Geochemistry of an endorheic thalassohaline ecosystem:

The Dziani Dzaha crater lake (Mayotte Archipelago, Indian Ocean)

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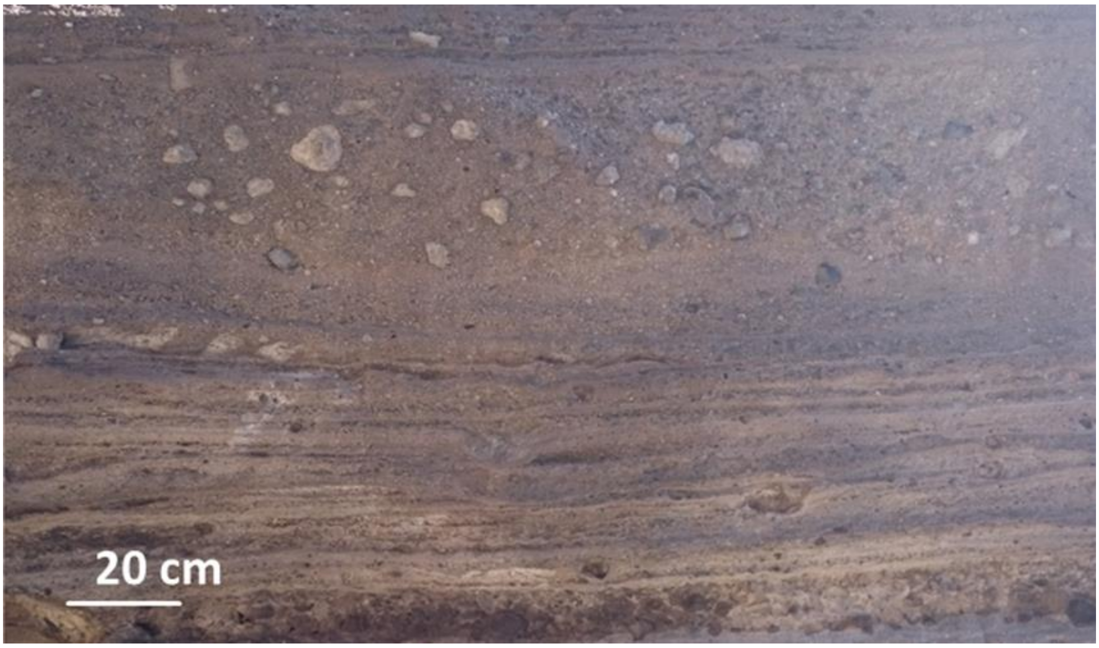
Supplementaries

Supplementary 1



Fragments of igneous rocks embedded in layers of ashes and pumices outcropping on the external East edge of the crater. (Nov. 2015)

Supplementary 2

Materials and Methods

Meteorological parameters

Average daily air temperature (24 h), rain fall, average daily wind speed (24 h at 10 m height) and irradiance were provided by Météo France from the Pamandzi airport station located 3.9 km South of the lake. Fig. 3 shows the periodic variations in air temperature (together with water temperatures at different depths) while Fig. 4 shows the daily recording of the rain height. Time serie of irradiance is shown in supplementary 3.

***In situ* measurements in the water column**

A permanent record of the water column temperatures has been done from April 2012 to November 2017 using five SBE 56T (SeaBird instruments) temperature sensors immersed along an anchored line at 0.5, 1, 2, 3 and 4m depth. The time step was set to 10 min. Precision is ± 0.005 °C. Since temperatures recorded at 3 and 4 m depth were quite the same, the 3m sensor was not replaced during the periodic control in November 2015. At the beginning of each sampling campaign, the halocline and O_2 gradients were localized at the two sampling stations (CLB site 4m depth and Deep Site (DS) 17 to 18 m depth). This was performed by *in situ* measurements using a multiparameter probe (YSI 6600) which records depth, temperature, salinity, dissolved O_2, pH and Eh.

The lake water level was continuously recorded at 5 min resolution with a limnigraph (OTT Orpheus Mini, accuracy ± 0.2 cm), set up close to the CLB station. Due to the device's vulnerability to corrosion by the lake waters, lake level values are only available for the periods 15/04/2014 to 04/10/2014 and 24/04/2015 to 02/11/2015.

Water and sediment sampling

The water column was sampled at the stations CLB and DS. For each field survey, samples were collected at different depths taking into account the water column structure, the sampling steps being reduced to 25 cm in the vicinity of the salinity and O_2 gradients. The sampling was performed using a horizontal 1.2 L Niskin sampler (General Oceanics). For each sampled depth, several sub-samples of water were collected without filtration. One sub-sample was transferred in a clean 500 mL HDPE (high density polyethylene) flask. Another one dedicated to the analysis of dissolved sulfide (ΣS(-II)) was immediately transferred using silicon tubing into Exetainer™ vials (12 mL) filled at reflux in order to prevent any contact with oxygen and then poisoned with 0.25 mL of saturated $HgCl_2$ solution. Another sub-sample dedicated to dissolved methane analysis was transferred into a 30 mL glass bottle filled at reflux and then poisoned with 0.5 mL of saturated $HgCl_2$ solution. Unfiltered samples dedicated to SO_4^{2-} analysis were transferred in 50 mL Falcon™ tube containing a few drops of concentrate zinc acetate solution in order to precipitate ZnS (and incidentally $ZnCO_3$) and prevent a possible oxidation of sulfide species. The filtrate was used specifically for the analysis of sulfate.

