Diatom based transfer function for estimating the chemical composition of fossil water. Calibration based on salt lakes of the Lipez area in the southwestern Bolivian Altiplano.

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Abstract: Diatom assemblages and water chemistry were studied in 13 shallow salt lakes in the southern part of the Bolivian Altiplano. At each locality bottom sediment and water samples were collected simultaneously. Relationships between the composition of the diatom assemblages and variations in water chemistry were collated in order to permit the estimation of ancient water chemistries based on changes in the make up of fossil diatom associations in older sediments. Weighted Averages treated by Partial Least Squares regression (WA and WA-PLS methods) allowed an estimation of optima and the relative tolerances of 61 species to variations in salinity and to the relative quantities of the 15 chemical elements studied, among them boron and lithium.

Key Words: Flora; diatom; Bolivia; Quaternary; water ionic content; water chemistry; transfer function; ecology

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Résumé : ***Fonction de transfert pour l'estimation de la composition chimique des eaux fossiles à partir des diatomées. Calibration sur des lacs salés du Lipez, SW de l'Altiplano bolivien.-*** L'étude des assemblages de diatomées et de la composition chimique des eaux a été effectuée dans 13 lacs salés peu profonds localisés dans le Sud de l'Altiplano Bolivien. Les points et les dates de prélèvement sont les mêmes pour les deux types d'étude. Les relations entre les assemblages de diatomées et les variables chimiques mesurées sont effectuées dans le but d'estimer ces variables dans le passé à partir des diatomées fossiles conservées dans les sédiments. La méthode des moyennes pondérées (WA et WA-PLS régression) a permis d'estimer les optima et les tolérances de 61 espèces à la salinité et aux différents éléments chimiques dont le bore et le lithium.

Mots-Clefs : Flore ; diatomée ; Bolivie ; Quaternaire ; composition ionique ; chimie des eaux ; fonction de transfert ; écologie

Introduction

It is now well-known that during the last 30,000 years the water level of the lacustrine basins of the Bolivian Aliplano varied markedly. Organisms such as ostracods, diatoms and plant remains preserved in the sediments suggest that modifications in the balance between precipitation and evaporation were associated with drastic changes in salinity. In Lake Titicaca, the highest salinities occurred during the early and mid-Holocene when the level of the lake was below the spillway. In the Uyuni-Coipasa closed basin, salinities remained high even when the levels of the lake were highest. The processes involved in arriving at such high levels of ionic concentration in ancient deep lakes and the associated climatic conditions are still not well identified. To resolve this problem, future research will require estimations as accurate as possible of salinities in ancient lakes and their variations throughout time. Diatoms are the best tool for attaining this objective because they are always present in the cored sediments. Moreover, existing environments offer a large range of salinities ranging between the very low levels in the lakes and wetlands of the glacial valleys and the very high concentrations of the shallow lakes in the arid areas of the southern Altiplano of Bolivia.

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Figure 1: Map of Bolivia. Map showing the location of the western Lipez. From West to East, the area is divided into 4 main geomorphic units: the Western Cordillera, the Altiplano, the Eastern Cordillera and the Amazonian « llanos ».

The first work linking diatom assemblages with ionic composition in existing environments (SERVANT-VILDARY & ROUX, 1990) was carried out in the southwestern part of the Bolivian Altiplano (South-Lipez). It served as the basis for an estimate of statistical relationships used to reconstruct the paleosalinity during the last Glacial period of a paleolake in the same area (ROUX, SERVANT-VILDARY & SERVANT, 1991). Recently, 11 samples collected near the northern border of the Salar de Uyun permitted the addition of 11 modern samples to the preexisting data set of this time frame (SYLVESTRE, SERVANT-VILDARY & ROUX, 2001).

In this paper, we present a revision of the data from the Lipez area. Samples from the Salar de Uyuni were not used because measurements on boron and lithium concentrations are lacking. This revision is based on two regression methods: weighted averaging (WA) leave-one-out and weighted averages plus least squares (WA-PLS). Moreover, we present an extensive diatom iconography, not published previously.

A. The studied area

The western Lipez area is located in the southernmost part of the Bolivian Altiplano (21° - 22° S, 67° - 68° W), near the boundary with Chile at around 4,500 m elevation (Figures 1 and 7).

