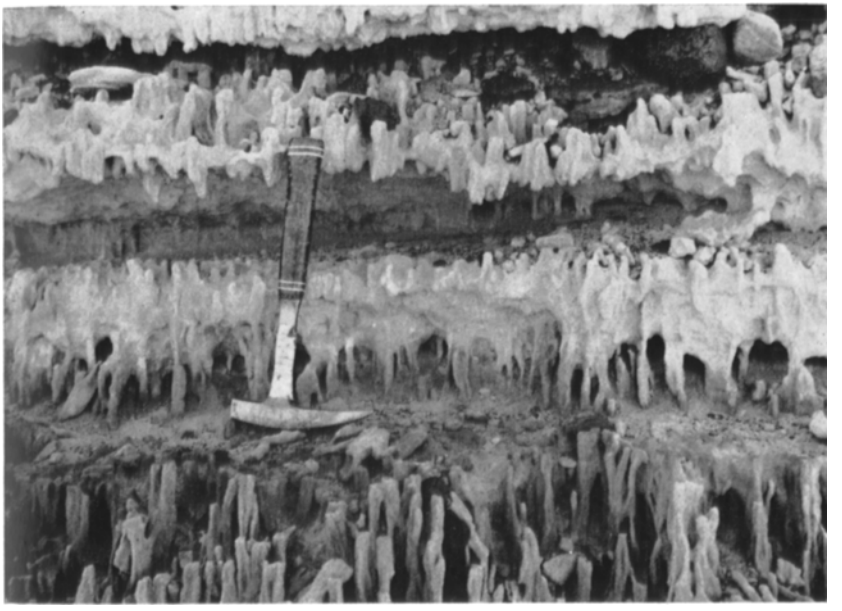
FIG. 3 (lower left)—Parallel ridges and troughs on a specimen from the Lower Miocene Dobrotov beds (*from* Denissova, 1959, fig. 1b).

FIG. 4 (lower right)—A specimen from the Lower Miocene Dobrotov beds showing broad narrow crests (*from* Denissova, 1959, fig. 1c).

it is concluded that the marks on the Antarctic sample are ripple marks. They belong to the group of symmetrical ripple marks, that is, ripples formed by an oscillation-wave movement of water, and their extreme peculiarity compels their differentiation as a special variety termed "sleeper-shaped" or "cross-tie-shaped" ripple marks, from their resemblance to the sleepers of railway tracks.

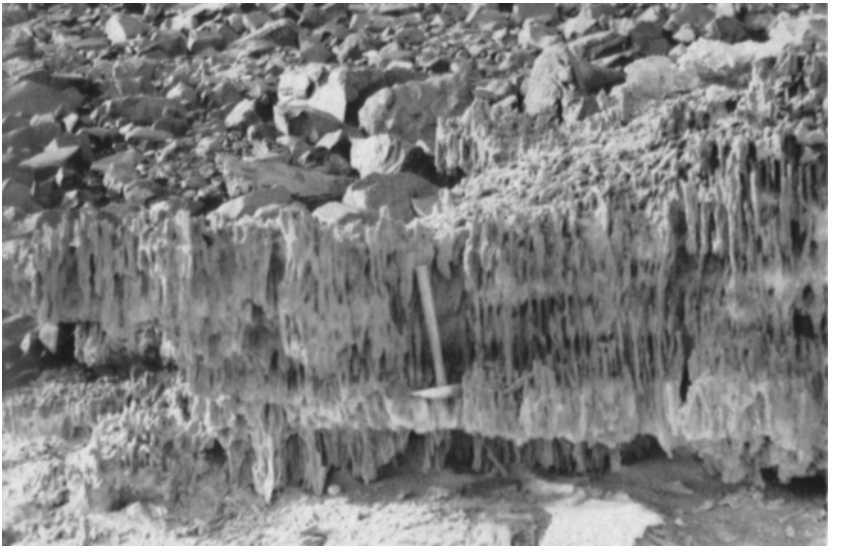
Photographs 2 and 3. The faces (Figs. 5 and 6) cut across several sandstone beds, and have very peculiar weathering surfaces, with structures thickness of one bed, or occasionally through several beds. Their shapes are roughly similar to the depositional stalactite and stalagmite forms found in limestone caves, though of course they have nothing else in common. Nor can they be called stylolites, which are also formed in carbonate rocks but are of a quite different character.