Samples of sediment and stromatolites were also collected in 2010 and 2011. In 2010, a 10 cm long surface sediment core (DZ10 C0) and a stromatolite were collected by snorkeling. In 2011 the sediment superficial layer was sampled by snorkeling, directly into a glass jar tightly closed underwater to prevent any oxygen contamination.

Analysis of the sampled solids were done at the IPGP laboratory. After lyophilization, rinsing with MilliQ™ water and re-drying the samples were very finely ground in an agate mortar and analyzed by X-Ray Diffraction Powder (XRDP) and Scanning Electron Microscopy (SEM-EDAX).

In situ measurements of _CO_2 and CH_4 fluxes_ at the air-water interface

CO_2 and CH_4 fluxes at the air-water interface were determined by the floating chamber (FC) method (Lambert et Fréchette, 2005). The gas concentration evolution was monitored in the FC volume by circulation in on-line detectors: Licor LI820 for CO_2 (NDIR detector) and Panterra Neodym for CH_4 (semi-conductor detector). In addition, samples were taken from the FC through a septum, at the beginning and at the end of deployment (Start-End method) for further GC analysis of methane concentration, in order to calibrate the measurements done by the CH_4 detector. Deployments of the FC were performed in successive triplicates, during ca. 10 to 20 min, at different stations in the lake and at different times of the day and different seasons, from 2012 to 2016. CO_2 fluxes, together with water subsurface temperature and pH, were also recorded continuously for 24 hours during two nychthemeral cycles conducted on the 30-31 Oct. 2014 and on the 09-10 Aug. 2016.

Water samples processing and analyses performed during field campaigns

Back to the field laboratory (less than two hours after sampling), the sub-samples in the 500 mL flasks were filtrated first on pre-calcinated quartz filters using a filtration unit under pressure. A second filtration was then performed using a 50 mL syringe fitted with 0.2 µm Minisart® filters. The quartz filters were dried overnight at 50°C in an oven for further elemental CHNS analysis of the suspended particles. The doubly filtered water was used immediately to measure total alkalinity and nutrients concentrations: total N(-III)), soluble-reactive phosphorus (SRP) and dissolved silica. Nutrients analyses were performed according to conventional colorimetric methods using an Aqualytic Spectro Direct, while total alkalinity was measured according to Gran's titration procedure (Gran, 1952). For each of the filtered samples two 12 mLaliquots were stored Falcon™ tubes; one dedicated to major cations analysis was acidified with a few drops of 14 M HNO_3 "suprapur" (Merck™) and the other one was kept at 4°C for major anions analysis at Paris IPGP laboratory. A subsample of 0.2 µm-filtrated water was kept for further DOC (Dissolved Organic Carbon) analysis.

Dissolved hydrogen sulfide concentrations (ΣS(-II)) were analyzed using the dedicated non filtered sub-samples, after settling, by colorimetry of oxidized methylene blue at 660 nm using 10 mm cells according to the method described in the kit Merck Spectroquant® and CEAEQ (2005).

Analyses performed in the IPGP laboratory

Water samples

All the necessary dilutions were done with ultrapure water (milliQ®) using an analytical balance (accuracy ± 0.1 mg). The Cl^- concentration was measured by titration with a standard acidified $AgNO_3$ solution (about exactly 0.5 mol L^{-1}) using 2.5 mL of the acidified aliquot to prevent precipitation of Ag_2CO_3 and Ag_2S (in originally anoxic samples). Precision was ± 1%.

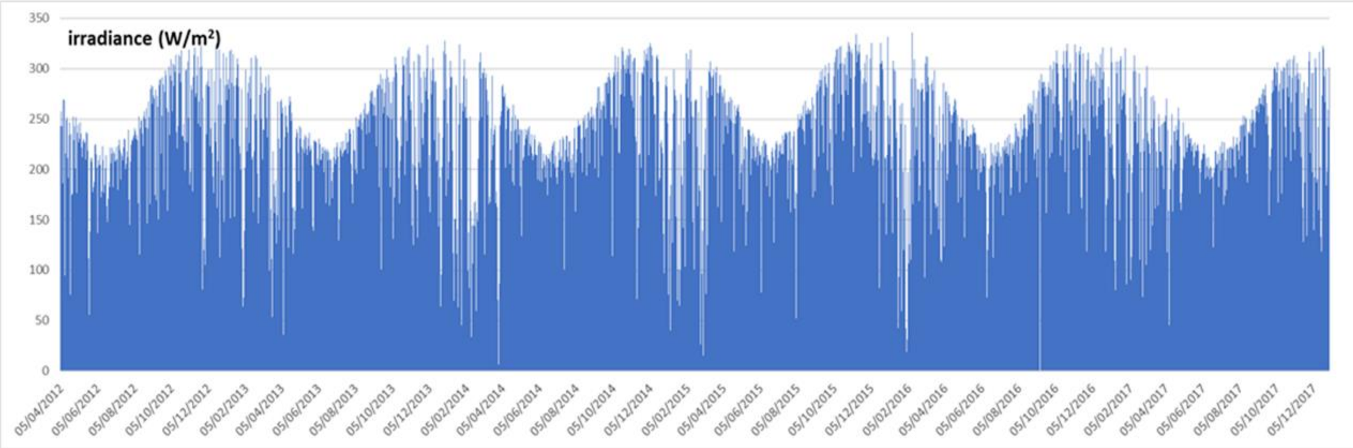
Br^-, NO_3^- and SO_4^{2-} concentrations were determined by Ionic Chromatography (ICS1100 Thermofisher®) using unacidified aliquots diluted 50 to 100 times. NO_3^- was always below the limit of detection (1 µmol L^{-1} with a UV detection). Precision was ± 3%. Cations were analyzed using an ICP-AES spectrophotometer (Thermo Scientific iCAP 6200). Samples were previously diluted by weighting (500 to 1000 times) with a 2 % solution of suprapur HNO_3 (Merck™). DOC was analyzed with a TOC analyzer (Thermo Flash 2000®) on ten times diluted samples acidified with H_3PO_4 1%. Precision was ± 10%. Dissolved CH_4 was analyzed by the headspace method and gas chromatography (GC) analysis (Trace GC Ultra Thermo Scientific, equipped with FID); three CH_4 standard (Messer, Suresnes, France) were used for the calibration curve.

