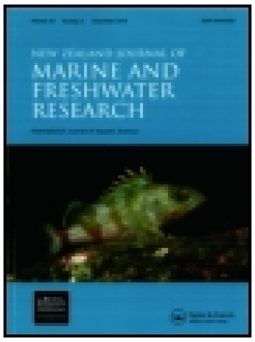

Taylor & Francis
Taylor & Francis Group

New Zealand Journal of Marine and Freshwater Research

ISSN: 0028-8330 (Print) 1175-8805 (Online) Journal homepage: http://www.tandfonline.com/loi/tnzm20

# Ecological implications of possible enteropneust faecal casts in tertiary deposits near castlepoint, New Zealand

David J. Cullen

**To cite this article:** David J. Cullen (1967) Ecological implications of possible enteropneust faecal casts in tertiary deposits near castlepoint, New Zealand, New Zealand Journal of Marine and Freshwater Research, 1:3, 283-290, DOI: 10.1080/00288330.1967.9515205

**To link to this article:** http://dx.doi.org/10.1080/00288330.1967.9515205

Published online: 30 Mar 2010.

# ECOLOGICAL IMPLICATIONS OF POSSIBLE ENTEROPNEUST FAECAL CASTS IN TERTIARY DEPOSITS NEAR CASTLEPOINT, NEW ZEALAND

DAVID J. CULLEN

New Zealand Oceanographic Institute, Department of Scientific and Industrial Research, Wellington

*(Received for publication 23 May 1967)*

SUMMARY

Unusual "spiral" faecal casts from mid-Tertiary beds of the Castlepoint area of North Island, New Zealand, are described and compared with modern enteropneust casts photographed at abyssal depths in the south-west Pacific. Evidence suggests that the fossil casts originated in relatively shallow depths, and this discrepancy emphasises the caution required in the use of trace fossils for palaeoecological interpretations.

## INTRODUCTION

In recent years interest has revived in occurrences of "trace fossils" (tracks, trails, burrows, faecal casts, fucoids, etc.) in sediments and sedimentary rocks. Studies of algal "mats" in modern sediments of south Florida have led Ginsburg (1955, 1957) to suggest analogy between these structures and the stromatolites and fucoids in Pre-cambrian and Palaeozoic sediments, and to stress the possible palaeoecological use of these fossils. The palaeoecology of worms and problematica has been briefly discussed by Howell (1957) and Caster (1957), who also provide annotated bibliographies relating to these phyla.

More recently, Schafer (1962) has advocated, with many examples, the study of modern organic structures of known origin as a guide to the palaeoecology of trace fossils. Hantzschel (1962) has compiled a comprehensive list and systematic descriptions of known ichnogenera based on information scattered throughout earlier geological literature, and the palaeoecological implications of several varieties of trace fossils have been outlined by Ager (1963) and Seilacher (1964). Contemporary "spiral" worm tracks, photographed on the ocean floor, have been described by Bourne and Heezen (1965) and their distribution and significance discussed, while Farrow (1966) has derived a bathymetric zonation of Jurassic sediments in northern England from evidence afforded by trace fossils.

Trace fossils are not a common feature in New Zealand rocks. Worm casts and tubes do occur sporadically in Cenozoic strata, but to a large extent they have been neglected since other fossils in these beds (notably Foraminifera and Mollusca) have proved more profitable for stratigraphic and palaeoecologic studies. Rather more attention has been given, however, to annelid tubes in certain otherwise unfossiliferous Mesozoic rocks in both North Island (Webby 1958) and South Island (Bather 1905, 1906).

## MORPHOLOGY OF THE CASTLEPOINT FAECAL CASTS AND LITHOLOGY OF THE ASSOCIATED SEDIMENTS

During a recent field excursion to the Wairarapa district several distinctive biogenic structures of unusual type were discovered by the author in a beach exposure of a thick sequence of Tertiary graded-bedded arenites and pelites, 5 miles north of Castlepoint, on the east coast of North Island, New Zealand (Fig. 1). These structures occur upon surfaces of sandstone layers as convex ridges, approximately 5 mm across, which meander in a regular manner to form a series of concentric loops. The loops become progressively longer and overlap one another outward from a focal point to reach a maximum length of about 20 cm (Fig. 2). The spacing between successive convolutions remains more or less equidistant, the axes lying about 1.25 cm apart. The "horizontal" convolute structures are accompanied by a scattering of infilled, cylindrical burrows of normal type, perpendicular or oblique to the sedimentary lamination.