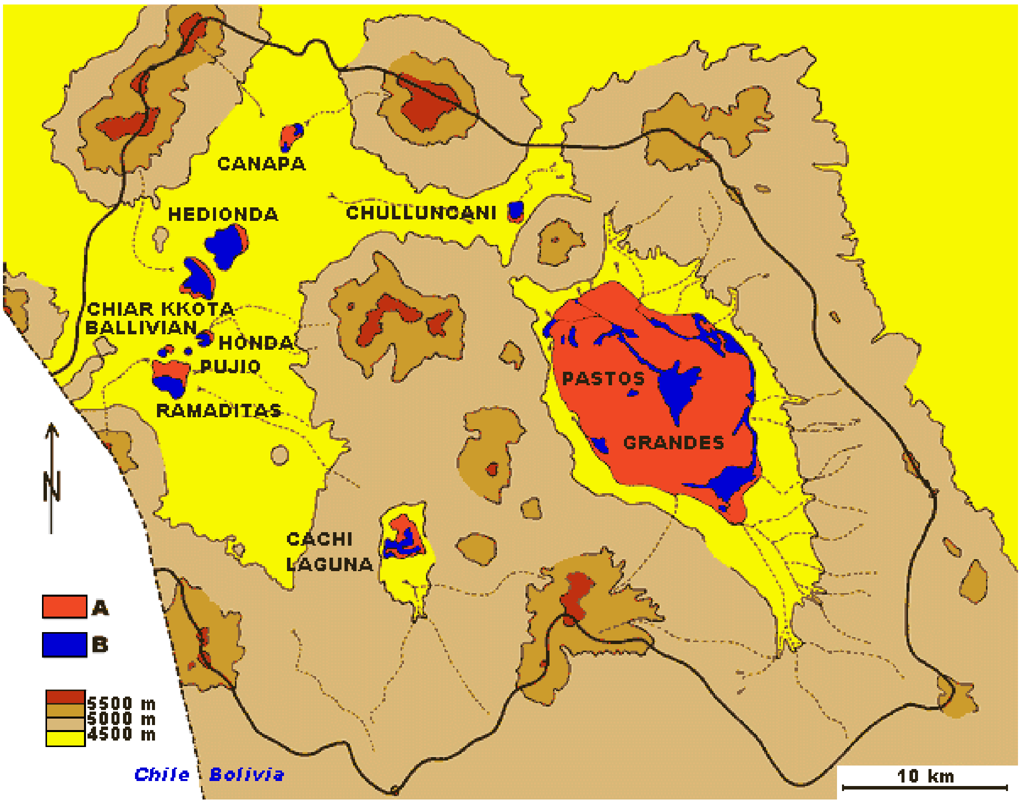


Figure 2: Location of the lakes. Location of the lakes where modern diatoms have been studied in the Pastos Grandes area. See Figure 4 for the locations of Laguna Colorada, Puripica and Laguna Verde lakes, sited farther south (after BALLIVIÁN & RISACHER, 1981, modified).

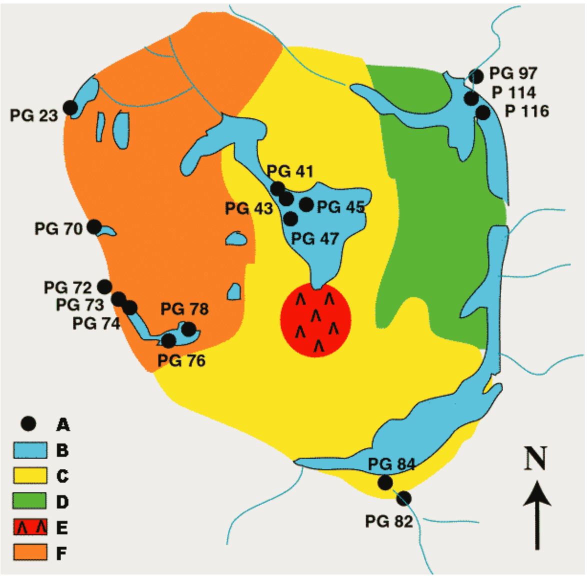


Figure 3: Pastos Grandes. Location of the surface sediment samples taken for diatom analyses.

