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TANG-

Metal contents of manganese nodules from the Southwestern Pacific Basin.

Metallgehalte von Manganknollen aus dem Südwestpazifischen Becken.

Während einer Forschungsfahrt des neuseeländischen Forschungsschiffes Tangaroa waren 1974 große Manganknollenfelder mit hoher Belegungsdichte im Südwestpazifischen Becken bei den Cook-Inseln entdeckt worden (1).
Die inzwischen erfolgte chemische Analyse der Knollen ergab Durchschnittsgehalte von 16,7 % Mn; 21,1 % Fe; o,22 % Cu; o,4o % Ni und o,38 % Co.
Die höchsten Kupfer- und Nickel-Gehalte liegen bei 1 % und damit unterhalb der Grenze von 3 %, die heute im allgemeinen überschritten sein muß, wenn das Erz als ökonomisch interessant angesehen werden soll. Vergleiche von Analysen verschiedene Knollengrößenfraktionen zeigten, daß hier wenig Unterschiede in den chemischen Zusammensetzung bestehen. Auch sind die Wertmetallgehalte in den noch gut erhaltenen vulkanogenen Knollenkernen heute vergleichbar denen in den Rindenzonen.

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During a recent cruise of the New Zealand Oceanographic Institute research vessel Tangaroa to the Southwestern Pacific Basin, an extensive field of manganese nodules was recorded in the region S.W. of Rarotonga (in the Cook Islands Group) where densities in excess of 2o g/m^2 of sediment surface were discovered. Most nodules represent a spheroidic type with large nuclei (fig. 1). Nodules were also found in the region south of Rarotonga but displayed a wide range of morphologies and were generally present in lower abundance.

In order for manganese nodules to be considered of economic grade, two basic criteria need to be satisfied; high surface densities of the nodules on the sea floor and high metal contents. In this case, the first criterion has been satisfied. Here, we report data on the metal contents of the nodules.

Representative samples of nodules from each dredge haul were analyzed for a range of metals using atomic absorption techniques; SiO_2 was determined gravimetrically. Precision of the analytical method was of the order ± 1 to 5 %. In each case, bulk nodule samples were analyzed after grinding them, including the nucleus and after drying at 11o^{o} C.

The results presented in table 1 indicate a total variation in composition of a factor of 1.6 to 3.5 for each element, which is not exceedingly high. This excludes sample 37 DT, manganese crusts taken immediately south of Rarotonga in relatively shallow water, which are characterized by lower contents of Mn, Cu, Ni, Zn and Mo and higher contents of SiO_2 and CaO and obviously contain high proportion of detrital minerals. Compared with nodules from the entire South Pacific (Table 2), nodules

from the Southwestern Pacific Basin are on average higher in Mn, Fe and Co and lower in Cu and Ni. In general, the Mn/Fe ratio of the nodules is less than one but exceeds unity in some samples south of Rarotonga. The Ni/Cu ratio is of the order of a factor of 2 and the cobalt content is relatively high, exceeding the copper values in most cases.

The chemical analyses show certain relations between the elements. Si, Al and Ca are generally representative of the detrital components of the nodules. In this case, however, the character of Ca as a detrital guide element is not very clear. The economically interesting elements Ni, Cu, Zn, Mo and Co are following the manganese. In some cases cobalt is more closely related to the iron.

Nodules of different size from 6 stations were analyzed separately. In spite of the relatively large nuclei of volcanic origin, the metal contents do not differ very much. In 4 cases nodule nuclei and external layers were analyzed separately. Even here the differences are not important especially concerning nickel and copper, thus indicating a postdepositional transformation and element exchange.

Two morphologically differing nodule types from station 63 showed differences in their chemical composition, an observations which could be made also in the North Pacific. There is no relation between water depth and nodule composition within the Southwestern Pacific Basin.

From an economic standpoint, the most important parameter is the combined contents of the ore metals Cu + Ni in the nodules. Here, the Cu + Ni contents sum to a

maximum of 1.o2 % (Fig. 2). In particular nodules from the region S.W. of Rarotonga (where the highest surface densities are encountered) are lower than this value in the range o.35 - o.7o %. Since a combined Cu + Ni content of 3 % is required for the nodules to be of economic interest, it can be inferred that nodules from this region are not of economic grade. Future cruises of the New Zealand Oceanographic Institute to investigate nodule occurrences will be directed to the region of the Samoan Passage, north of the region studied here.