Undoubtedly the curious sculpture of these Beacon Sandstone faces is due that may be described roughly as pipes extending vertically through the to erosion, but the question arises, Why does the feature appear only in some beds and not throughout the whole sandstone sequence? (See, for example, the smooth face of Fig. 5.) Evidently the sculptural features are connected with some heterogeneity in the rock itself, that is, with the presence of more dense or compact ingredients remaining not only as bas-relief protrusions but also as isolated pillars and fine columns nearly separated from the main mass of the rock. These may be simple sandy concretions, but their comparative regularity, density in space, and their vertical orientation perhaps indicate, as suggested by R. F. Hecker (pers. comm.), that we are dealing with traces of the life-activity of some marine



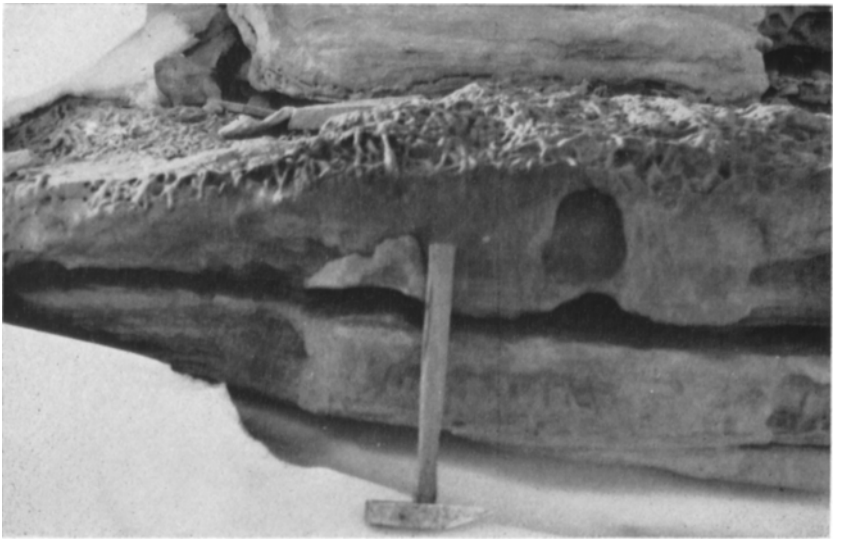
H. J. Harrington, photo

FIG. 5—Sculptured surface of beds in a sequence near the foot of the north side of Beacon Height West.



I. G. Speden, photo

FIG. 6—Sculptured surface of a bed. Locality as for Fig. 5.



I. G. Speden, photo

FIG. 7—Probable worm traces; lower northern slopes of Beacon Height West.

organisms. Indeed features roughly similar to these are known as *Scolithus*, and are considered to be fossil records of the former presence of organisms like the so-called "sand-corals", that is, reef-buildings of Sabellaria or sea-worms (Richter, 1920; 1921; Abel, 1935, p. 464; Lessertisseur, 1955, p. 59). However, this tempting possibility must be rejected in this case because the constructions of the "sand-coral" Scolithus or *Pfeifenquarzite*. differ in having much more regular cylindrical tubes. Their regularity moreover does not suffer when weathered, but becomes even more evident.

In the literature there are many descriptions of different kinds of sand tubes or pillars. Many drawings of cylindrical marks and tubes ranging from a few millimetres to several metres in diameter, and occurring within the Oligocene sandstones of Gebel Ahmar in the vicinity of Cairo, have been given by Shukri (1954), who attributes them to the activity of fumaroles and hot springs during a declining phase of volcanic activity. These tubes, as well as those described by Hawley and Hart (1934) from Ontario, are however different from those at Beacon Heights. For the Beacon Sandstone pillar structure such an explanation is quite inapplicable: its nature remains wholly obscure. It may be suggested only that probably the pillars that stand out in relief after erosion are more compact than the surrounding rock and have an inorganic origin.*

Photograph 4. The side of a sandstone bed, and part of its upper surface are shown on this photograph (Fig. 7). The lower surface of the bed is

*It is shown by S. E. Shaw elsewhere in this Number, that the sandstones of Beacon Height West have a cement consisting of authigenic quartz overgrowths. Slightly greater cementation of the pipes in the photograph could perhaps be related to a disturbance of the packing and permeability of the sandstone, or to differential cementation of areas lithologically differentiated to a small degree by organisms. (H.J.H. and I.G.S.)

