# DEPARTMENT OF ~~NATIONAL RESOURCES~~ NATIONAL DEVELOPMENT

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



Record 1979/62

## DEEP-SEA SEDIMENTS AND MANGANESE NODULES FROM THE SOUTHERN TASMAN SEA

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## Abstract

Two manganese nodules having a high clay content, a low Mn:Fe ratio, and low contents of valuable metals (Ni 0.25%, Cu 0.17%, Co 0.06%) were recovered in a grab sample during a short geological cruise in HMAS Kimbla in the southern Tasman Sea in May 1979. Five stations were occupied. Free-fall grabs recovered sediment or pumice from four stations; nothing was recovered from the fifth. The carbonate compensation depth in the region is about 4500 m. Reddish brown clay, but no manganese nodules, was recovered in the central southern Tasman Sea, from depths of 4900-5100 m. The nodules, together with grey calcareous mud, were obtained from a depth of 4300 m, farther to the northwest, near Gascoyne Seamount (250 n. miles SE of Sydney).

The results suggest nodules with high metal values are likely to exist only in the broad and deep depression in the central southern Tasman Sea southeast of Gascoyne Seamount, where sedimentation rates are low and oxidising conditions prevail. Whether nodule fields are present or not will only be resolved by considerably more sampling.

## Introduction

Although manganese nodules have been widely studied in the Pacific Ocean, little work has been done in the Tasman Sea, presumably because existing knowledge suggests that nodules are sparse in the region and, furthermore, that they contain only low concentrations of valuable metals. Indeed Noakes & Jones (1976) plotted 13 camera stations in the Tasman Sea, south of Lord Howe Island and north of the southwestern tip of New Zealand, none of which revealed nodules. In the same general region they plotted only one station with nodules; an analysis gave 0.20% Ni, 0.06% Cu and 0.08% Co.

However, in 1951 the Danish research vessel Galathea had collected two manganiferous samples at 159°39'E, 39°45'S, in a water depth of 4800 m; the material consisted of crusts on a whale's earbone and on pumice. Analysis showed metal contents of about 1.25% Ni, 0.6% Cu and 0.18% Co (Ahrens, Willis, & Oosthuizen, 1967), values which were of potential economic significance if a nodule field existed in the region.