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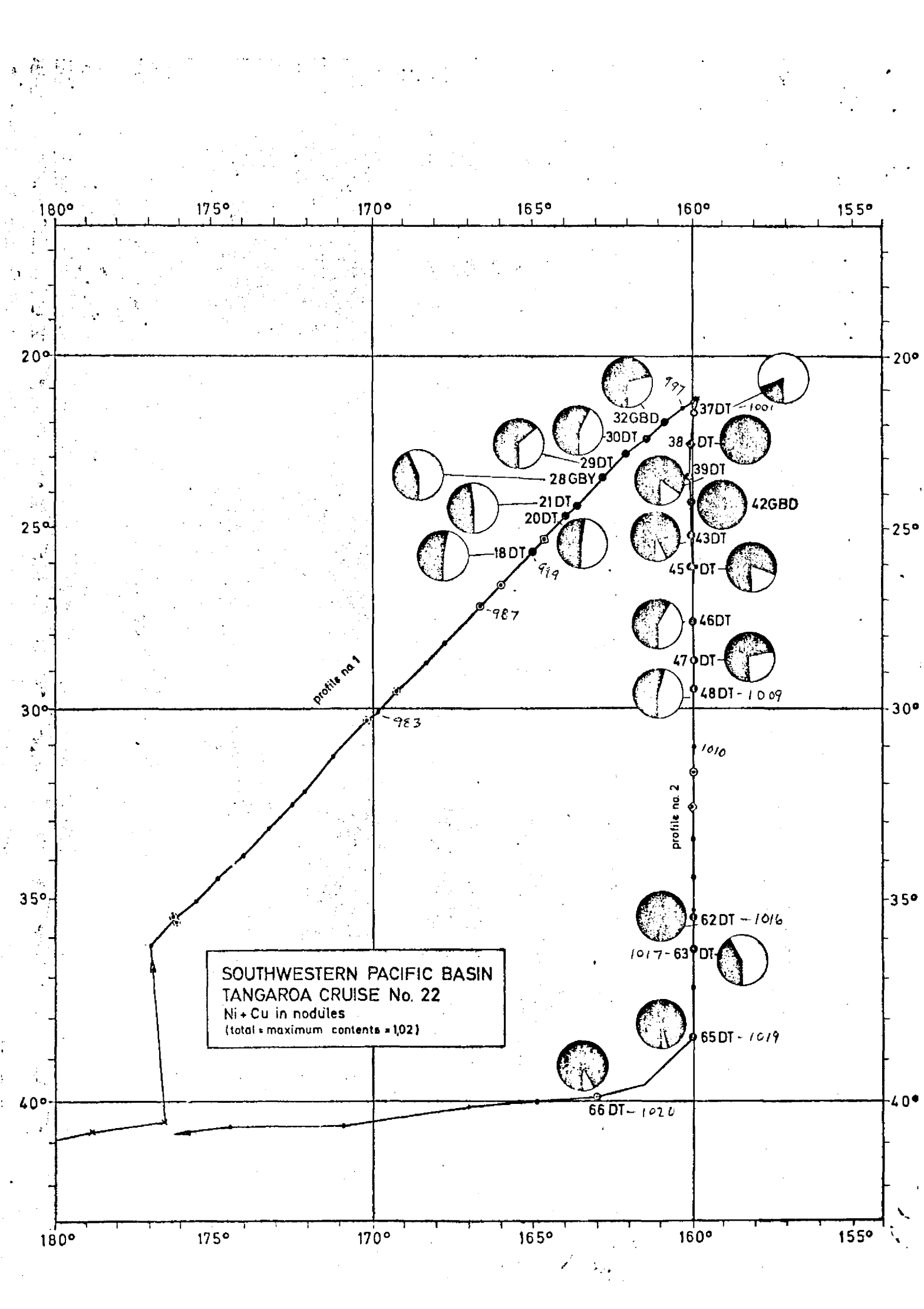
References

(1) Glasby, G.P.; Bäcker, H.; Meylan, M.A.; McDougall, I.C. & Singleton, R.J.:
Nachweis bedeutender Manganknollenfelder im Südwestpazifik bei Neuseeland; mt 5 (1974), 5, 145 - 147.