smooth, but on its upper surface and a little beneath it there is developed a complicated intermingling of sandy cylindrical tubes. Such phenomena are often observed in nature, are undoubtedly of organic origin, and in general may be explained in two ways. Interminglings of very similar shape are due to sandy fillings of the holes of higher Crustacea (crabs and middle-tailed crayfish). These are the so-called *Rhizolites* and *Ophiomorpha,* and illustrations of them are to be found in a series of contributions, some of the more recent being those of Glaessner (1948), Häntzschel (1952), and Hecker (1956). Ophiomorpha from the Miocene sandstones in the environs of Lvov have been described by Vialov (*in* Vialov and Pishvanova, 1959). The holes of Decapoda are often perpendicular to bedding, but sometimes form irregular and diversely oriented interminglings. Leaving details aside, it may be noted that a tubercular sculpture, and the presence of an outer ring in cross sections, are characteristic of Ophiomorpha, but the outer ring is not always clearly developed. On casts of the holes there may be very fine folds that are the impressions of scratches or movements of the animal within its hole. Judging from Fig. 7, these sculptural features are missing, and the orientation of the intermingled holes is varied, but usually approaches sub-horizontal. Moreover fossil Decapoda are known only from the Triassic onwards. Therefore it seems that Decapoda are not the cause of the features shown in the photograph.

Another plausible explanation is that such features represent traces of the activities of worms, and this is the explanation that is adopted. This opinion is confirmed by an examination of photographs 5A and 5B, which show other interminglings on a larger scale.

Photographs 5A and 5B. On the surfaces of two small plates of sandstone measuring 12·5 × 12·5 cm and 13 × 16 cm there are to be seen intermingled cylindrical rollers or tubes that have mainly a horizontal orientation and cross one another in different directions. The diameter of the rollers is about 0·9 to 1·2 cm. Generally they are almost rectilinear, and sometimes rather bent. On portions of some rollers there are obvious segmentations and some impressed lines, the width of the segments ranging up to 0·4 cm. There is no doubt that the rollers are records of the life-activity of worms.

Similar rounded rollers or tubes occur among the hieroglyphs of the Flysch sediments, where they are always found on the lower surface of a bed. They represent secondary (negative) moulds of the crawling traces of worms (Polychaeta) left by the animals on the bottom—i.e., on the upper surface of the layer upon which the bed with bas-relief rollers lies.

The specimens from Beacon Height West are probably of excreta still in the position of deposition on the upper suface of a bed. The observed light segmentation marks boundaries between different portions of undigested inorganic material ejected from the worm's intestine. This explanation may be applied also to the interminglings shown in photograph 4 (Fig. 7).

Photograph 6. Analogous intersecting tubes, preferentially distributed in a horizontal manner, occupy the whole of this block (Fig. 8). The length of the slab is about 30 cm and its width 15 cm. The rolls are rectilinear or slightly bent, and sometimes branching, as for example at the left edge of the slab. There are quite thin tubes along with thicker ones. These also are traces of the excreta of worms.



H. J. Harrington, photo

FIG. 8—Probable traces of the excreta of worms; lower northern slope of Beacon Height West. Also typical of photographs 5A and 5B, studied by the author but not reproduced in this paper.

Photograph 7. Two kinds of marks are developed on these sandstone slabs (Fig. 9). One consists of rather shallow rounded pits, with flat floors in the centre of which there are small tubercles or pimples. In Fig. 9, near the right-hand lower edge of the right-hand specimen, the central pimple occupies a considerable part of the pit, and there is only a narrow surrounding ring. The diameter of the pits is fairly constantly about 1·5 cm.

The second kind of mark consists of small straight parallel elongated notches or pits (Fig. 9). Each row of pits is drawn out lengthwise and forms a narrow band, up to 1·5 cm in width; some bands are a little bent. The width of the pits is approximately equal to the width of the interven-