Sediment samples

Freeze-dried sediments and stromatolites were rinsed with ultra-pure water in order to eliminate, as much as possible, the salts crystallized from the pore water during freeze-drying, and oven dried again. EDAX analysis were performed using a Scanning Electron Microscope (Auriga 40; Zeiss) in order to characterize the mineralogy of the stromatolite and of the sediment collected in September 2010.

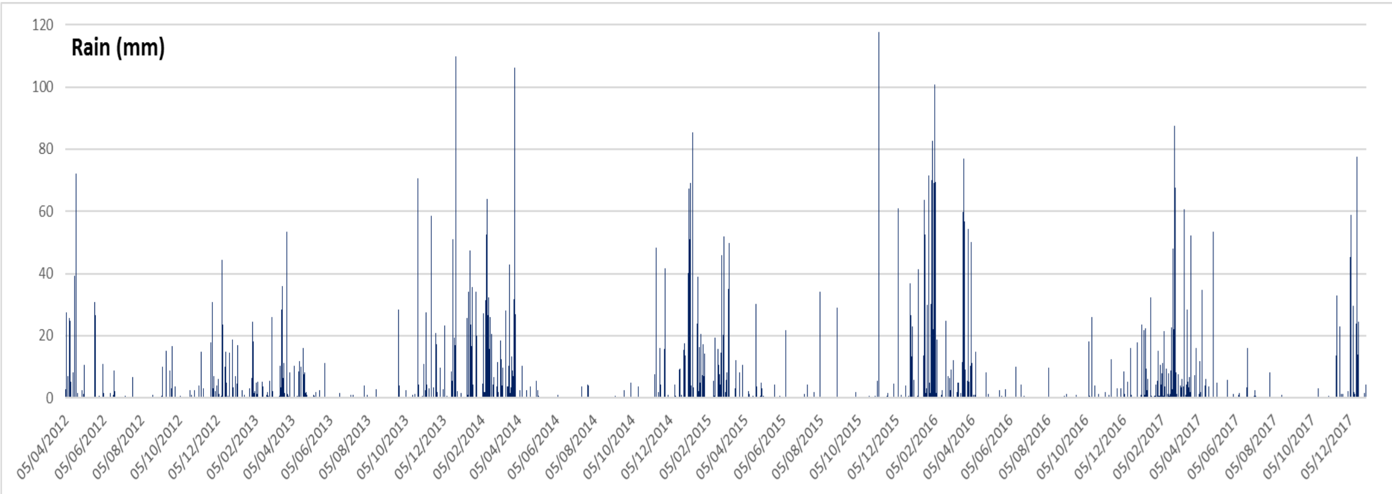
The pre-calcined quartz filters bearing the settling particles were decarbonated by phosphoric acid. An aliquot of the decarbonated filter was analyzed by CHNS using a Flash 2000 (Thermo Scientific™) analyzer.

Supplementary 3



Irradiance data (W m^{-2}) obtained from Météo France (Pamandzi Airport Station) between April 2012 and December 2017.

rain height (mm) between April 2012 and December 2017



supplementary 4 :

$$E_{vap} = \frac{Q_{LH}}{\rho_w \cdot L_e}$$

where E_{vap} is the water evaporation rate in kg m^{-2} s^{-1}, Q_{LH} the flux of latent heat in W m^{-2}, ρ_w the water density (kg L^{-1}) and L_e the latent heat of vaporization which can be calculated from the following expression given by Yu *et al*. (2008):

L_e (J.kg^{-1}) = $(2.501 - 0.00237\times\theta)\times10^6$ where θ is the surface temperature (°C).