(2) Glasby, G.P. & Lawrence, P.I.:
Manganese deposits in the South Pacific Ocean.
N.Z. Oceanogr. Inst. Charts, Misc. Ser. 33 - 39 (1974).

Fig. 1


180°
175°
170°
165°
160°
155°
20°
25°
30°
35°
40°
997
32GBD
37DT - 1001
30DT
38 DT
29DT
39DT
28GBY
42GBD
21DT
20DT
43DT
18DT
919
45 DT
987
46DT
47 DT
48DT - 1009
profile no. 1
983
1010
profile no. 2
62DT - 1016
1017 - 63 DT
65DT - 1019
66 DT - 1020
SOUTHWESTERN PACIFIC BASIN
TANGAROA CRUISE No. 22
Ni + Cu in nodules
(total = maximum contents = 1,02)

TANG - 39 nodules

Nr.	H_2O 110°C	% SiO_2	% Mn	% Fe	% AL_2O_3	% CaO	% Cu	% Ni	% Co	% Zn	% Mo	Station, fraction (No of Nodules used)	G
1	29,9	16,81	15,7	23,1	7,2	2,3o	o,21	o,34	o,35	o,o8	o,o2	18DT, 4o-6o(1)	989
2	29,5	16,96	15,3	22,5	7,1	2,18	o,19	o,32	o,34	o,o8	o,o3	18DT, 2o-4o(5)	989
3	27,8	2o,o9	16,5	22,6	7,o	2,11	o,2o	o,38	o,33	o,o8	o,o3	18DT, <2o (6)	989
4	3o,o	19,99	13,5	21,9	8,2	2,11	o,19	o,3o	o,35	o,o6	o,o2	2oDT, 4o-6o(1)	991
5	29,3	18,o1	14,2	23,2	8,o	2,o4	o,21	o,32	o,35	o,o7	o,o2	2oDT, 2o-4o(6)	991
6	27,1	15,71	14,8	26,2	7,o	2,o4	o,22	o,34	o,37	o,o6	o,o2	2oDT, <2o (17)	991
7	3o,6	16,o3	14,6	25,8	6,9	2,14	o,17	o,28	o,41	o,o8	o,o3	21DT, 2o-4o(8)	992
8	28,7	15,33	14,4	26,7	7,o	2,28	o,19	o,26	o,37	o,o8	o,o2	21DT, <2o (22)	992
9	3o,6	19,oo	14,7	22,6	7,9	2,49	o,17	o,26	o,46	o,o6	o,o2	28GBY, 4o-6o(3)	993
1o	32,4	25,88	16,o	23,7	6,6	2,22	o,16	o,29	o,46	o,o7	o,o3	28GBY, 2o-4o(7)	993
11	29,7	14,79	15,6	24,2	6,6	2,18	o,2o	o,3o	o,41	o,o8	o,o3	28GBY, <2o (15)	993
12	41,9	14,46	15,9	26,9	5,2	2,63	o,12	o,23	o,54	o,o7	o,o2	28GBY, O.L. 2o-4o(4)	993
13	3o,5	14,5o	17,5	21,8	5,9	2,24	o,23	o,41	o,48	o,o8	o,o3	29DT, Ø (17)	994
14	32,9	12,51	17,8	23,5	5,4	2,35	o,25	o,44	o,58	o,o8	o,o3	29DT, O.L. (2)	994
15	31,5	17,86	15,2	21,9	7,1	2,89	o,22	o,34	o,43	o,o7	o,o3	3oDT, 6o-8o(1)	995
16	3o,9	16,65	15,3	22,o	6,7	2,9o	o,21	o,34	o,44	o,o9	o,o3	3oDT, 4o-6o (2)	995
17	29,8	15,66	16,o	22,o	6,2	2,75	o,21	o,4o	o,45	o,o8	o,o3	3oDT, 2o-4o(7)	995
18	27,2	14,36	17,o	21,8	6,3	2,48	o,25	o,43	o,46	o,o8	o,o3	3oDT, <2o (15)	995
19	29,4	13,66	19,6	2o,o	6,o	2,99	o,23	o,47	o,52	o,o7	o,o4	32GBD, Ø (4)	996
20	48,4	25,o2	8,9	2o,2	7,o	4,82	o,o6	o,13	o,3o	o,o5	o,o1	37DT, Ø (2o)	1001
21	21,3	14,85	19,8	17,6	7,o	2,29	o,32	o,7o	o,42	o,o9	o,o4	38DT, small n. (5)	1002
22	25,9	27,21	12,9	14,1	1o,4	1,84	o,27	o,64	o,2o	o,o8	o,o3	38DT, inf.rock (7)	1002