Although traces of both cross-bedding and graded-bedding occur in the associated sediments, evidence from these features is, in the main, ambiguous, and the attitude of the beds remains locally obscure. For this reason it is difficult to decide whether the convolute structures represent faecal casts on the upper surfaces of sandstone layers, or infilled burrows (parallel to the bedding) adhering to the soles of these layers. As would be expected in either case, the sediment that forms the biogenic structures is identical texturally and mineralogically with the sediment on the adjacent surfaces of the sandstone layers—a poorly-sorted glauconitic arenite with angular particles (predominantly quartz and feldspar) ranging from very fine to medium sand grade (0.06–0.5 mm).

Faecal casts very similar to the convolute structures from Castlepoint are known to exist on the floors of modern oceans. Morphologically, the Castlepoint trace fossils closely resemble the very characteristic enteropneust faecal casts photographed at abyssal depths in the Kermadec Trench and figured by Bourne and Heezen (1965) in their account of "spiral" tracks on the sea floor. The Wairarapa specimens are considerably smaller than those actually illustrated by Bourne and Heezen, but these authors quote the range in "diameter" of this particular type of track as lying between 20 and 200 cm. The length of the convolutions in the Castlepoint fossils corresponds roughly to the lower of these values. The structures are similar in other respects: the ratio of length of axis of the convolutions to the distance between axes, for instance, is more or less constant (approximately 7.5:1) for the fossil and modern specimens.

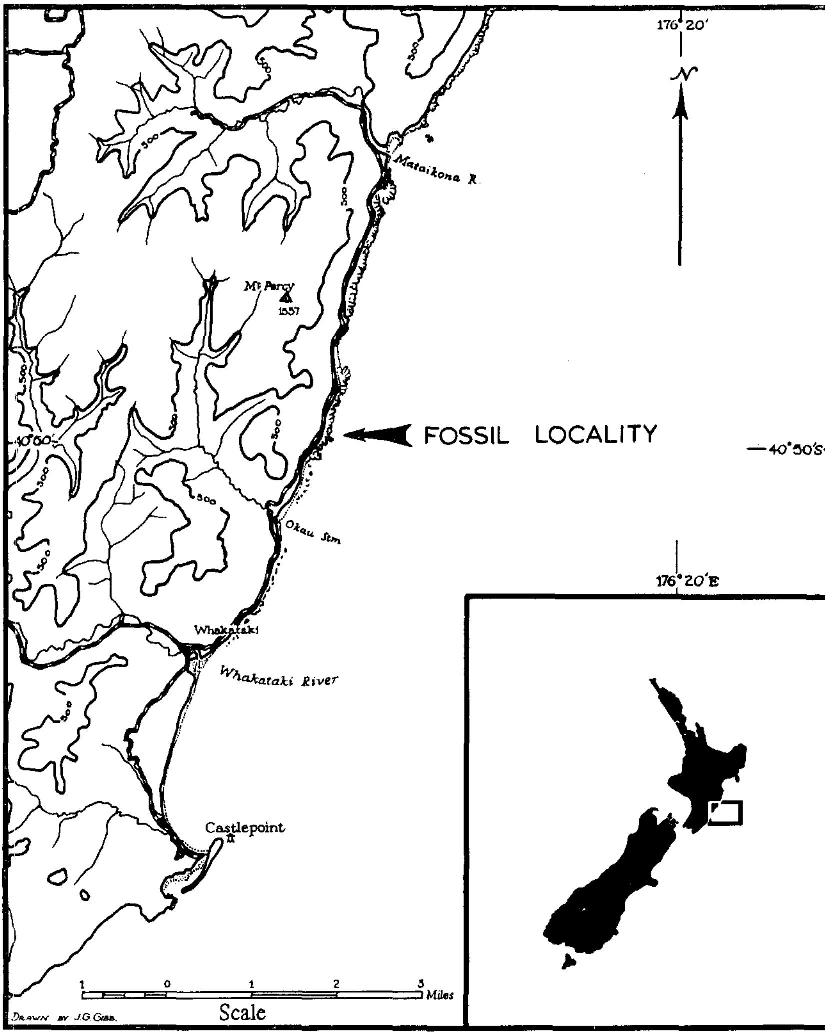


FIG. 1—Map showing the location of the mid-Tertiary worm cast occurrences near Castlepoint.