Estimation of Q_{LH} for the Indian Ocean between 10 and 20° S is 110 to 120 W m^{-2} (http://lecalve.univ-tln.fr/oceano/fiches/fiche5C.htm). Setting θ = 30°C, L_e = 2.43 10^6 J.kg^{-1} and an average density of 1.040 kg L^{-1} for Dziani Dzaha water, relation (1) yields after units conversion an E_{vap} value of 1370 to 1500 mm.yr^{-1}, very close to both the average rainfall value of 1247 mm yr^{-1} (this study) and the 1410 mm yr^{-1} estimated by Korzun (1978). Given the uncertainties on these numbers, it is not possible to exclude some limited water exchanges between the lake and its aquifer through the highly fractured bedrocks, as also suggested in the synthetic geological cross section published by Sanjuan *et al* (2008). These features make this lake an endorheic and almost stationary hydrosystem. Nevertheless, the evaporation rate could exceed precipitation and lead to the present-day salinity of the lake, which is concentrated nearly twice with respect to seawater.

Supplementaty 5 : From April to October 2014 (172 days), the lake level decreased on average by 3.7 mm day^{-1} while the rainfall was on average of 0.23 mm day^{-1}: evaporation thus exceeded precipitation by far. Between the April 24 and November 02 2015 (193 days), the lake level increased linearly by 3.4 mm day^{-1} while the rainfall was only of 0.6 mm day^{-1}.

Supplementary 6 :

Evaporation models

H_2O (liq) ⇆ H_2O (gas)

$\Delta G = \mu\ (gas) - \mu\ (liq)$

With: $\mu\ (gas) = \mu^0\ (gas) + RTln\ p(H_2O_{gas})$ where:

μ^0 (gas): chemical potential in the standard state (P_0 = 1 bar, T_0 = 298 K)

p is the partial pressure of water vapor normalized to the standard state p_0 (1 bar, 298 K). Consequently, p has no unit and merges with fugacity.

The same can be written for the liquid:

$\mu(liq) = \mu^0(liq) + RTln\ a(H_2O)$ where:

μ^0 (liq): chemical potential in the standard state.

Activity of water in the Dziani Dzaha can be written $a(H_2O) = \gamma.z(H_2O)$ where γ is the activity coefficient and z the molar fraction of pure water.

For the evaporation, equilibrium must be shifted to the right with $\Delta G < 0$.

Considering the atmosphere as a medium of infinite dimension with respect to the lake, one can consider $\mu(gas)$ as substantially constant on the long term, then $\Delta G = k - \mu(liq)$.

On the other hand, the term $\mu(liq)$ evolve during evaporation since the mole fraction $z(H_2O)$ keep decreasing. The current molar fraction of water in the lake can be estimated as follows:

- *in pure water the number of moles H_2O is n_0 = 55.6 mol L-1*
- *the total number of moles of dissolved species is about 2.2 mol L^{-1}. The molar fraction*

T (°C)							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	31,3	32,3	31,0	32,9			33,8
0,25	31,9	32,2			32,2	27,2	33,4
0,50	32,5	31,7		31,7	31,5		32,9
0,75	32,1	30,4			30,7	27,2	32,7
1,00	31,5	29,5	31,0	31,0	30,5	25,9	32,4
1,25	31,1	29,2				25,9	32,2
1,50	30,9	28,8		30,7	30,3	26,1	31,7
1,75	30,7	28,9		30,5		27,0	30,9
2,00	30,6	29,3		30,4		27,7	30,6
2,25		29,9		30,3			
2,50	30,5	30,2	30,2	30,2	30,2		30,5
2,75		30,2		30,2			
3,00	30,5	30,2		30,2		28,4	
3,50	30,5	30,2	30,0		30,1		30,5
4,00		30,2		30,2			
5,00		30,2	29,9	30,2	30,1	28,5	30,4
7,00		30,2	29,9	30,2	30,1	28,5	30,4
8,00	30,5						
9,00		30,2	29,9	30,2	30,1	28,6	30,4
11,00		30,2	29,9	30,2	30,1	28,6	30,4
12,00	30,5					28,6	
13,00		30,2	29,9	30,2	30,1	28,6	
13,50		30,2	29,9			28,6	
14,00	30,7	30,2	29,7	30,1		29,1	30,4
14,50		30,1	29,5				
15,00		30,0	29,5	30,0	30,1	29,8	
15,50			29,5				
16,00	30,7	29,8	29,6	29,8	30,0	30,4	30,4
16,50			29,6				
17,00	30,6	29,6	29,6	29,7		30,5	
17,50	30,6						
18,00		29,5				30,3	

of H_2O ($z = n_0 / (n + n_0)$) is therefore currently equal to 0.96, whereas it was 0.98 in the initial seawater (Copin-Montégut, 1996). It results that the term - μ (liq) increases with time and ΔG increases.

