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Geologic reconnaissance and geochemical analysis of ferromanganese crusts of the Ratak Chain, Marshall Islands

by

W.C. Schwab[1], A.S. Davis[2] J.A. Haggerty[3] T.H. Ling[1] and J.A. Commeau[1]

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1. Woods Hole, Mass.
2. Menlo Park, Cal.
3. University of Tulsa, Okla.

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INTRODUCTION

The U.S. Geological Survey R/V S.P. LEE (cruise L9-84-CP) left Majuro, Ratak chain of the Marshall Islands, on July 28, 1984 and reached Hawaii on August 15, 1984. The main objective of this cruise was to study the distribution and composition of ferromanganese-oxide crusts in the Marshall Islands area (Fig. 1). A total of 5410 km of 12-kHz and 3.5-kHz seismic-reflection data, and 730 km of 80-in^3 to 148-in^3 airgun seismic-reflection data were collected. A description of these data and the ship-tracklines are presented in Schwab and Bailey (1984). This open-file report describes the types of samples collected and tabulates the results of our preliminary geochemical analyses of the ferromanganese-oxide crusts.

DISCUSSION

The existence of ferromanganese-oxide precipitates that encrust the hard substrate of sea-floor edifices, such as seamounts, guyots, atolls, island slopes, and linear volcanic ridges, have been known for several decades (Cronan, 1977; Frazer and Fisk, 1980), but were not studied in a detailed, systematic way until the German MIDPAC expedition of 1981 (Halbach and others, 1982). These ferromanganese-oxide crusts are predominantly hydrogenous in origin, in contrast to abyssal ferromanganese nodules, which have a substantial diagenetic input (Halbach and others, 1981). Their concentrations of trace metals, such as cobalt, nickel, and platinum, are higher than those of abyssal ferromanganese nodules and hydrothermal crusts from spreading centers (Toth, 1968; Craig and others, 1982; Halbach and others, 1984) and thus, appear to be a potential target for commercial exploitation.

The sampling equipment used and the types of samples collected in this reconnaissance study are listed on Table 1. Eighteen stations were occupied; 13 dredge hauls were collected on seamount, atoll, and island flanks and three box cores were taken from the sediment cap of an unnamed seamount in the north Marshall Islands (Fig. 1). Every dredge haul recovered ferromanganese-oxide crusts, agreeing with the inferences of Halbach and Feller (1980) that crusts form on every hard substrate where currents or other factors preclude significant sedimentation. These samples can be viewed and studied at the U.S. Geological Survey offices in Menlo Park, Cal.

Preliminary chemical analyses of bulk samples of Marshall Islands ferromanganese-oxide crusts were conducted using x-ray fluorescence techniques (Table 2). The average values of manganese (26.02%), iron (15.43%), copper (0.11%), titanium (1.09%), calcium (2.41%), phosphorous (0.38%), cobalt (1.01%), and nickel (0.50%) obtained from the Marshall Islands crusts agree with the mean composition of seamount crusts from the Mid-Pacific Mountains and the Line Islands Ridge collected during the MIDPAC-81 expedition (Halbach and Manheim, 1984). In our view, the preliminary results of the L9-84-CP cruise, along with the findings of the MIDPAC-81 expedition, encourage more serious economic and technical evaluation of ferromanganese-oxide crusts within the central Pacific basin.