Both the fossil and modern convolute casts differ from the normal faecal casts created by burrowing organisms. Whereas the latter remove material from *below* the sediment surface and eject it above, the organisms responsible for the convolute structures were presumably itinerant deposit-feeders, moving freely (during the formation of the casts, at least) *upon* the sediment surface. Thus, the fact that ridge-like convolute structures have been raised above an essentially flat sediment surface, with no obvious provenance for the material, poses a minor space problem. It is suggested that as the deposit-feeders methodically traversed the sea-floor, sediment was ingested from a zone with cross-sectional area roughly equivalent to that of the faecal cast. In the case of the Wairarapa fossil casts, where the width of the feeding zone (taken as the distance between loop axes) averages about 12.5 mm, this would imply penetration in the order of one millimetre. Successive traverses would lower the sediment surface in the immediate vicinity of the casts by this amount, so that the slight burrowing effect would become obscured—even more so perhaps as the sediment compacted. Photographs of modern enteropneust faecal casts (Bourne and Heezen 1965) show a distinct disturbed zone with dark, mottled appearance, alongside the actual casts.

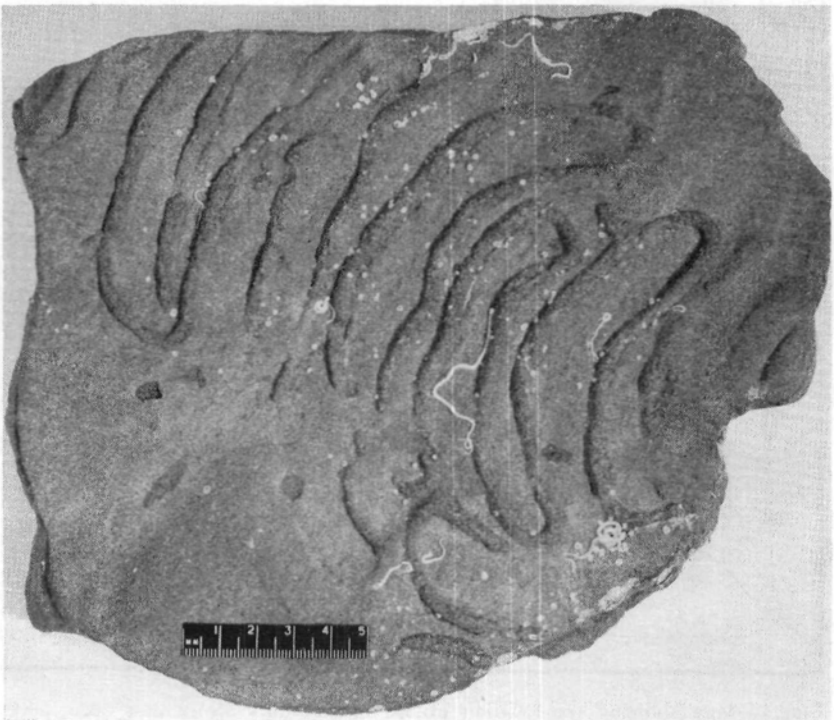


Photo: J. J. Whalan

FIG. 2—Surface of arenite slab, showing convolute faecal casts parallel to the bedding, and some burrows perpendicular or oblique to the bedding. The sediment filling the burrows is finer than that of the faecal casts and associated arenite. (Scale in cm. Illumination from right.)

## PALAEOECOLOGICAL CONSIDERATIONS

Evidence suggests that the distribution of "spiral" tracks on the floors of *modern* oceans is related to bathymetry. According to

Bourne and Heezen (1965), tracks of this type are common in the south-west Pacific at depths greater than 4,000 m, but have not been recorded from numerous stations in shallower regions. These authors do not specify the depth range of the shallower stations, but seem to imply coverage of intermediate depths approaching 4,000 m. Very similar tracks have, in fact, been photographed at slightly shallower depths (3,735 m) on the southern flank of the Pacific-Antarctic Ridge (Koster 1966).

In the case of the Tertiary fossil casts, however, there is some doubt as to the abyssal origin of the graded-bedded deposits in which they occur. The latter are almost identical in facies with a sequence of Tongaporutuan (Upper Miocene) sediments exposed in central Hawke's Bay, about 70 miles north of Castlepoint—a sequence regarded by Kingma (1958) as having accumulated in a shallow basin in which the bottom slopes were insufficient to generate turbidity currents. Kingma maintains that the presence in these beds of micro-banding, cross-bedding, Foraminifera, plant remains, and differences in calcium carbonate content all indicate prolonged sedimentation, and not rapid deposition at depth by turbidity currents. All of these features are characteristic of the Castlepoint sequence in which the faecal casts were found, and it could similarly be argued that the casts originated in shallow water.

Although Kingma's views upon the bathymetric significance of these features are by no means universally accepted, there are certain other factors that indicate that the Castlepoint sequence may not have been deposited in an abyssal environment.