Data Lake Dziani Dzaha (April 2012 to November 2017)

pH							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	9,36	9,92	9,18	9,45			8,97
0,25	9,34	9,93			9,05	9,26	8,97
0,50	9,28	9,93		9,44	9,05		8,97
0,75	9,25	9,93			9,05	9,26	8,97
1,00	9,20	9,91	9,19	9,39	9,05	9,25	8,97
1,25	9,15	9,90				9,24	8,96
1,50	9,08	9,88		9,24	9,05	9,19	8,96
1,75	9,02	9,79		9,11		8,92	8,96
2,00	8,99	9,56		9,04		8,81	8,96
2,25		9,48		9,03			
2,50	8,97	9,47	9,19	9,02	9,05		8,96
2,75		9,47		9,02			
3,00	8,97	9,46		9,02		8,78	
3,50	8,97	9,46	9,19		9,04		8,96
4,00		9,46		9,01			
5,00		9,46	9,19	9,02	9,04	8,77	8,96
7,00		9,46	9,19	9,02	9,04	8,77	8,96
8,00	8,98						
9,00		9,47	9,19	9,02	9,04	8,77	8,96
11,00		9,47	9,19	9,02	9,04	8,75	8,95
12,00	8,98					8,75	
13,00		9,47	9,19	9,02	9,04	8,76	
13,50		9,47	9,18			8,76	
14,00	9,03	9,48	9,08	9,05		8,78	8,96
14,50		9,49	9,02				
15,00		9,48	8,98	9,00	9,03	8,82	
15,50			8,95				
16,00	9,00	9,43	8,92	8,85	8,88	8,79	8,96
16,50			8,91				
17,00	8,94	9,41	8,91	8,74		8,65	8,98
17,50	8,92						
18,00		9,40					

Salinité en psu							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	20,6	33,9	64,0	46,5			64,1
0,25		34,4			65,5	51,1	64,4
0,50	37,8	34,6		46,6	65,8		64,3
0,75	47,2	34,7			65,0	52,8	64,2
1,00	44,8	34,4	61,8	46,5	65,0	53,4	64,3
1,25	45,9	34,5				54,0	64,4
1,50	47,4	34,7		47,4	64,6	54,5	64,8
1,75	50,5	35,4		51,1		55,5	64,7
2,00	56,3	37,7		61,6		57,6	63,7
2,25		54,8		63,3			
2,50	59,8	64,6	62,6	63,9	64,6		63,5
2,75		66,0		63,9			
3,00	60,0	66,2		64,1		58,5	
3,50	60,0	66,3	62,7		64,6		63,5
4,00		66,6		61,5			
5,00		66,6	62,8	61,6	64,6	59,2	63,5
7,00		66,8	62,8	61,9	64,6	59,6	63,5
8,00	60,1						
9,00		66,9	62,8	62,2	64,5	59,9	63,5
11,00		66,9	62,8	62,5	64,6	60,2	63,5
12,00	60,3					60,5	
13,00		67,0	62,9	63,0	64,5	60,8	
13,50		67,2	63,0			61,2	
14,00	62,0	67,8	67,4	65,8		61,3	63,5
14,50		70,0	68,8				
15,00		70,5	69,2	68,1	64,6	61,8	
15,50			69,1				
16,00	62,3	71,0	69,3	70,7	64,9	61,9	63,5
16,50			69,3				
17,00	62,4	70,9	69,3	70,8		61,9	
17,50	62,6						
18,00						61,9	

redox E en mV							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	-228	-199	-135,3	74			-81
0,25	-230	-201			-207	-145	-88
0,50	-237	-201		23	-258		-98
0,75	-243	-238			-289	-184	-111
1,00	-253	-242	-135,3	-26	-294	-209	-128
1,25	-333	-370				-242	-140
1,50	-349	-387		-99	-296	-304	-162
1,75	-357	-396		-236		-371	-185
2,00	-358	-409		-235		-372	-196
2,25		-413		-234			
2,50	-358	-417	-135,3	-234	-301		-199
2,75		-423		-233			
3,00	-358	-424		-233		-368	
3,50	-358	-424	-135,3		-304		-204
4,00		-423		-198			
5,00		-417	-135,3	-207	-307	-368	-215
7,00		-379	-135,3	-215	-305	-372	-227
8,00	-362						
9,00		-339	-135,3	-209	-305	-347	-225
11,00		-337	-135,3	-213	-309	-330	-209
12,00	-354					-325	
13,00		-331	-135,3	-197	-317	-325	
13,50		-330	-135,3			-325	
14,00	-365	-331	-129,4	-198		-327	-203
14,50		-332	-125,3				
15,00		-332	-122,9	-210	-342	-331	
15,50			-121,2				
16,00	-363	-331	-119,9	-208	-360	-334	-203
16,50			-119,3				
17,00	-359	-331	-119,1	-214		-335	
17,50	-350						
18,00		-332				-336	

O2 µ mol/L							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	389	405	30,0	170			238
0,25	328	400,8	9,7		75,4	255,0	185
0,50	101	359,1	5,6	79	8,9		140
0,75	43	289,2	5,4		0,20	171,4	108
1,00	17	88,8	5,0	33	0,61	131,2	84
1,25	12	0,9				85,5	46
1,50	9	1,5	4,9	0,1	1,01	11,9	1
1,75	8	0		0,2		1,9	0
2,00	8	0	4,9	0,2		1,3	0
2,25		0		0,2			
2,50	8	0		0,2	0,81		0
2,75		2,1		0,2			0
3,00	8	1,2	4,7	0,2		0,0	0
3,50	7	0,3			1,01		0
4,00		0,6	4,2	0,1			0
5,00		0	3,8	0,1	1,22	0,0	0
7,00		0,6	3,1	0,1	1,22	0,0	0
8,00	6		2,9				
9,00		0	2,8	0,0	1,42	0,0	0
11,00		2,7	2,2	0,0	1,82	0,0	0
12,00	6		1,9			0,3	0
13,00		0	1,9	0,0	2,03	0,6	0
13,50		0,6				1,3	0
14,00	6	0,6	1,9	0,1		1,6	0
14,50		0,9					
15,00		0,9	1,9	0,1	2,84	1,3	0
15,50							
16,00	6	0,6	1,9	0,1	2,43	0,6	0
16,50							
17,00	6	1,5	1,9	0,2		1,9	0
17,50	6						
18,00		0,6				2,9	0