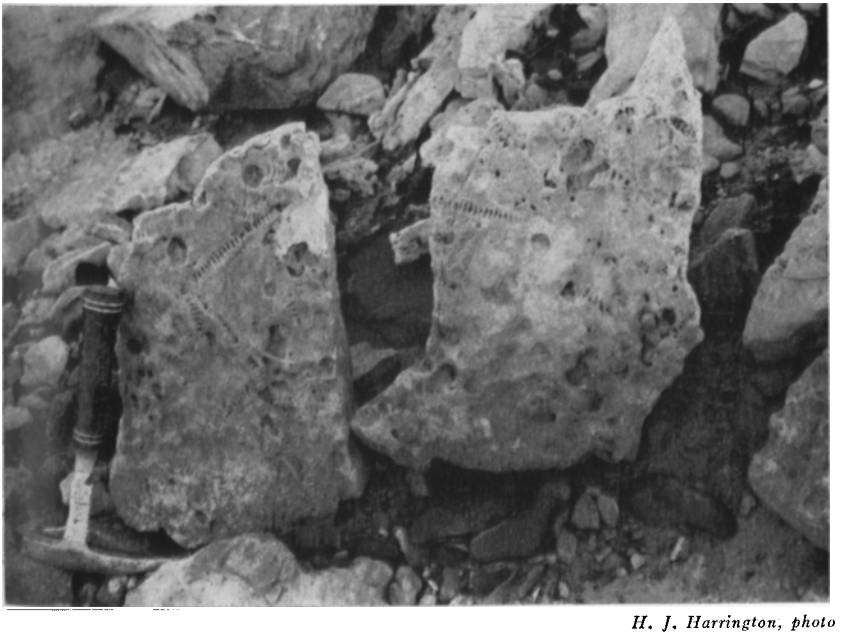
ing partitions or walls. In some cases the impression is given that the notched bands are connected with the circular pits, as if gradational into them (as, for example, in the upper corner of the left-hand specimen, and to the left of centre in its lower third between two straight dentate bands, and on the right-hand specimen in its upper part, and at the right and left of its very lowest part). If this is really so it seems that the circular pits are cross-sections, and the elongated dentate bands are longitudinal sections of the same marks.

The pits and the walls between them are adjacent to fine side-walls almost always clearly distinguishable at the edges of the dentate bands. It appears that the markings are cylindrical tubes with thin outer walls, hollow within and divided by thin transverse septae or "tabulae". The pits upon the surface of a slab are thus portions of the cavities between septae.

The general features of these tubes are shown in Figs. 9, 10. It is difficult to judge their exact origin. They are clearly organic, but whether they are fossils *sensu strictu* or indirect traces of life-activities, has not been decided.

At first sight it could be considered that they might be crinoid stems, but this supposition must be rejected because there is no trace of carbonate material. The septae between the tube walls and the pits consist of the same sandy material as the enclosing rock. Nor can they be tabulate corals, because these have a carbonate skeleton and are colonial forms.

No record of similar markings has been found in the literature. There is a remote similarity to part of *Protovirgularia* McCoy, originally classified in



H. J. Harrington, photo

FIG. 9—The mode of occurrence and distribution of *Beaconites antarcticus* "gen." et "sp." nov., in blocks at about 1,000 ft above Upper Taylor Glacier, north slope of Beacon Height West.

the Octocorallia, but now reclassified by Häntzschel (1958, fig. 5). *Protovirgularia* have feeble transversal furrows but not pits, and do not possess a tubed structure. They are only surface traces.

This example of the Problematica remains enigmatical. However, it is classed with the Problematica and is here provisionally called *Beaconites antarcticus*. The description of this form genus and species is as follows:

Beaconites antarcticus "gen." et "sp." nov.
(Figs. 9 and 10)

Cylindrical hollow tubes (or semicylindrical grooves), diameter up to 1·5 cm, straight or bent, with septae of the same thickness as the length of adjacent hollow portions of the tubes. They occur on bedding planes and also appear to enter the beds obliquely or perpendicularly to the bedding.

On both slabs there are small round pits, showing as black points, which may be cross sections of the worms' tubes directed into the bed perpendicular to its surface. At least in surface section they are very like sections shown by Abel (1935, p. 394, fig. 330) and by Lessertisseur (1955, p. 59, fig. 34–C).

