

APPENDIX 7. ESTIMATED MEAN OCEANIC CONCENTRATIONS OF THE ELEMENTS

Atomic number	Element	Species	Type of distribution ^a	Oceanic mean concentration (ng kg ⁻¹)
1	Hydrogen	H ₂ O	—	—
2	Helium	Dissolved gas	c	7.6
3	Lithium	Li ⁺	c	180 × 10 ³
4	Beryllium	BeOH ⁺	s + n	0.21
5	Boron	B(OH) ₃	c	4.5 × 10 ⁶
6	Carbon	Inorganic ΣCO ₂	n	27.0 × 10 ⁶
7	Nitrogen	Dissolved N ₂	c	8.3 × 10 ⁶
		NO ₃ ⁻	n	0.42 × 10 ⁶
8	Oxygen	Dissolved O ₂	inverse n	2.8 × 10 ⁶
9	Fluorine	F ⁻	c	1.3 × 10 ⁶
10	Neon	Dissolved gas	c	160
11	Sodium	Na ⁺	c	10.78 × 10 ⁹
12	Magnesium	Mg ²⁺	c	1.28 × 10 ⁹
13	Aluminum	Al(OH) ₃ ⁰	s	30
14	Silicon	H ₄ SiO ₄ ⁰	n	2.8 × 10 ⁶
15	Phosphorus	NaHPO ₄ ⁻	n	62 × 10 ³
16	Sulfur	SO ₄ ²⁻	c	898 × 10 ⁶
17	Chlorine	Cl ⁻	c	19.35 × 10 ⁹
18	Argon	Dissolved gas	c	0.62 × 10 ⁶
19	Potassium	K ⁺	c	399 × 10 ⁶
20	Calcium	Ca ²⁺	almost c	412 × 10 ⁶
21	Scandium	Sc(OH) ₃ ⁰	(s + n)	0.7
22	Titanium	Ti(OH) ₄ ⁰	s + n	6.5
23	Vanadium	NaHVO ₄ ⁻	almost c	2.0 × 10 ³
24	Chromium	CrO ₄ ²⁻ (VI)	r + n	210
		Cr(OH) ₃ ⁰ (III)	r + s	2
25	Manganese	Mn ²⁺	s	20
26	Iron	Fe(OH) ₃ ⁰	s + n	30
27	Cobalt	Co(OH) ₂ [?]	s	1.2
28	Nickel	Ni ²⁺	n	480
29	Copper	CuCO ₃ ⁰	s + n	150
30	Zinc	Zn ²⁺	n	350
31	Callium	Ga(OH) ₄ ⁻	s + n	1.2
32	Germanium	H ₄ GeO ₄ ⁰	n	5.5
33	Arsenic	HAsO ₄ ²⁻ (V)	r + n	1.2 × 10 ³
		As(OH) ₃ ⁰ (III)	r + s	5.2
34	Selenium	SeO ₄ ²⁻ (VI)	r + n	100
		SeO ₃ ²⁻ (IV)	r + n	55
35	Bromine	Br ⁻	c	67 × 10 ⁶
36	Krypton	Dissolved gas	c	310
37	Rubidium	Rb ⁺	c	0.12 × 10 ⁶
38	Strontium	Sr ²⁺	almost c	7.8 × 10 ⁶
39	Yttrium	YCO ₃ ⁺	n	17
40	Zirconium	Zr(OH) ₅ ⁻	s + n	15
41	Niobium	Nb(OH) ₆ ⁻	almost c	0.37
42	Molybdenum	MoO ₄ ²⁻	c	10 × 10 ³
43	Technetium	TcO ₄ ⁻	—	—
44	Ruthenium	RuO ₄ ⁻	?	< 0.005
45	Rhodium	Rh(OH) ₃ ⁰ ?	n	0.08
46	Palladium	PdCl ₄ ²⁻ ?	n	0.06
47	Silver	AgCl ₂ ⁻	n	2
48	Cadmium	CdCl ₂ ⁰	n	70
49	Indium	In(OH) ₃ ⁰	s	0.01
50	Tin	SnO(OH) ₃ ⁻	s	0.5

Appendix 7 *Continued*

Atomic number	Element	Species	Type of distribution ^a	Oceanic mean concentration (ng kg ⁻¹)
51	Antimony	Sb(OH) ₆ ⁻	s?	200
52	Tellurium	Te(OH) ₆ ⁰	r + s	0.05
		TeO(OH) ₃ ⁻	r + s	0.02
53	Iodine	IO ₃ ⁻	almost c	58 × 10 ³
		I ⁻	(r + s)	4.4
54	Xenon	Dissolved gas	c	66
55	Cesium	Cs ⁺	c	306
56	Barium	Ba ²⁺	n	15 × 10 ³
57	Lanthanum	LaCO ₃ ⁺	n	5.6
58	Cerium	Ce(OH) ₄ ⁰	s	0.7
59	Praseodymium	PrCO ₃ ⁺	n	0.7
60	Neodymium	NdCO ₃ ⁺	n	3.3
61	Promethium	—	—	—
62	Samarium	SmCO ₃ ⁺	n	0.57
63	Europium	EuCO ₃ ⁺	n	0.17
64	Gadolinium	GdCO ₃ ⁺	n	0.9
65	Terbium	TbCO ₃ ⁺	n	0.17
66	Dysprosium	DyCO ₃ ⁺	n	1.1
67	Holmium	HoCO ₃ ⁺	n	0.36
68	Erbium	ErCO ₃ ⁺	n	1.2
69	Thulium	TmCO ₃ ⁺	n	0.2
70	Ytterbium	YbCO ₃ ⁺	n	1.2
71	Lutetium	LuCO ₃ ⁺	n	0.23
72	Hafnium	Hf(OH) ₅ ⁻	s + n	0.07
73	Tantalum	Ta(OH) ₅ ⁰	s + n	0.03
74	Tungsten	WO ₄ ²⁻	c	10
75	Rhenium	ReO ₄ ⁻	c	7.8
76	Osmium	OsO ₄ ⁰	almost c	0.009
77	Iridium	Ir(OH) ₃ ⁰	s?	0.00013
78	Platinum	PtCl ₄ ²⁻	c	0.05
79	Gold	AuOH(H ₂ O) ⁰	c	0.02
80	Mercury	HgCl ₄ ²⁻	(s + n)	0.14
81	Thallium	Tl ⁺	c	13
82	Lead	PbCO ₃ ⁰	anth. + s	2.7
83	Bismuth	Bi(OH) ₃ ⁰	s	0.03
84	Polonium	PoO(OH) ₃ ⁻	s	—
85	Astatine	—	—	—
86	Radon	Dissolved gas	c	—
87	Francium	Fr ⁺	—	—
88	Radium	Ra ²⁺	n	0.00013
89	Actinium	AcCO ₃ ⁺	n	—
90	Thorium	Th(OH) ₄ ⁰	s	0.02
91	Protactinium	PaO ₂ (OH) ⁰	s	—
92	Uranium	UO ₂ (CO ₃) ₃ ⁴⁻	c	3.2 × 10 ³
93	Neptunium	NpO ₂ ⁺	—	—
94	Plutonium	PuO ₂ (CO ₃)(OH) ⁻	(r + s)	—
95	Americium	AmCO ₃ ⁺	(s + n)	—

^ac, conservative; n, nutrient-like; s, scavenged; r, redox sensitive; anth., anthropogenic.

Vertical Profiles of Elements in the North Pacific Ocean

(compiled by Y. Nozaki, 2001)