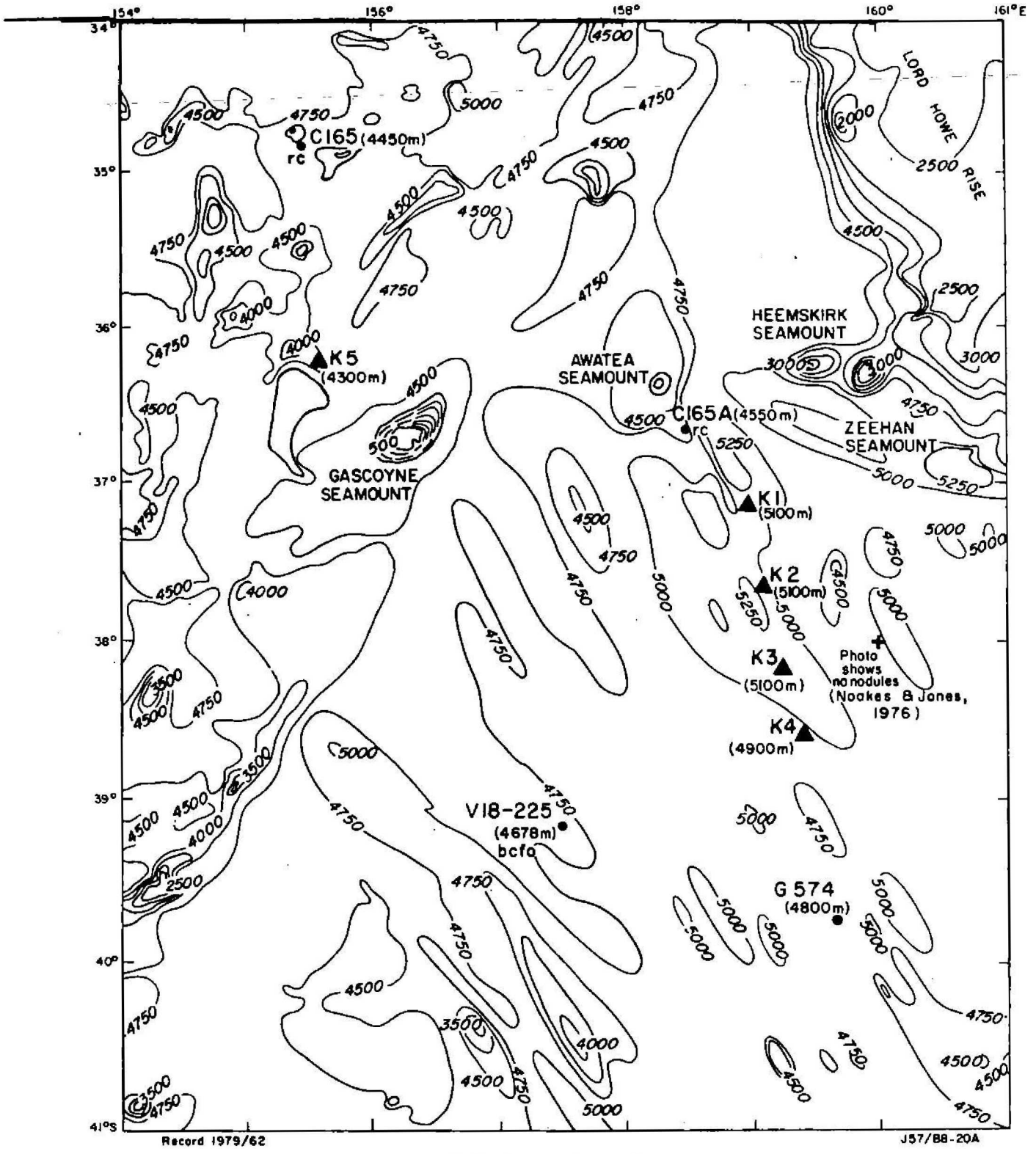
Accordingly the Bureau of Mineral Resources (BMR) and Monash University planned a cruise to search for manganese nodules in the region of the Galathea station (G574, Fig. 1). The cruise took place in HMAS Kimbla from 24 to 29 May 1979; sampling was carried out with Monash University's Benthos free-fall grabs, two to a station, and all grabs were recovered. The grabs sample a bottom area of about 40 x 40 cm, and their round-trip time in the prevailing water depths of 5000 m was about 21/2 hours. Bad weather curtailed the sampling program near the Galathea station after four of the planned six stations had been occupied. Another station was occupied on the return trip to Sydney. Navigation relied on celestial observations and dead reckoning and, given the bad weather, stations may be as much as 10 nautical miles from their listed positions. An echosounder malfunction meant that water depths had to be estimated from charts and from the round-trip times of the free-fall grabs.

The bathymetry in Figure 1 was compiled from 1:1 000 000 GEBCO sounding sheets dated 1974 and 1975, and the 1:1 000 000 Port Jackson and Bellona oceanic charts of the New Zealand Oceanographic Institute dated 1975 and 1977. The chart shows that a north-northeast trending ridge through the Gascoyne Seamount separates the region into two distinctive areas. The southeastern area is dominated by ridges and depressions trending northwestward, and is mostly more than 4750 m deep. The northwestern area is dominated by ridges and depressions trending north-northeastward, and is generally 4500 to 4750 m deep. Stations 1 to 4 were in the southeast in a broad depression generally more than 5000 m deep, and Station 5 was in a local depression (northwest of Gascoyne Seamount) whose maximum depth exceeds 4750 m.

A recent compilation sponsored by the Office of the Geographer, US Department of State (Rawson & Ryan, 1978), shows marl to be the dominant sediment in the region, but local variations depending on topography, water depth and deep ocean currents are to be expected. Conolly (1969) discussed the sediments in the western Tasman Sea, and showed that the carbonate compensation depth lies at about 4500 m. He showed three stations in the area of Figure 1: HMS Challenger recovered red clay from Stations 165 and 165A at depths of about 4600 m, and R.V. Vema recovered brown clayey foraminiferal ooze in Core V18-225 from 4678 m.

I wish to thank the captain of HMAS Kimbla, Commander T.A. Moyes, and his crew, for their unstinted support during the cruise; B. Cruikshank (BMR carried out the chemical analyses. D. Moreton and G. Hicks of Monash University made a major shipboard contribution to the success of the cruise, being responsible for the sampling.