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Table 1. Station Operation

Sample Number	Date of Occupation	Latitude	Longitude	Water Depth (m)	Sampling Device	Samples Collected
D1 Majuro Atoll	J.D.210	07°15.0'N	171°00.5'E	2250-2230	Chain Dredge	10 kg volcanic breccia with thin Mn oxide crust
D2 Majuro Atoll	J.D.210	07°14.1'N	171°0.3'E	1480-1500	Chain Dredge	250 kg poorly indurated limestone with thein Mn oxide crust
D3 Majuro Atoll	J.D.210	07°15.5'N	170°59.1'E	2000-3100	Chain Dredge	1 kg basalt and limstone coquina
D4 Unnamed Seamount	J.D.211	08°44.8'N	169°44.3'E	3550	Chain Dredge	4 kg volcanic breccia with phosphatized limestone matrix and rounded basalt cubbles
D6 Unnamed Seamount	J.D.211	08°45.3'N	169°47.5'E	2900	Chain Dredge	150 kg volcanic breccia in phosphatized limestone matrix, angular pieces of basalt, and pieces of Mn oxide crust without substrate. Mn oxide crust up to 4 cm thick
D10 Jemo Island	J.D.213	10°05.1'N	169°36.6'E	1000-1680	Chain Dredge	2 kg limestone with thin Mn oxide coating
D12 Unnamed Seamount	J.D.214	11°01.2'N	170°10.6'E	1575-2000	Pipe Dredge	0.25 kg Mn oxide crust without substrate; crust about 3 cm thick
D13 Unnamed Seamount	J.D.214	11°00.5'N	170°12.2'E	2000	Chain Dredge	1.0 kg of Mn oxide crust without substrate; about 2 cm thick
D14 Unnamed Seamount	J.D.215	11°00.3'N	170°13.8'E	1800	Chain Dredge	0.6 kg of Mn oxide crust without substrate; about 2 cm thick
D15 Unnamed Seamount	J.D.216	12°11.0'N	168°59.7'E	1300-1800	Chain Dredge	50 kg volcanic breccia with phosphatized chalk matrix, loose basalt pebbles, and Mn oxide crust (3 cm thick) without substrate
D17 Unnamed Seamount	J.D.217	13°54.3'N	167°37.6'E	1600	Chain Dredge	3 kg chalk with Mn oxide crust (ranging in thickness from 5 mm to 4 cm)
D18 Unnamed Seamount	J.D.217	13°54.0'N	167°39.2'E	1600	Chain Dredge	50 kg volcanic breccia with phosphatized chalk matrix with Mn oxide crusts up to 6 cm thick
BC1 Unnamed Seamount	J.D.218	13°55.6'N	167°27.7'E	1380	Box Core	5 cm of penetration. Recovered a nannoplankton-foram ooze.
BC2 Unnamed Seamount	J.D.218	13°55.7'N	167°26.8'E	1380	Box Core/ Bottom Camera	40 cm of penetration. Recovered a nannoplankton-foram ooze along with a bottom photo
BC3 Unnamed Seamount	J.D.218	13°54.8'N	167°35.6'E	1395	Box Core/ Bottom Camera	30 cm of penetrstion. Recovered a nannoplankton-foram ooze along with a bottom photo
D20 Taongi Attol	J.D.218	14°32.5'N	169°0.2'E	1700-2000	Chain Dredge	1.5 kg limestone coquina with thin Mn oxide coating

Table 2. Mean composition of ferromanganese-oxide crusts in weight percent dry matter (110°C)

Sample #	Average Thickness	Si	Al	Mg	Cu	Ni	Co	Fe	Ti	Mn	Ca	K	P
D1	0.1 cm	2.60	0.57	0.97	0.09	0.55	1.27	14.71	0.97	26.51	2.47	0.48	0.37
D4	0.3 cm	2.99	0.70	0.90	0.08	0.30	0.83	17.99	1.13	23.79	2.23	0.42	0.36
D6	2.0 cm	1.93	0.92	1.03	0.08	0.65	1.33	13.37	1.24	28.76	2.28	0.52	0.29
D12	2.5 cm	3.71	1.03	0.88	0.10	0.50	0.76	16.04	1.14	24.32	2.17	0.50	0.33
D13	2.0 cm	3.27	0.94	0.91	0.09	0.49	1.11	15.97	1.14	25.77	2.19	0.51	0.33
D14	1.0 cm	1.36	0.74	1.00	0.12	0.62	1.10	13.18	1.20	28.43	3.21	0.46	0.55
D15	3.0 cm	2.06	0.47	0.85	0.18	0.46	0.87	15.80	0.93	25.89	2.40	0.44	0.39
D17	2.0 cm	2.43	0.64	0.98	0.11	0.54	0.96	14.61	1.03	26.84	2.46	0.48	0.35
D18	3.0 cm	3.70	0.91	0.89	0.11	0.41	0.89	17.20	1.01	23.90	2.31	0.50	0.41