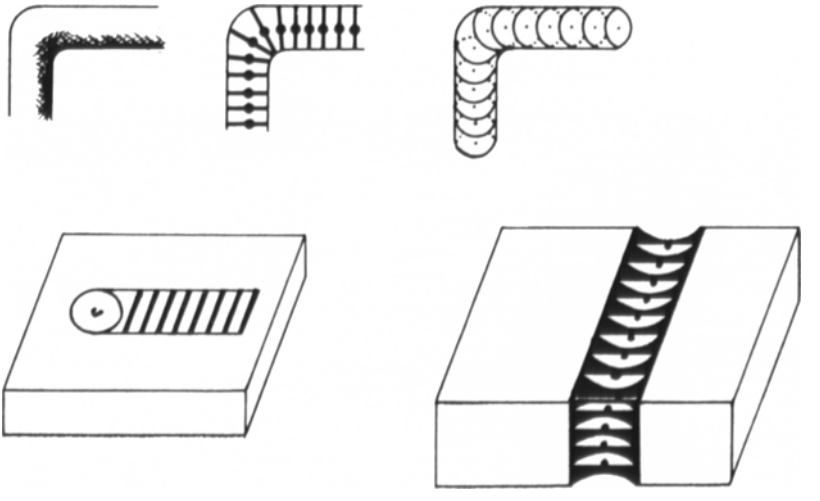
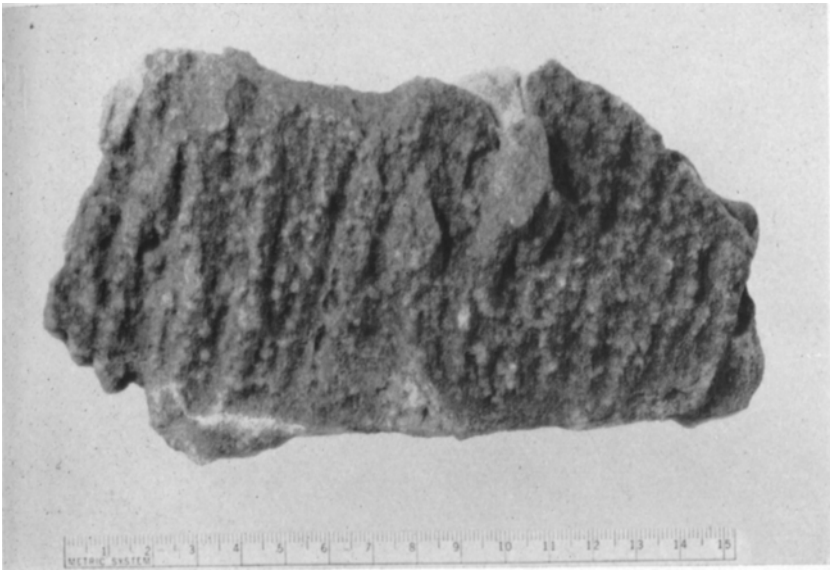


FIG. 10—Reconstructed drawings of *Beaconites antarcticus* "gen." et "sp." nov. For description, see text.

Photograph 8. The surface of the sandstone block, measuring 16 × 10 cm, is dotted with small strongly protruding tubercles or pimples 2 to 4 mm in diameter. These cannot be casts of raindrops, though at first sight they have some resemblance to them. Raindrop impressions and casts never have such sharp relief. A comparison with Vialov's collection of raindrop impressions and casts, both recent and fossil, shows considerable differences. The Antarctic tubercles are evidently inorganic, and are indicative of local cementation of the sandstone, but otherwise are enigmatical.



S.N. Beatus, photo

FIG. 11—Tuberculated and ridged surface of a quartzose sandstone bed. The small tubercles are like those described for photograph 8.

Photograph 9. Fine highly dispersed pimples are also observed on this specimen, which is 15·5 × 9 cm in size, but they occur on an irregularly undulating surface (Fig. 11), unlike those of photograph 8 which are developed on a smooth surface. The undulations are almost parallel to one another and consist of elongated small ridges separated by depressions. Some of the ridges are wider than the depressions and are rounded in cross-section (at left in figure), and others are finer, narrower, and only slightly raised, evidently being rather eroded. These undulations are probably traces of ripple marks.

SOME CONCLUSIONS

Bedding-plane markings and other "Problematica" are common in the Beacon Sandstone, though scarcely mentioned in the literature. Occurrences are of great interest, and are worthy of close attention because, though some cannot be explained at present, others throw some light on the conditions of sedimentation and features of the enviroment.

Since masses of traces of the vital activities of worms as described above are not known in other than a normal marine environment, their presence in the Beacon Sandstone at Beacon Height West shows with certainty that normal or almost normal marine conditions of sedimentation prevailed in the vicinity at the time of their deposition.