H2S µmol/L							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	0	9	31	0,5		pas de mesures	0,6
0,25	0	8			244		0,7
0,50	0	8		2,9	249		0,8
0,75	0	8			257		0,6
1,00	0	7	39	1,0	244		0,7
1,25	0	8					0,6
1,50	0	17		2,0	236		0,6
1,75	3685	353		397			0,8
2,00	6241	4041		1805			0,9
2,25		4975		2416			
2,50		5084	35	2194	242		10
2,75		5183		2273			
3,00		4687		1963			
3,50		5213	67		240		16
4,00		5461		2130			
5,00		5441	90	2238	241		83
7,00		5213	135	2366	232		89
8,00							
9,00		5054	128	2086	244		89
11,00		5183	135	2214	257		113
12,00	6386						
13,00		5064	138	2219	267		
13,50		5402	156				
14,00	6492	5263	2683	2115			100
14,50		5292	2680				
15,00		5372	2707	2445	328		
15,50			2769				
16,00	6598	5620	2695	2189	2348		127
16,50			2843				
17,00	6560	5978	2852	2322	4504		
17,50	6579				5843		
18,00		5829					

Cl Concentrations en mM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	655	460	892	667			923
0,25	650	461			926	624	901
0,50	656	469		651	931		938
0,75	656	468			948	600	916
1,00	666	472	892	640	938	626	945
1,25	654	475				622	935
1,50	656	468		647	948	623	951
1,75	698	494		670		624	943
2,00	808	663		780		766	936
2,25		955		843			
2,50	829	853	885	874	969		938
2,75		872		868			
3,00	856	789		858		851	
3,50	844	883	890		943		936
4,00		908		889			
5,00		866	890	889	948	851	923
7,00		925	890	889	948	864	940
8,00	852						
9,00		900	899	904	964	863	923
11,00		892	895	881	948	861	914
12,00	847					862	
13,00		896	886	894	948	856	
13,50		898	890			857	
14,00	913	929	951	919		879	924
14,50		941	969				
15,00		954	985	929	948	950	
15,50			977				
16,00	880	950	1011	980	920	961	940
16,50			984				
17,00	882	926	988	995	979	966	
17,50	880				999		
18,00		957				967	

Na Concentrations en mM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	777	563	1016	774			1093
0,25	771	549			1116	717	1090
0,50	774	545		778	1091		1123
0,75	791	556			1105	697	1103
1,00	785	545	997	775	1107	703	1080
1,25	783	535				724	1135
1,50	781	547		765	1155	685	1108
1,75	833	578		789		714	1133
2,00	959	788		918		893	1125
2,25		1150		1007			
2,50	986	1105	999	1080	1144		1128
2,75		1163		1045			
3,00	953	1056		1053		969	
3,50	954	1154	1017		1138		1143
4,00		1177		1083			
5,00		1115	1012	1078	1135	989	1128
7,00		1115	995	1068	1120	978	1179
8,00	941						
9,00		1144	1011	1080	1127	957	1193
11,00		1138	997	1088	1114	980	1134
12,00	945					937	
13,00		1141	1000	1078	1154	981	
13,50		1163	990			979	
14,00	968	1188	1067	1110		1020	1140
14,50		1227	1085				
15,00		1220	1092	1121	1112		
15,50			1112				
16,00	984	1224	1014	1212	1089	1084	1162
16,50			1059				
17,00	992	1218	1025	1213	1201	1101	
17,50	966				1155		
18,00		1241				1100	

K Concentrations en mM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	29	22	39	32			38
0,25	29	21			44	27	38
0,50	29	21		33	43		38
0,75	30	22			40	26	38
1,00	29	22	38	33	39	26	38
1,25	29	21				27	38
1,50	29	22		32	45	26	38
1,75	31	23		33		27	38
2,00	35	31		39		33	38
2,25		42		44			
2,50	36	42	38	47	44		37
2,75		45		45			
3,00	36	40		46		36	
3,50	37	45	38	0	40		37
4,00		46		47			
5,00		44	38	48	44	37	38
7,00		44	38	46	44	37	38
8,00	37						
9,00		45	38	47	44	36	37
11,00		45	38	47	44	36	38
12,00	37					35	
13,00		45	38	47	46	37	
13,50		46	38			37	
14,00	39	47	42	48		38	37
14,50		49	41				
15,00		49	42	49	45	40	
15,50			43				
16,00	39	49	40	53	44	41	38
16,50			41				
17,00	40	49	40	54	50	42	
17,50	39				48		
18,00		50				43	