The arenites associated with the faecal casts contain only a poor microfauna, determined by Mr N. de B. Hornibrook (Senior Micropalaeontologist, New Zealand Geological Survey) as being of probable Waitakian or Otaian (Upper Oligocene–Lower Miocene) age. Fleming's (1962) reconstruction of New Zealand Lower Miocene palaeogeography reveals the development of a localised sedimentary trough over the northern Wairarapa at that time, separated from an emerging land mass to the west by an extremely narrow shelf. That this trough had a limited extent, in both space and time, is suggested by Kustanowich's (1964) postulated *eastern* provenance for certain of the Miocene sediments near Castlepoint, and by his observation that Upper Miocene and upper Middle Miocene deposits are completely absent from the area. In view of these findings, it seems unlikely that abyssal depths would have been attained in the trough, as the bottom slopes required would be excessively steep—considerably steeper than any around New Zealand today, except perhaps for certain sectors of the Kermadec and Tonga trenches. While rapid subsidence of the floor of the trough is presumed, to account for the great thickness of Lower and Middle Miocene deposits in the Castlepoint area, there is no reason to suppose that the rate of subsidence exceeded that of sedimentation, and it is unlikely that abyssal depths ever developed in the trough.

Petrology furnishes some evidence as to the depth of deposition of the arenites associated with the fossil faecal casts near Castlepoint. The presence in the arenites of primary calcite and calcareous foraminiferal tests, together exceeding 20% by weight of the sediment, suggests an origin in depths less than 3,000 to 4,000 m—the depth below which calcium carbonate tends to dissolve in sea water (Sverdrup *et al.* 1942; Peterson 1966; Berger 1967). By plotting calcium carbonate content as a function of depth, Sverdrup *et al.* (1942) have shown that Pacific Ocean sediments containing carbonate in excess of 20% by weight occur, on average, at depths between 2,000 and 4,000 m, with the greater proportion in the shallower part of this range (Fig. 3). Below 4,000 m, sediments with carbonate in excess of 20% are comparatively rare. For "nearshore" deposits, the same authors have found that sediments containing more than 20% carbonate are restricted to depths less than 3,000 m.

Another characteristic of the Castlepoint arenites is the inclusion within them of large grains (up to 0.25 mm) of glauconite, a mineral normally associated with deposition in fairly shallow water and restricted in Recent sediments of the south-west Pacific, to depths between 100

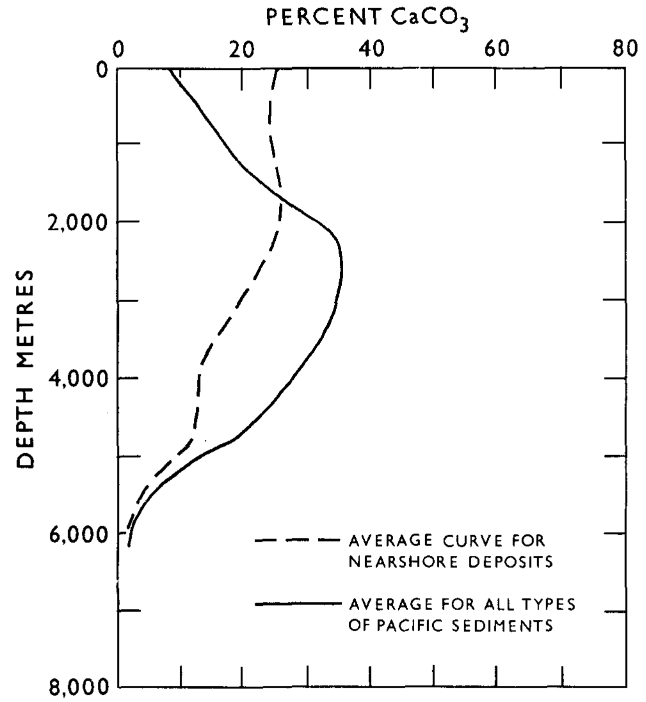


FIG. 3—Graphic plot of the percentage of calcium carbonate in marine sediments of the Pacific as a function of depth. (After Sverdrup *et al.* 1942.)

and 1,000 m (Pantin 1966). Although the mere presence of glauconite cannot be claimed as diagnostic of shallow deposition, the relatively high proportions (estimated at 5–10%) of this mineral in the arenites does suggest accumulation in proximity to the glauconite source area, with the inferred probability that final deposition was in reasonably shallow water near by.