The form of Problematica to which the name *Beaconites antarcticus* is given above is most probably due to marine organisms.

The ripple marks of this section of the Beacon Sandstone are in general of kinds recorded in the literature. They are of aqueous and not of eolian

origin, and their symmetrical profiles indicate that they were formed by waves and not by currents. It is difficult to use them to determine the depth of the water, because recent underwater photography has shown that wave ripples occur at very great depths, up to 3,000 metres (Ksiazkewicz, 1960). Nevertheless the general character of the sandstone of the Beacon System indicates deposition in rather shallow water.

There is some special interest in the ripple marks in that they include an example of a very rare type having flat ridges and flat troughs. To this type the name sleeper-shaped or cross-tie-shaped ripple marks has been given above.

REFERENCES

ABEL, O. 1935: "Vorzeitliche Lebensspuren." Fischer, Jena.

CRANWELL, L. M.; HARRINGTON, H. J.; SPEDEN, I. G. 1960: Lower Tertiary Microfossils from McMurdo Sound, Antarctica. *Nature, Lond. 186 (4726)*: 700–2.

CROHN, P. W. 1959: A Contribution to the Geology and Glaciology of the Western Part of Australian Antarctic Territory. *Bull. Bur. Mineral Resour. Geol. Geophys., Aust. 52 (Aust. Nat. Antarct. Res. Exped., Reports, Series A, Vol. 3. Geology)*.

DAVID, T. W. E.; PRIESTLEY, R. E. 1914: Glaciology, Physiography, Stratigraphy, and Tectonic Geology of South Victoria Land. *Rep. Brit. Antarct. Exped. 1907–09. Geology, 1*: 1–319.

DENISSOVA, T. A. 1959: Ripple Marks in the Dobrotov Deposits of the Pre-Carpathian. *Trans. Far-East Polytechn. Inst. Vladivostok 54, Fasc. 1*: 35–40 (in Russian).

EDWARDS, W. N. 1928: The Occurrence of *Glossopteris* in the Beacon Sandstone of Ferrar Glacier, South Victoria Land. *Geol. Mag. 65 (7)*: 323–7.

FERRAR, H. T. 1907: Report on the Field Geology of the Region Explored during the *Discovery* Antarctic Expedition, 1901–04. *Nat. Hist. Rep. Nat. Antarct. Exped. 1 (Geol.)*: 1–100.

GLAESSNER, M. F. 1948: Decapod Crustacea (Callianassidae) from the Eocene of Victoria. *Proc. Roy. Soc. Vict. 59 (1)*: 1–7.

GOULD, L. M. 1935: Structure of the Queen Maud Mountains, Antarctica. *Bull. Geol. Soc. Amer. 46 (6)*: 973–84.

HAMILTON, W. M. 1958: *Annual Report of the Department of Scientific and Industrial Research for the year ended 31st March 1958*. Govt. Printer, Wellington.

HAMILTON, WARREN; HAYES, P. T. (1960): Geology of Taylor Glacier – Taylor Dry Valley Region, South Victoria Land, Antarctica. *U.S. Geol. Surv. Prof. Pap. 400–B*: 376–8.

HANTZSCHEL, W. 1952: Die Lebensspur Ophiomorpha Lundgren im Miozän bei Hamburg, ihre weltweite Verbeitung und Synonymie. *Mitt. Min.-Geol. StInst. Hamburg 21*: 142–53.

HANTZSCHEL, W. 1958: Oktokoralle oder Lebenspur? *Mitt. Min.-Geol. StInst. Hamburg 27*: 77–87.

HARRINGTON, H. J. 1958: Nomenclature of Rock Units in the Ross Sea Region, Antarctica. *Nature, Lond. 182*: 290.

HARRINGTON, H. J.; SPEDEN, I. G. 1962: Section through the Beacon Sandstone at Beacon Height West, Antarctica. *N.Z. J. Geol. Geophys. 5 (5)*: 707–17 (this issue).

HAWLEY, J. E.; HART, R. C. 1934: Cylindrical Structures in Sandstones. *Bull. Geol. Soc. Amer. 45*: 1017–34.

HAWLEY, J. E. 1936: Cylindrical Structures in Sandstones. Reply to Discussion. *Bull. Geol. Soc. Amer. 46 (Supplement)*: 2014–5.

