TABLE 2 Concentration and source of biologically important chemical species in submarine hydrothermal vent environments[a]

Chemical species	Vent fluids conc/kg SW	Seawater conc/kg	Sources in vents	Biological significance
CO_2	3.9–215 mmol	2.3 mmol	Magma degassing, water/rock reactions, fermentation	Carbon source for chemoautotrophs and methanogens
CH_4	0.05–4.5 mmol	0.3 nmol	Magma degassing, reduction of CO_2, methanogenesis	Aerobic and anaerobic microbial oxidation
H_2	0.1–50 mmol	0.3 nmol	Magma degassing, water/rock reactions, microbial fermentation	Methanogenesis; aerobic and anaerobic oxidation by microorganisms
S (as H_2S)	3–110 mmol	Not detected 28 mmol (as SO_4^{2-})	Water/rock reactions, chemical reduction to anhydrate, microbial reduction of SO_4^{2-}	H_2S is the primary energy source for aerobic chemoautotrophs including symbionts; oxidized sulfur species reduced by high diversity of microorganisms; present in some amino acids and Fe-S clusters as protein cores
N (as NH_3 or NH_4^+)	<0.01–1 mmol[a]	<0.01 mmol 30 μ mol (as NO_3^-)	Organic-N in buried sediments, possibly N_2-fixation by microorganisms and/ or chemical reduction of N_2[b]	A source of nitrogen for subsurface microorganisms; oxidation to NO_3^- or NO_2^- by nitrifying bacteria
P (as PO_4^{2-})	0.5 μ mol	2.5 μ mol	Water/rock reactions (P_2O_5 in basalts), SW PO_4^{2-}	All organisms require P for nucleic acids, energy reactions and fatty acids; animals and aerobic microbes use SW-PO_4^{2-} and/or detrital organic PO_4^{2-} compounds
Fe	0.009–18 mmol as Fe(II)	<1 nmol	Water/rock reactions (12% iron in crust), major component of sulfides as pyrite	Energy source for Fe(II) oxidizing bacteria. Fe(III) as electron acceptor for specific groups of vent microbes. Trace element required by all organisms
Mn	0.1–4.5 mmol as Mn(III)	<1 nmol	Water/rock reactions	Energy source for Mn(III) oxidizing bacteria. Trace element required by all organisms
Si	2.7–23 mmol	0.16 mmol	Water/rock reactions, SW entrainment, major component of outer layers of sulfide deposits	Some evidence for microbially mediated Si precipitation in sulfides

(*Continued*)

TABLE 2 (*Continued*)

Chemical species	Vent fluids conc/kg SW	Seawater conc/kg	Sources in vents	Biological significance
Zn	2–100 μmol	0.01 μmol	Water/rock reactions, major component of sulfides as pyrite	Trace element required for key enzymes including alkaline phosphatase and RNA polymerase
Cu	0.02–44 μmol	0.007 μmol	Water/rock reactions, major component of sulfides as chalopyrite	Trace element required for enzymes including oxidative enzymes involved in electron transfer; component of haemocyanin in arthropods; toxic in μ mol concentrations
Co	20–200 nmol	0.03 nmol	Water/rock reactions	Trace element required by all organisms usually involving enzymes requiring B_{12} coenzymes (contain Co)
Cd	1–180 nmol	<1 nmol	Water/rock reactions	Toxic to all organisms in nmol levels; binds to S, N centers of proteins and DNA
Pb	9–359 nmol	0.01 nmol	Water/rock reactions	Toxic to all organisms in nmol levels
Mo	1–33 nmol	<1 nmol	Water/rock reactions	Trace element required for specific enzymes including nitrogenase
W[c]	<0.01–2.1 μmol	<1 nmol	Water/rock reactions	Trace element required for specific enzymes by hyperthermophilic archaea
Ni[c]	<0.01–53 μmol	<1 nmol	Water/rock reactions	Important component in coenzymes (F-430) of methanogens and enzymes of hyperthermophilic archaea

[a]Chemical data from Butterfield et al. 1995; Elderfield & Schultz 1996; Lilley et al. 1993; Von Damm 1990, 1995.

[b]There are experimental data for the reduction of N_2 to NH_3 under hydrothermal vent conditions (Brandes et al. 1998).

[c]Data from high temperature fluids from nine different sites at Endeavour on the Juan de Fuca Ridge (Baross & Adams, unpublished).