## CONCLUSION

Several lines of evidence indicate that, in direct contrast to the present-day abyssal distribution of "spiral" faecal casts in the south-west Pacific (Bourne and Heezen 1965), similar structures in the mid-Tertiary sediments of the Castlepoint region may have been formed at comparatively shallow depths. While nothing is known of the distribution of "spiral" casts in Tertiary sediments of undisputed abyssal origin, their known occurrence in shallower Tertiary deposits contrasts with the *restriction* of comparable tracks to abyssal depths in the modern oceans, and suggests a radical change in the ecology of the responsible organisms since Miocene times. It is, of course, possible that the fossil and modern casts were produced by entirely different classes of animal, but the morphological similarity between these structures favours the suggestion that they owe their origin to organisms of closely-related genera or species. The uncertainties inherent in such a supposition serve to underline the difficulties encountered in the use of trace fossils for paleoecological reconstructions, and emphasise the caution required in assuming extrapolations from present-day environments.

## ACKNOWLEDGMENTS

The author wishes to thank Dr C. A. Fleming and Dr G. Stevens (New Zealand Geological Survey), and Mr I. N. Estcourt (New Zealand Oceanographic Institute) for suggesting improvements to the text.

## REFERENCES

AGER, D. V. 1963: "Principles of Paleoecology." McGraw-Hill, New York, 371 pp.

BATHER, F. A. 1905: The Mt. Torlesse annelid. *Geol. Mag. dec. V 2:* 532–41.

———1906: The age of the Mt. Torlesse annelid. *Geol. Mag. dec. V 3:* 46–7.

BERGER, W. H. 1967: Foraminiferal ooze: solution at depths. *Science 156:* 383–5.

BOURNE, D. W. and HEENZEN, B. C. 1965: A wandering enteropneust from the abyssal Pacific, and the distribution of "spiral" tracks on the sea floor. *Science 150:* 60–3.

CASTER, K. E. 1957: Problematica. *In* H. S. Ladd, "Treatise on marine ecology and paleoecology" vol. 2, pp. 1025–32. *Mem. geol. Soc. Am. 67.*

FARROW, G. E. 1966: Bathymetric zonation of Jurassic trace fossils from the coast of Yorkshire, England. *Palaeogeogr. Palaeoclim. Palaeoecol. 2:* 103–51.

FLEMING, C. A. 1962: New Zealand biogeography, a paleontologist's approach. *Tuatara 10:* 53–108.

GINSBURG, R. N. 1955: Recent stromatolitic sediments from south Florida (Abstract). *J. sedim. Petrol. 25:* 129.

———1957: Early diagenesis and lithification of shallow-water carbonate sediments in south Florida. *In* "Regional aspects of carbonate deposition" pp. 80–100. *Spec. Publs Soc. econ. Paleont. Miner., Tulsa. No. 5.*

HANTZSCHEL, W. 1962: Trace fossils and problematica. *In* "Treatise on Invertebrate Paleontology (Part W)" pp. 177–245. Geol. Soc. America and Univ. Kansas Press.

HOWELL, B. F. 1957: Vermes. *In* H. S. Ladd, "Treatise on marine ecology and paleoecology" vol. 2, pp. 805–16. *Mem. geol. Soc. Am. 67.*

KINGMA, J. T. 1958: The Tongaporutuan sedimentation in central Hawke's Bay. *N.Z. Jl Geol. Geophys. 1:* 1–30.

KOSTER, S. 1966: Recent sediments and sedimentary history across the Pacific-Antarctic Ridge. *Sediment. Res. Lab. Fla. St. Univ. Contr. 17.* 83 pp.

KUSTANOWICH, S. 1964: Geology of the Tinui Valley-Castlepoint region, north-eastern Wairarapa. Unpub. M.Sc. Thesis, Victoria University of Wellington. 129 pp.

PANTIN, H. M. 1966: Sedimentation in Hawke Bay. *Bull. N.Z. Dep. scient. ind. Res. 171.* 70 pp.

PETERSON, M. N. A. 1966: Calcite: rates of dissolution in a vertical profile in the central Pacific. *Science 154:* 1542–4.

SCHAFER, W. 1962: "Aktuo-paläontologie nach studien in der Nordsee." W. Kramer, Frankfurt. 666 pp.

SEILACHER, A. 1964: Biogenic sedimentary structures. *In* J. Imbrie and N. D. Newell, "Approaches to Paleoecology." pp. 296–316. J. Wiley, New York.

SVERDRUP, H. V., JOHNSON, M. W., and FLEMING, R. H. 1942: "The Oceans." Prentice-Hall, New Jersey. 1087 pp.

WEBBY, B. D. 1958: A Lower Mesozoic annelid from Rock Point, south-western Wellington, New Zealand. *N.Z. Jl Geol. Geophys. 1:* 509–13.