Ca µ mol/L							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	94,9	95,8	pas de mesures	pas de mesures	84		68
0,25	94,3	85,2	fiables	fiables	66	99	63
0,50	83,2	88,2			67		62
0,75	120,4	84,4			59	96	64
1,00	87,1	83,7				95	64
1,25	88,1	83,8				94	75
1,50	89,1	79,7			77	91	58
1,75	79,4	76,8				97	55
2,00	69,8	63,0				73	61
2,25		52,6					
2,50	69,6	53,7			74		65
2,75		51,1					
3,00	61,0	55,4				61	
3,50	66,7	54,1			75		51
4,00		51,3					
5,00		49,4			75	57	49
7,00		55,0			70	57	56
8,00	64,9						
9,00		48,8			66	57	51
11,00		53,1			95	60	56
12,00	65,2					58	
13,00		52,9			70	67	
13,50		50,6				56	
14,00	67,0	56,8				60	48
14,50		66,4					
15,00		61,1			70	60	
15,50							
16,00	69,6	62,1			63	63	63
16,50							
17,00	67,0	58,7			43	58	
17,50	64,6				38		
18,00		55,5				75	

Mg µ mol/L							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	3534	3076	4724	4070			4372
0,25	3602	3014			4732	3429	4382
0,50	3515	2993		4104	4594		4453
0,75	3599	3082			4838	3331	4359
1,00	3565	3068	4605	4100	4650	3373	4382
1,25	3542	3002				3470	4419
1,50	3536	3038		4013	4852	3288	4393
1,75	3650	3145		4134		3415	4457
2,00	3958	3817		4466		3793	4355
2,25		4456		4802			
2,50	4045	4326	4654	4985	4799		4400
2,75		4505		4840			
3,00	3994	4143		4913		3913	
3,50	3980	4393	4633		4818		4326
4,00		4534		4965			
5,00		4318	4926	5012	4790	3963	4362
7,00		4341	4666	4846	4708	3927	4422
8,00	3994						
9,00		4435	4643	4888	4766	3848	4327
11,00		4356	4634	4954	4679	3914	4426
12,00	4020					3764	
13,00		4351	4631	4849	4851	3938	
13,50		4500	4637			3918	
14,00	4173	4625	4790	5020		4055	4297
14,50		4861	4734				
15,00		4892	4678	5066	4682	4245	
15,50			4705				
16,00	4283	4890	4374	5118	4566	4397	4366
16,50			4534				
17,00	4292	4873	4418	5077	4568	4475	
17,50	4210				4336		
18,00		4892				4433	

Alcalinité. Concentrations en mM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	182,8	139,1	258,9	180,2			244,9
0,25	183,0	138,1			255,7	165,2	248,7
0,50	175,3	137,9		185,2	257,3		249,3
0,75	182,6	139,8			255,5	165,0	250,0
1,00	181,6	138,8	263,8	181,5	255,0	164,1	251,0
1,25	179,0	139,0				165,3	247,3
1,50	182,2	140,4		182,0	254,8	165,6	248,4
1,75	197,6	147,9		188,1		165,8	249,1
2,00	230,3	205,4		218,0		213,8	251,1
2,25		261,8		239,0			
2,50	239,1	262,8	261,1	242,8	255,0		250,6
2,75		275,1		242,9			
3,00	241,4	248,6		243,3		229,7	
3,50	242,5	275,0	259,7		248,7		246,3
4,00		281,0		251,7			
5,00		274,5	263,0	256,2	248,7	235,9	249,5
7,00		273,6	265,0	256,3	256,6	236,5	247,8
8,00	242,9						
9,00		277,7	261,7	256,6	256,2	233,6	251,1
11,00		275,1	263,0	253,7	255,7	233,5	250,4
12,00	242,1					234,9	
13,00		276,4	261,7	253,8	258,5	233,8	
13,50		279,0	260,6			236,0	
14,00	247,7	282,4	290,3	261,9		241,3	250,5
14,50		294,9	297,4				
15,00		295,4	281,7	265,0	254,5	259,0	
15,50			304,7				
16,00	252,6	294,8	303,8	287,8	247,4	263,7	249,8
16,50			304,5				
17,00	255,6	295,4	304,3	297,6	291,2	273,8	
17,50	254,7				295,4		
18,00		296,9				277,5	

SO4 µM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	2708	1637	2615	2212			2678
0,25	2672	1604			2751	2153	2698
0,50	2696	1666		2232	2850		2753
0,75	2667	1665			2796	2096	2763
1,00	2679	1657		2219	2897	2149	2730
1,25	2679	1645				2209	2794
1,50	2568	1648		2245	2782	2087	2833
1,75		1534		2199		2154	2755
2,00		1253	2902	400	2773	2360	2712
2,25							
2,50							
2,75							
3,00							
3,50							
4,00							
5,00				< DL			
7,00							
8,00							
9,00				< DL			
11,00							
12,00							
12,50				< DL			
13,00							
13,50				< DL			
14,00							
14,50							
15,00				< DL			
15,50							
16,00							
16,50							
17,00				< DL			
17,50							
18,00				< DL			

