(*Reprinted from Nature, Vol.* 185, *No.* 4709, *pp.* 336–337, *January* 30, 1960)

Manganese Deposition on the Shells of Living Molluscs

RECENTLY, there has been a renewal of interest in manganese deposition on the sea bed, particularly that brought about by biological rather than inorganic processes[1–5]. During the past fifty years[1–14] various theories have been put forward concerning the method of manganese deposition, yet the only measurements on the rate of deposition are those of Petterssen[11,12], and Buttler and Houtermans[13] on manganese nodules of deep-sea origin. These authors give a rate of the order of 1 mm. in 1,000 years.

During a survey of the sublittoral fauna of the Clyde sea area from 1949 onwards, it has been observed that the shells of many living molluscs are encrusted with a black deposit. In particular, this was the case of molluscs taken from muds and sandy-muds at depths of 15–105 fathoms. Although this has been recorded before[7–9,15], past analyses were limited to nodules, and deposits on stones and empty shells. While many species of living molluscs in the Clyde have manganese deposited on their shells, it is significant that deposits are more common and much heavier on shells with a dull, matt periostracum than on those with a glossy periostracum. Yellow, and olive-coloured shells seem to be most affected, although deposits occur on shells of other colour. Thus species of *Nucula* clearly show the difference between glossy and matt surfaces, for while matt *N. sulcata* and *N. nucleus* may be completely covered with the black deposit (none of the older shells of many hundreds examined is free of deposit), glossy *N. turgida* and *N. tenuis* from the same substratum and of the same age rarely show any deposit. When present in the two latter species the deposit is confined to a small, thin film at the umbo. Although the list is not exhaustive, other species noted for their black deposit are *Corbula gibba*, *Venus casina*, *Nuculana minuta*, *Cyprina islandica*, *Mysella bidentata*, *Glycymeris glycymeris*, the underside of *Pecten maximus* and *Chlamys septemradiata*, *Natica alderi*, *Neptunea antiqua* and the tips of *Dentalium entalis*. All these species live at or close to the surface of the bottom sediment.

Analysis confirms that a high percentage of manganese is present in the deposits on these shells, far more than in the bottom sediment in which they live (Table 1). The percentage of manganese is close to

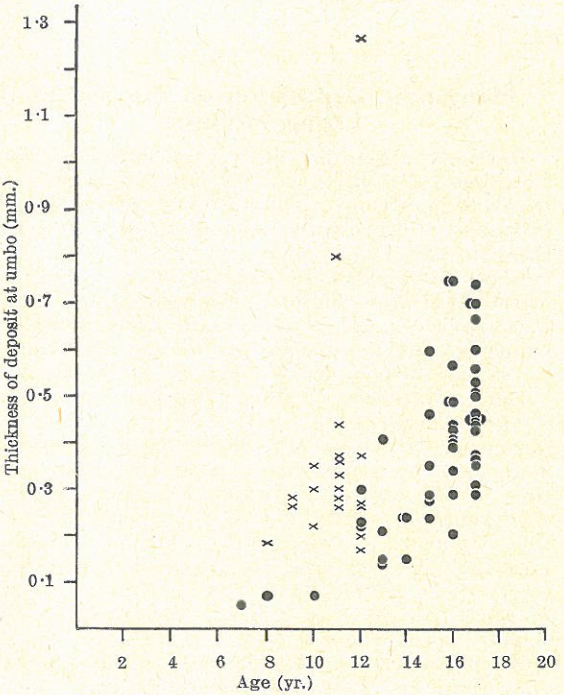

Fig. 1. Rate of manganese deposition on the shells of living *Nucula nucleus* (×) and *N. sulcata* (●)