The Benthos grabs recover material in a net with 6 mm mesh. Fine sediment tends to wash out, but enough was recovered to give some idea of the local deepsea sediment. General station data are presented in Table 1.




rc: red clay ; bcfo: brown clayey foram ooze

Fig. 1 Bathymetry, southern Tasman Sea, showing location of Kimbla (K), Galathea(G) Vema (V) and Challenger (C) deep water stations

Table 1. General Station Data

| Station | Position | | Water depth (m) | Recovered |
|---|---|---|---|---|
| | E | S | | |
| 1 | 158°55' | 37°10' | 5100 | A trace of brown clay with small pieces of pumice; pectenoid pelecypod; attached serpulids and forams. BMR Reg No. 79630201. |
| 2 | 159°05' | 37°40' | 5100 | Several grams of brown clay with small pieces of pumice; discoid coral; attached forams. BMR Reg. No. 79630202. |
| 3 | 159°15' | 38°10' | 5100 | Nil |
| 4 | 159°25' | 38°35' | 4900 | Several small pieces of pumice. BMR Reg. No. 79630204. |
| 5 | 155°35' | 36°15' | 4300 | 1-2 kg of greenish grey calcareous mud and two large manganese nodules. BMR Reg. No. 79630205. |

## Sediments sampled

The samples from Stations 1, 2, and 4 indicate that the southeastern sediments are yellowish to reddish brown clays, containing little calcareous material. Pieces of grey pumice about 1 cm across are common; they contain quartz, feldspar, and hornblende phenocrysts, and commonly support encrusting foraminifera and attached horn-shaped serpulids more than 1 cm long. A thin, translucent shell of a pectenoid pelecypod, about 1 cm across, with a white inner part and a colourless rim, was recovered at Station 1. A highly corroded discoid Scleractinian coral, also about 1 cm across, was recovered from Station 2.

The fine fractions of the sediments from Stations 2 and 5 were split into size fractions for microscopic examination; the $CaCO_3$ content was determined by evolution of $CO_2$ at Australian Mineral Development Laboratories, Adelaide. Revelant details are listed in Table 2.

Table 2. Sediment Composition

| Station | Water depth (m) | Weight % carbonate | Weight % of various fractions | | |
|---|---|---|---|---|---|
| | | | Sand >63 μm | Coarse Silt 40-63 μm | Mud <40 μm |
| 2 | 5100 | 0.8 | 0 | 1 | 99 |
| 5 | 4300 | 28.6 | 17 | 4 | 79 |

The sediment at Station 2 is almost entirely mud, but contains a few highly corroded fragments of planktonic foraminifera, a little quartz and glass, and fragments of opaque material (probably iron-manganese oxides). The sediment at Station 5 is also mostly mud, the coarser fractions being dominated by

largely whole but corroded planktonic foraminifera. Other significant components of the sand fraction are calcareous benthonic foraminifera, and siliceous sponge spicules and nets. Fresh angular quartz and feldspar make up about 25 percent of the coarse silt fraction. Minor components of both sand and silt fractions are brown glass, volcanic rock fragments, biotite, manganese micronodules, Radiolaria, echinoid spines, and sponge spicules. The fine fraction consists largely of clay minerals.

Taken as a whole the results indicate that Station 2 lies below the carbonate compensation depth, and Station 5 above it, in accord with Conolly's, (1969) finding that it lies at about 4500 m. In both areas the sediment is dominantly mud (finer than 40 μm), probably largely of volcanic origin. The fresh angular silt-sized quartz and fledspar at Station 5 suggest derivation from acid or intermediate volcanics, perhaps by turbidity currents stemming from the Lord Howe Rise or Gascoyne Seamount. Sediment colours and general character suggest that the sediment milieu in the southeast is oxidising, whereas it is neutral or slightly reducing in the northwest.

## Manganese nodules

The absence of manganese nodules in the southeastern stations suggests that either they are absent there, or their distribution is patchy. Galathea's dredge would have sampled far more of the sea bed than did the free-fall grabs, but it also recovered no true nodules.

The two nodules from Station 5 (dredge 5B) are subspherical, with a rather irregular and rough surface, and are about 10 cm in diameter (Fig. 2). They consist of numerous concentric shells, many less than 0.1 mm thick, of brown to black metal oxides and pale yellowish clay in roughly equal proportions. Enclosed within the shells are pumice fragments up to 1 cm long, which have been almost entirely altered to clay minerals and silica. The cores of both nodules consist of a number of smaller nodules (1-2 cm diameter) formed around pumice fragments. A few radial cracks about a millimetre thick are filled with metal oxides. The high proportion of clay appears to have prevented the growth of the cuspate structures in the concentric shells which characterise

most nodules from the Pacific and Indian Oceans. Changes in the proportions of metal oxides and clay minerals laid down over time can be correlated between the two nodules.