23	28,2	15,87	17,5	19,1	7,o	2,21	o,31	o,54	o,43	o,o9	o,o4	39DT, Ø (38)	1003
24	28,2	13,9o	21,2	17,6	6,3	2,87	o,32	o,7o	o,45	o,o9	o,o4	42GBb, Ø<4o (12)	1004
25	31,8	17,31	19,o	17,1	7,4	2,39	o,37	o,57	o,38	o,o9	o,o4	43DT, 6o-8o(1)	1005
26	29,6	19,34	16,4	18,4	7,9	2,19	o,26	o,53	o,37	o,o7	o,o3	45DT, Ø (11)	100
27	29,o	22,38	13,8	13,9	8,5	1,97	o,2o	o,39	o,35	o,o7	o,o2	46DT, Ø<4o(2o)	100
28	38,8	14,66	16,o	26,4	4,6	2,5o	o,11	o,26	o,57	o,o7	o,o2	46DT, O.L. (1o)	100
29	27,1	15,72	16,3	22,o	7,1	2,o1	o,27	o,44	o,38	o,o8	o,o3	47DT, Ø (3o)	100
3o	28,8	16,3o	15,2	23,2	6,7	2,o9	o,19	o,35	o,37	o,o8	o,o3	48DT, Ø<4o(25)	100
31	47,1	15,8o	14,6	23,3	-	2,31	-	o,2o	o,42	o,o8	-	52DT, Ø crusts (1o)	1012
32	26,1	21,85	19,9	12,9	8,o	2,57	o,34	o,66	o,22	o,1o	o,o3	62DT, Ø<4o(15)	1016
33	2o,1	19,49	18,1	17,6	7,6	2,4o	o,23	o,47	o,27	o,o8	o,o3	63DT, poly (1)	1017
34	3o,o	18,62	18,3	2o,7	6,5	2,27	o,16	o,32	o,31	o,o7	o,o2	63DT, 2o-4o(3)	1017
35	3o,5	19,4o	15,1	21,4	6,4	2,1o	o,13	o,26	o,32	o,o7	o,o3	63DT, 4o-6o(3)	1017
36	31,2	18,12	15,9	22,4	5,8	2,51	o,13	o,31	o,36	o,o7	o,o2	63DT, O.L. 2o-6o(5)	101
37	29,6	2o,27	15,o	21,7	7,1	2,24	o,14	o,24	o,29	o,o6	o,o3	63DT, core 2o-4o(2)	1017
38	27,1	15,85	18,1	11,1	7,8	2,31	o,32	o,65	o,19	o,1o	o,o3	65DT, Ø (1o)	1019
39	28,o	21,78	19,o	14,4	6,8	2,2o	o,31	o,61	o,18	o,12	o,o3	66DT, Ø (8)	1021

Table 1

Table 2

	S.W. Pacific Basin	South Pacific
Mn	16.7	15.9
Fe	21.1	14.2
Cu	o.22	o.29
Ni	o.4o	o.55
Co	o.38	o.28

Figure captions

Fig.1 Spheroidic-botryoidal nodules from the Southwestern Pacific Basin recovered during the Tangaroa cruise 22, Station TA22 - 63 DT, 5450 m water depth.
Diameter of the largest nodule is 55 mm.

Fig.2 Location of the analyzed nodules and regional distribution of the combined copper and nickel content. Full circle = maximum content at station 42 (1,02 % Ni + Cu).

Table 1 Analyses of nodules (PREUSSAG laboratory Berkhöpen). Analyses made of dried powdered whole nodules (total dissolution). SiO_2 determined gravimetrically, the other components by atomic absorption. Size fractions in mm; O.L. = outer layer. Ø = average; n. = nodules; inf. = infiltrated; poly = polynucleate nodules).

Table 2 Comparison of mean analysis of manganese nodules from the Southwestern Pacific Basin (this study) and of the entire Southn Pacific, calculated from (2).