that estimated for nodules from the same area. As figures for the rate of growth of *Nucula* species are available[16] micrometer measurements of the thickness of the deposit at the umbo give some idea of the rate of deposition. Shells of *N. sulcata* and *N. nucleus* less than 5 years old have a thin coating that is not easily measured; but the deposit on the dorsal side of shells more than 8 years old can be easily flaked off and its thickness determined. The results are shown in Fig. 1. It will be seen that, exceptionally, a deposit 1·27 mm. thick can be laid down in 12 years, but most fall in the range 0·30–0·70 mm. in 17 years (1 mm. in 25–60 years). It is possible that some of the deposit may be rubbed off by the movements of the *Nucula*, although the umbo, which is always affected, probably projects above the surface of the mud and so avoids friction with the substratum. Maximum deposition of manganese occurs on shells and non-living loci at the surface of the bottom sediment[8]. The deposit on living molluscs is remarkably compact and hard, perhaps suggesting origin from biological

Table 1

Locality	Manganese (per cent)
Nodules from Minard Narrows (Clyde)	18·7
Nodules from other sources (Goldberg) (ref. 3)	10·8–24·15
Substratum Arran Deep (Clyde) 60 fm.	0·1
Substratum North Sea 30 fm.	0·1
N. sulcata, Cumbrae Deep (Clyde), 60 fm.	8·5
N. sulcata, Arran Deep (Clyde), 60 fm.	17·9
Astarte montagui, Inverkip Bay (Clyde), 25 fm.	11·5

activity rather than the adsorption of precipitated particles. The possible origin of the Clyde nodules and deposits from streams flowing off manganese and iron-rich bogs cannot be neglected, although a higher percentage of manganese in the bottom sediments might be expected. Such an origin was discussed by Murray and Irvine[9]. The figures given above suggest that the largest nodules (approx. 6 mm. diam.) in a sample taken from the Minard Narrows (L. Fyne) are 75–190 years old. This is in contrast with 3,000 years for deep-sea nodules of the same size.

I am indebted to Dr. A. Gilchrist of the Metallurgy Department, King's College, Newcastle upon Tyne, who kindly carried out the manganese estimations.

J. A. Allen

Dove Marine Laboratory,
Cullercoats.
Oct. 13.

[1] Graham, J. W., and Cooper, S. C., *Nature*, **183**, 1050 (1959).
[2] Graham, J. W., *Science*, **129**, 1428 (1959).
[3] Goldberg, E. D., *J. Geol.*, **62**, 249 (1954).
[4] Goldberg, E. D., and Arrhenius, G. O. S., *Geochim. Cosmochim. Acta*, **13**, 153 (1958).
[5] Dorff, P., "Die Eisenorganismen" (2) "Biologie des Eisen-mid Mangankreislaufs" (1935).
[6] Murray, J., and Renard, A. F., "Deep Sea Deposits", Challenger Rept. (1891).
[7] Buchanan, J. Y., *Trans. Roy. Soc. Edin.*, **36**, 459 (1891).
[8] Irvine, R., and Gibson, J., *Proc. Roy. Soc. Edin.*, **18**, 54 (1891).
[9] Murray, J., and Irvine, R., *Trans. Roy. Soc. Edin.*, **37**, 721 (1894).
[10] Correns, C. W., Deutsche Atlantische Exped. *Meteor* 1925–1927, Wiss. Erg., **3**, 298 (1939).
[11] Petterssen, H., *Göteborgs VetenskSamh. Handl.*, Ser. B, **3** (1945).
[12] Petterssen, H., *Göteborgs VetenskSamh. Handl.*, Ser. B, **2** (1943).
[13] Buttler, H. V., and Houtermans, F. G., *Naturwiss.*, **37**, 400 (1950).
[14] Buser, W., Int. Oceanogr. Congr. Preprints, 962 (1959).
[15] Chumley, J., "The Fauna of the Clyde Sea Area" (1918).
[16] Allen, J. A., *J. Mar. Biol. Assoc. U.K.*, **33**, 457 (1954).

Printed in Great Britain by Fisher, Knight & Co., Ltd., St. Albans