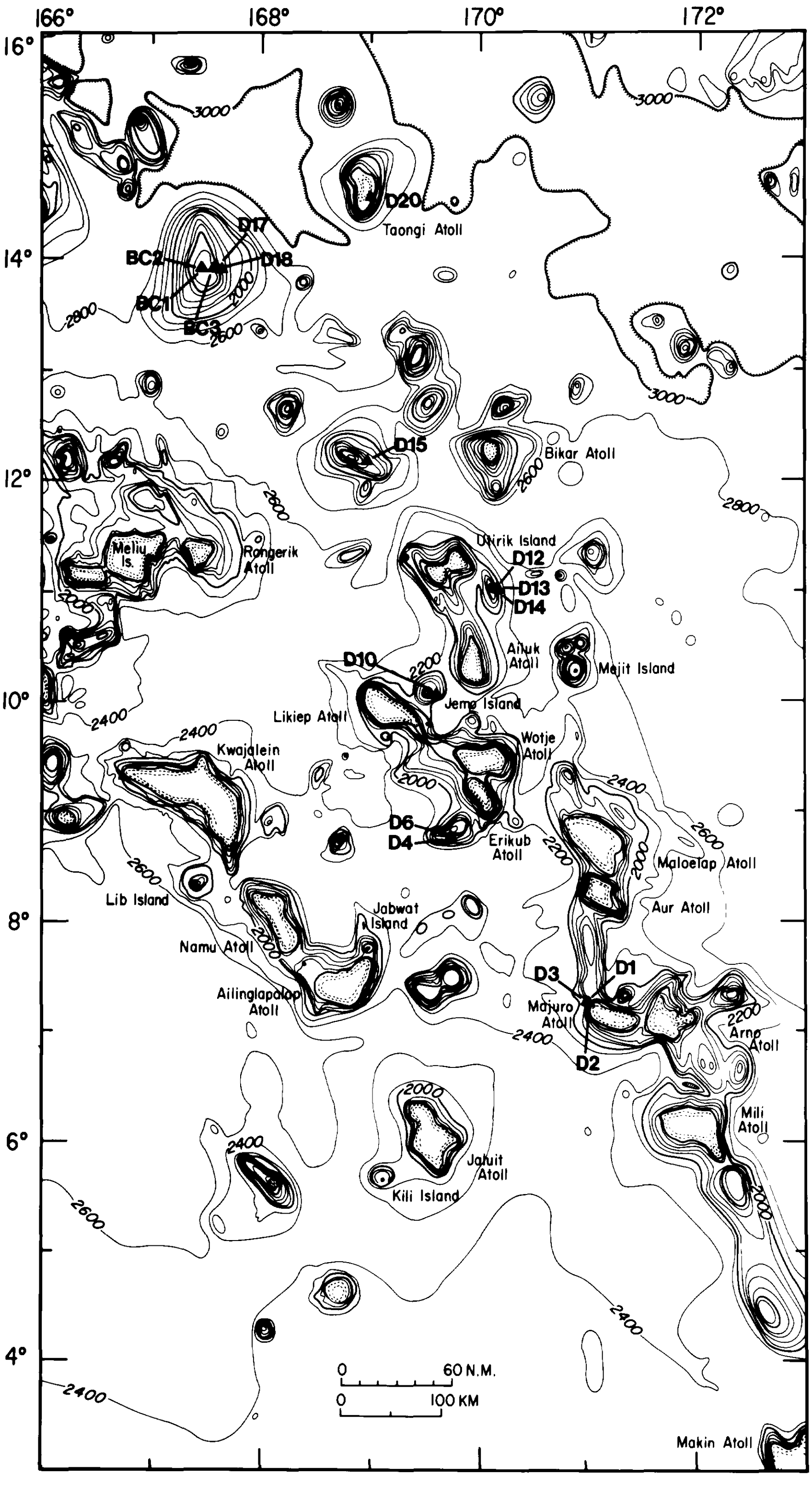

Figure 1. Bathymetric map of the Radak chain of the Marshall Islands (from Chase and others, 1971) showing sample locations. The contour interval is 200 m.