Si µM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	185	192	228	219			216
0,25	180	194			240	259	229
0,50	213	196		217	239		230
0,75	168	196			239	255	234
1,00	217	195	225	217	241	243	227
1,25	218	193				242	225
1,50	214	194		218	240	241	225
1,75	191	190		213		242	229
2,00	198	194		223		220	229
2,25		200		223			
2,50	200	198	221	221	236		224
2,75		200		220			
3,00	215	200		216		216	
3,50	222	191	218		234		225
4,00		206		223			
5,00		197	218	223	237	215	224
7,00		199	216	220	239	215	223
8,00	265						
9,00		203	212	221	241	211	224
11,00		203	218	224	241	213	215
12,00	210					214	
13,00		198	213	220	241	218	
13,50		202	214			223	
14,00	234	202	193	230		219	220
14,50		215	197				
15,00		213	194	231	240	234	
15,50			195				
16,00	272	214	198	232	236	238	218
16,50			205				
17,00	254	215	201	252	272	239	
17,50	202				278		
18,00		211				237	

NH4 µM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	6,7	13,9	6	23			3,4
0,25	5,6	1,6			36	0,57	2,8
0,50	7,8	0,0		5	36	0,00	1,7
0,75	6,0	1,6			37	3,63	0,5
1,00	4,1	1,6	7	3	33	0,57	0,0
1,25	7,2	2,6				0,00	0,0
1,50	7,4	1,6		4	36	1,45	0,0
1,75	0,0	0,0		27		0,00	2,3
2,00	0,0	0,1		69			0,0
2,25		0,3		30			
2,50	0,0	1,6	53	34	22		0,0
2,75		32,1		33			
3,00	279	36,0		29		0,00	
3,50	349	389	4		20		6,2
4,00		382		32			
5,00		417	6	27	81	0,00	8,0
7,00		392	16	30	24	0,13	6,2
8,00	347						
9,00		371	14	28	29	0,00	4,9
11,00		463	17	40	17	0,00	2,4
12,00	347					0,00	
13,00		434	15	35	26	0,00	
13,50		524	15			0,00	
14,00	368	909	2615	405		125	17,9
14,50		2134	3402				
15,00		2608	3700	690	20	1346	
15,50			4601				
16,00	947	3157	4842	4208	351	2289	13,0
16,50			3468				
17,00	1615	4185	4588	6060	666	5583	
17,50	1361				1280		
18,00		3341				6721	

P µM							
prof. m	avr-12	avr-14	nov-14	avr-15	nov-15	aou-16	nov-17
0,00	0,0	25	112	1,2	0		0,1
0,25	0,0	20			0	1,8	2,9
0,50	0,0	30		0,0	0		3,6
0,75	0,0	22			0	1,4	6,2
1,00	0,0	59	66	0,9	0	0,9	6,8
1,25	0,0				0	0,9	2,9
1,50	0,4			0,9	0	1,0	1,2
1,75	2,7			0,0	0	1,0	3,7
2,00	8,8	71		1,8	0	1,8	4,6
2,25		136		0,9	0		
2,50	6,0	124	121	2,1	0		0,9
2,75		154		2,4	0		
3,00	1,4	121		1,2	0	1,0	
3,50	0,0	157	123		0		0,7
4,00		133		7,2	0		
5,00		138	118	10,1	0	1,8	2,0
7,00		137	110	9,0	0	2,0	0,0
8,00	0,0				0		
9,00		140	104	9,2	0	1,8	1,4
11,00		144	109	7,2	0	1,5	2,4
12,00	0,0				0	1,3	
13,00		150	115	10,1	0	2,3	
13,50		150	117		0	1,5	
14,00	9,8	155	122	14,3	0	1,4	1,7
14,50		179	136		0		
15,00		170	187	11,3	0	2,0	
15,50			238				
16,00	51,6	193	294	64,2	0,31	3,0	4,1
16,50			307				
17,00	89,0	198	280	248	233	113	
17,50	128,6				268		
18,00		199				184	

COD	µ mol/L						
prof. m	avr-12	avr-14	avr-15	aou-16	nov-14	nov-15	nov-17
0,00	5224	3576	6581		6864		7635
0,25	5192	3511		6080		5876	6968
0,50	5207	3454	5935			6400	7227
0,75	5163	3456		5835		6255	7184
1,00	4995	3547	5834	5744	6747	6321	7005
1,25	4941	3497		5785			7005
1,50	5143	3458	5897	5860		6298	7219
1,75	5428	3692	5941	5932			6946
2,00	7606	6552	7607	7563			6947
2,25		8958	8161				
2,50	7121	8709	8232		6765	6263	6912
2,75		7817	8500				
3,00	6149	7119	8307	7968			
3,50	5962	7373			6713	6277	6774
4,00		7848	8195				
5,00		7715	8213	8042	6846	6198	7139
7,00		7864	8247	8350	6713	6337	7068
8,00	6054						
9,00		8151	8305	8124	6763	6449	7211
11,00		8033	8361	8234	6644	6420	6934
12,00	6208			8104			
13,00		8091	8304	8068	6606	6600	
13,50		7285		8195	6788		
14,00	6247	7604	8380	8562	7087		7188
14,50		8236			7642		
15,00		7706	8280	8226	7764	6455	
15,50					7732		
16,00	6382	7513	8845	7923	8065	6316	7061
16,50					8042		
17,00	6427	7370	9234	8579	8020	6840	
17,50	6190					6915	
18,00		7501		8043			

Calcul des concentrations moyennes totales				
mM				
Na	K	Mg	Cl	Alc
1067	40,3	4,43	846	250
Total dissous en négligeant les autres espèces minoritaires				
2207,73				
soit environ 2,2 mol/L				