

Supplementary Material: Controls on Critical Metal Enrichments in Ferromanganese Nodules from the Philippine Sea, at Water Depths of 4400–6000 m

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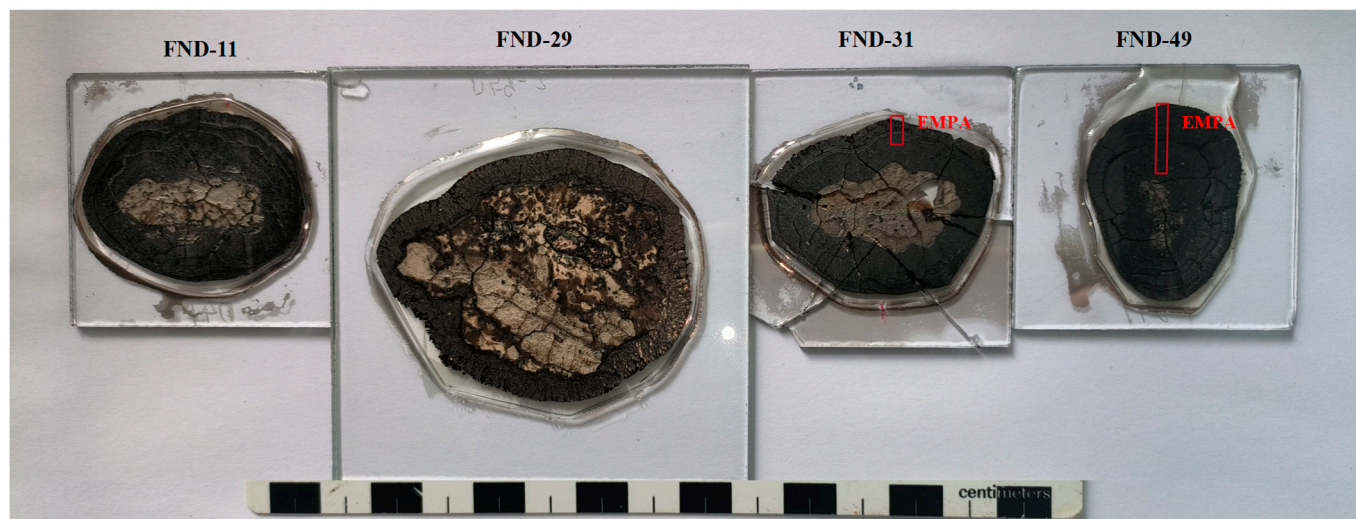


Figure S1. The cross sections of the nodules. Red rectangles are the investigated sections of EMPA.

Table S1. Locations and depths of the samples.

Sample Name	Longitude (°E)	Latitude (°N)	Water Depth (m)
FND-11	135°53'43.843"	16°28'12.692"	4971
FND-12	135°32'5.214"	16°28'13.515"	5177
FND-29	135°10'44.597"	17°2'57.854"	4433
FND-31	134°27'37.333"	17°2'48.859"	5350
FND-32	134°5'51.015"	17°2'54.187"	5496
FND-36	134°6'20.249"	17°19'24.407"	5499
FND-37	133°22'36.247"	17°20'3.366"	5920
FND-39	134°5'57.828"	17°37'47.846"	5682
FND-43	132°39'16.189"	17°37'39.036"	6008
FND-47	132°39'18.193"	18°13'48.722"	6017
FND-48	132°39'34.076"	18°30'45.545"	5921
FND-49	132°39'23"	18°47'29"	5905

Table S2. Trace element compositions of the three types of this study (LA-ICP-MS).

Samples	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y	Mn	Fe	ΣREE	$Eu_{SN}/Eu^*_{SN}{}^2$	$Ce_{SN}/Ce^*_{SN}{}^3$
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)		
Type-1-1	389.42	1695.74	84.89	358.10	83.76	19.55	87.46	12.86	79.52	16.17	45.27	6.21	42.84	6.46	291.33	242103.7	257896.3	3235.75	1.07	2.15
Type-1-2	354.84	1718.71	81.19	340.07	73.87	18.57	79.84	11.52	74.28	15.19	40.60	5.60	38.86	6.06	269.08	257345.1	242654.9	3143.45	1.13	2.34
Type-1-3	282.72	1483.95	64.29	266.13	59.03	15.50	65.33	9.69	60.39	228.58	12.81	37.46	5.33	37.41	5.66	295166.5	204833.5	2647.05	1.16	2.54
Type-1-4	305.79	1728.21	68.94	296.88	66.29	16.71	72.50	10.94	66.52	13.54	37.47	5.56	37.62	6.20	250.69	254791.8	245208.2	2997.40	1.13	2.75
Type-2-1	328.30	2374.82	83.21	353.72	76.92	17.67	72.33	10.74	58.89	10.71	28.67	4.10	25.93	3.77	187.30	92850.2	407149.8	3647.78	1.11	3.31
Type-2-2	314.01	1803.91	78.55	340.90	76.37	17.87	86.12	12.52	63.94	10.96	32.46	3.67	26.66	3.95	186.15	100316.2	399683.8	3068.98	1.03	2.65
Type-3-1	91.02	322.50	23.65	100.70	23.95	5.26	22.44	2.98	17.60	3.18	8.81	1.24	9.32	1.29	56.25	446919.7	53080.3	693.38	1.07	1.60
Type-3-2	95.80	321.78	21.65	87.13	18.07	5.05	22.92	3.03	19.49	3.89	10.97	1.58	11.45	1.65	72.49	436752.5	63247.5	700.84	1.14	1.63
Standard Samples																				
GBW07295	22.00	46.01	5.95	27.05	6.08	2.07	8.62	1.06	6.39	1.18	3.46	0.47	3.35	0.36	30.20	1534.35	94517.18	--	--	--
GBW07295	25.04	49.24	6.02	26.01	6.12	1.92	6.18	0.84	6.37	1.17	3.01	0.49	3.08	0.38	30.19	1405.33	87091.66	--	--	--

1. ΣREE = sum of rare earth elements. 2. Eu_{SN}/Eu^*_{SN} is Eu anomaly normalized to PAAS values. $Eu_{SN}/Eu^*_{SN} = 2 * Eu_{SN} / (Sm_{SN} + Gd_{SN})$. 3. Ce_{SN}/Ce^*_{SN} is Ce anomaly normalized to PAAS values. $Ce_{SN}/Ce^*_{SN} = 2 * Ce_{SN} / (La_{SN} + Pr_{SN})$. Dashed lines mean no calculated values for Standard Samples.

Table S3. Test chemical compositions values of the standard materials (XRF and ICP-MS).

Samples	SiO ₂	Al ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	P ₂ O ₅	MnO	TFe ₂ O ₃	Loss On ^b	Li	Cu	Co	Ni
	(%)											(ppm)			
Standard Samples															
GBW07295	15.3	5.0	2.9	3.1	1.0	2.8	1.2	0.9	31.5	15.4	15.6	79	6885	2893	10180
GBW07295	15.7	5.1	2.7	3.2	1.0	2.7	1.5	0.7	31.7	15.3	15.3	80	6879	2886	10180
Standard Samples															
Samples	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y
	(ppm)														
GBW07295	178	625	49	205	48	11.86	49.24	7.64	42.20	8.25	21.96	3.11	20.49	3.00	135.50
GBW07295	179	628	49	198	46	11.58	48.65	7.64	42.18	8.25	21.41	3.10	20.22	2.94	135.30