The metal contents of the nodules, after the nodules had been dried at 105°C, were determined at BMR using the atomic absorption method for Mn, Ni, Cu, and Co, and a volumetric method for Fe. The results are presented in Table 3, where they are compared with results from the Galathea station (Ahrens & others, 1967), with results from 24 nodules in the region off eastern Australia between 135°E and 170°E (Noakes & Jones, 1976), and with average values from the northeast Pacific area (Cronan, 1972).

Table 3. Analyses of manganese nodules

| Station/region | Weight % (dry basis) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fe | Mn | Ni | Cu | Co | Ni+Cu | Ni+Cu+Co |
| Kimbla 5B/1 | 16.0 | 6.7 | 0.29 | 0.21 | 0.07 | 0.50 | 0.57 |
| Kimbla 5B/2 | 15.6 | 5.0 | 0.22 | 0.14 | 0.05 | 0.36 | 0.41 |
| Region off eastern Australia | 14.7 | 8.3 | 0.18 | 0.10 | 0.09 | 0.28 | 0.37 |
| Galathea 574 | 8.19 | 26.2 | 1.25 | 0.60 | 0.19 | 1.85 | 2.04 |
| Galathea 574 | 7.33 | 27.3 | 1.30 | 0.60 | 0.18 | 1.90 | 2.08 |
| Northeast Pacific | 9.44 | 22.33 | 1.08 | 0.63 | 0.19 | 1.71 | 1.90 |


Fig. 2. Cross-section through nodules from Station 5.

The Tasman Sea metal values, with moderate Fe and low Mn, Ni, Cu, and Co are comparable to those from elsewhere in the eastern Australian region. In the case of the Tasman Sea nodules at least, the fact that only about half the contained minerals are metallic oxides and hydroxides (the other half consisting largely of clay minerals) helps to explain the low metal values. The Galathea samples, in marked contrast, have a high Mn:Fe ratio, and high contents of Ni, Cu and Co, and are very similar chemically to northeast Pacific nodules. Manganese nodule deposits currently regarded as potentially exploitable have combined Ni-Cu-Co contents in excess of 2 percent, although other factors, particularly nodule density, are also critical: in this context the nodules collected on the Kimbla cruise are of no economic significance.

## Discussion

The Kimbla cruise has shown that manganese nodules can be expected in local depressions in the area west of the Gascoyne Seamount. It has also shown that samples with high metal values such as in the crusts recovered from the Galathea station (159°39'E, 39°45'S) can be expected only in the deep, broad depression extending to the southeast of Gascoyne Seamount. The depression is far from land, is accessible to Antarctic deep water, and is below the carbonate compensation depth, so sedimentation rates are low and oxidising conditions prevail - conditions favourable to the development of nodule fields. Whether any fields of nodules with high metal values exist is still not known; the present sampling density is far too low.

## References

AHRENS, L.H., WILLIS, J.P., & OOSTHUIZEN, C.O., 1967: Further observations on the composition of manganese nodules, with particular reference to some of the rarer elements. Geochimica et Cosmochimica Acta 31, 2169-2180.

CONOLLY, J.R., 1969: Western Tasman Sea floor. N.Z. Journal of Geology & Geophysics, 12, 310-343.

CRONAN, D.S., 1972: Regional geochemistry of ferromanganese nodules in the world ocean. In D.R. Horn (Ed.), Papers from a conference on ferromanganese deposits on the ocean floor. Office of the International Decade of Ocean Exploration, National Science Foundation, Washington, DC., 19-29.

NOAKES, L.C., & JONES, H.A., 1976: Mineral resources off-shore. In C.L. Knight (Ed.), Economic Geology of Australia and Papua New Guinea: 1, Metals. Australasian Institute of Mining and Metallurgy, Monographs, 1093-1104.

RAWSON, M.D., & RYAN, W.B.F., 1978: Map of ocean floor sediment and polymetallic nodules, at a scale of 1:23 230 300. United States Department of State, Office of the Geographer.