HECKER, R. F. 1956: Ecological Analysis of Decapoda of the Fergana Gulf of the Paleogene Sea in Middle Asia. *Bull. Soc. Nat. Moscou. Ser. Geol. 31 (1)*: 77–87 (in Russian).

KSIAZKIEWICZ, M. 1960: Geologia morza na I Miedzynarodowym Kongresi Oceanagraficznym. *Kosmos B6. 2 (22)*: 127–72 (in Polish).

LESSERTISSEUR, J. 1955: Traces Fossiles d'Activitié Animale et leur Signification Paléobiologique. *Mém. Soc. Géol. Fr. 74*: 1–150.

LONG, W. E. 1960: Preliminary Report of the Geology of the Central Range of the Horlick Mountains, Antarctica. *Ohio State Univ. Res. Fndn Rep. 925–2. Pt. 7*: 1–23.

MAWSON, D. 1940: Sedimentary Rocks. *Australasian Antarct. Exped. 1911–14, Sci. Rep. 4 (11)*: 345–67.

MCKELVEY, B. C.; WEBB, P. 1959: Geological Investigations in South Victoria Land, Antarctica. Part 2—Geology of Upper Taylor Glacier Region. *N.Z. J. Geol. Geophys. 2 (4)*: 718–28.

NOCKOLDS, S. R. 1940: Petrology of Rocks from Queen Mary Land. *Australasian Antarct. Exped. 1911–14, Sci. Rep. Ser. A. 4 (2)*: 15–86.

RASTALL, R. H.; PRIESTLEY, R. E. 1921: The Slate-Greywacke Formation of Robertson Bay. *Nat. Hist. Rep. Brit. Antarct. (Terra Nova) Exped. 1910. Geol. 1 (4)*: 121–9.

RAVICH, M. G.; VORONOV, P. S. 1958: Geology of the East Antarctic Coast between 55° and 110° E. *Soviet Geol. 2*: 3–26 (in Russian with English Summary).

RICHTER, R. 1920: Ein Devonischer "Pfeifenquartzit", Verglichen mit der Heutigen "Sandkoralle" (Sabellaria, Annelidae). *Senckenbergiana 2 (6)*: 215–35.

RICHTER, R. 1921: Scolithus, Sabellarifex und Geflechtquartzite. *Senckenbergiana 3 (1 and 2)*: 49–52.

SEILACHER, A. 1953: Studien zür Palichnologie 1—Über die Methoden der Palichnologie. *N. Jb. Geol. Paläont. 96*: 421–52.

SHAW, S. E. 1962: Petrography of Beacon Sandstone Samples from Beacon Height West, Upper Taylor Glacier, Antarctica. *N.Z. J. Geol. Geophys. 5 (5)*: 733–9 (this issue).

SHROCK, R. R. 1948: "Sequence in Layered Rocks." McGraw-Hill, New York, 507 pp.

SHUKRI, N. 1954: On Cylindrical Structures and Colouration of Gebel Ahmar near Cairo, Egypt. *Bull. Fac. Sci. Cairo Univ., 32*: 1–23.

SIMPSON, G. G. 1936a: Cylindrical Structures in Sandstones in Patagonia. *Proc. Geol. Soc. Amer. for 1935*: p. 106.

SIMPSON, G. G. 1936b: Cylindrical Structures in Sandstones, Comment on Discussion. *Bull. Geol Soc. Amer. 46 (Suppl.)*: 2011–4.

VIALOV, O. S. 1955: On the Lower Paleozoic Flysch of the Turkestan Range. *Sci. Mem. Lvov Univ., Geol. Ser., 35 (8)*: 170–5 (in Russian).

VIALOV, O. S. 1959: Tectonics and History of Development of Antarctica. *C.R. Acad. Sci. Ukr. R.S.S. 8*: 878–80 (in Ukrainian with Russian and English summaries.

VIALOV, O. S.; PISHVANOVA, L. S. 1959: New Data on the Lower Tortonian Fauna of Podolia. *C.R. Acad. Sci. U.R.S.S. 126 (4)*: 834–7 (in Russian).

WOODWARD, A. S. 1921: Fish Remains from the Upper Old Red Sandstone of Granite Harbour, Antarctica. *Nat. Hist. Rep. Brit. Antarct. (Terra Nova) Exped. 1910, Geol. 1 (2)*: 51–62.