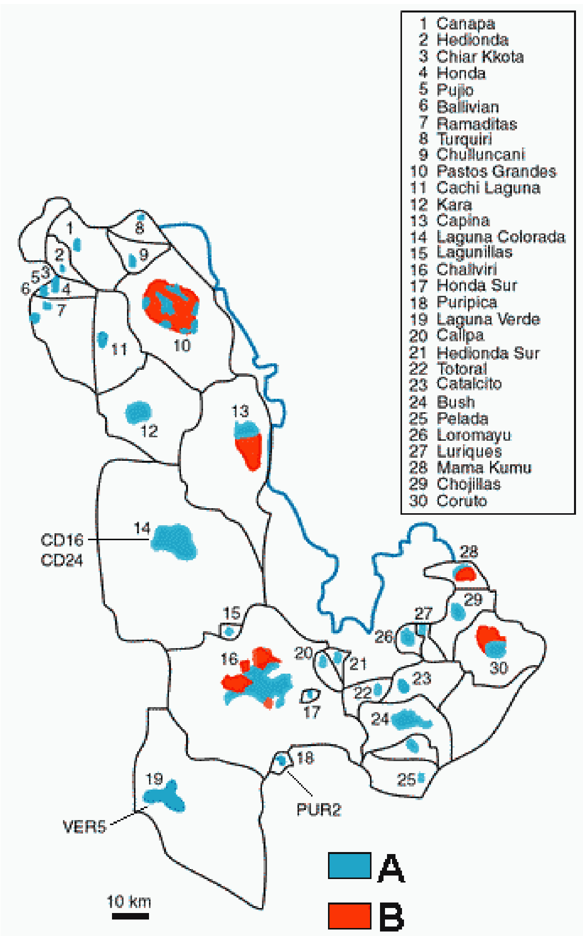


Figure 4: Location of the lakes. Location of the lakes in the Lipez area where water chemistry was studied.

The climate is cold and dry; the lowest temperatures are on the order of - 30°C, precipitation is 50 mm annually and evaporation 1,000-1,500 mm annually. The daily range in temperature is as much as 20°C. In winter (June - August), the area is influenced by mid-latitude atmospheric currents from the west, winds are strong (60 km/h), snow falls occasionally. In summer (December - February), precipitation is fed principally by water vapor from Amazonia.

Geological formations are predominantly volcanic: Mio-Pliocene ignimbrites and Quaternary volcanoes; a few are still active. These volcanic formations occupy very extensive tracts in the western Cordillera and in the southern part of the Bolivian Andes along the Argentina frontier.

The Lipez intravolcanic basins (Figures 2-4) are occupied by shallow endoreic lakes and evaporites (Figures 8-13). Calcareous crusts (Figure 14) and pisolites (Figure 15) are well developed at Pastos Grandes (RISACHER & EUGSTER, 1979; JONES & RENAUT, 1994).

These basins are fed mainly by ground-waters, at least in part, as in the Altiplano of the northern Chile (GEYH, GROSJEAN *et alii*, 1999), recharged during the Quaternary humid cycles, particularly in Late Glacial times. Seasonal and annual fluctuations in water-levels are small.

The lacustrine terraces observed on the edges of the basins (Figures 10-11, 13 and 16-17) (FERNANDEZ, 1980; SERVANT & FONTES, 1978) show three main highstands. They are correlated respectively with the three lacustrine phases in the Uyuni-Coipasa basin (SERVANT, FOURNIER *et alii*, 1995; SYLVESTRE, 1997; SYLVESTRE, SERVANT-VILDARY *et alii*, 1999): Minchin (> 20,000 ^{14}C yrs BP), Tauca (15,500-12,000 ^{14}C yrs BP) and Coipasa (~ 9,000 ^{14}C yrs BP). Great changes in water-level and salinity have been inferred from diatom assemblages in the Ramaditas-Ballivián Basin (ROUX, SERVANT-VILDARY & SERVANT, 1991; SERVANT-VILDARY & MELLO E SOUZA, 1993).

B. Water chemistry

The waters are characterized by a high ionic content. Essentially, they are sodium chlorides. Some are rich in boron and lithium (Table 1) (RISACHER, 1992a, 1992b; RISACHER & FRITZ, 1991a, 1991b, 1992, 1995).

Methods of analysis

- Alkalinity: titration by automatic potentiometry

- Cations: Na^+, K^+, Li^+, Ca^{++}, Mg^{++}: atomic absorption spectrometry (standard methods)

- Anions and neutral species: automatic colorimetry (Technicon autoanalizer)

- Cl^-: mercuric thiocyanate method

- SO_4^{--}: complexation by methythymol blue

- SiO_2: complexation by ammonium molybdate and reduction with ferrous iron

- B: complexation by azomethane H

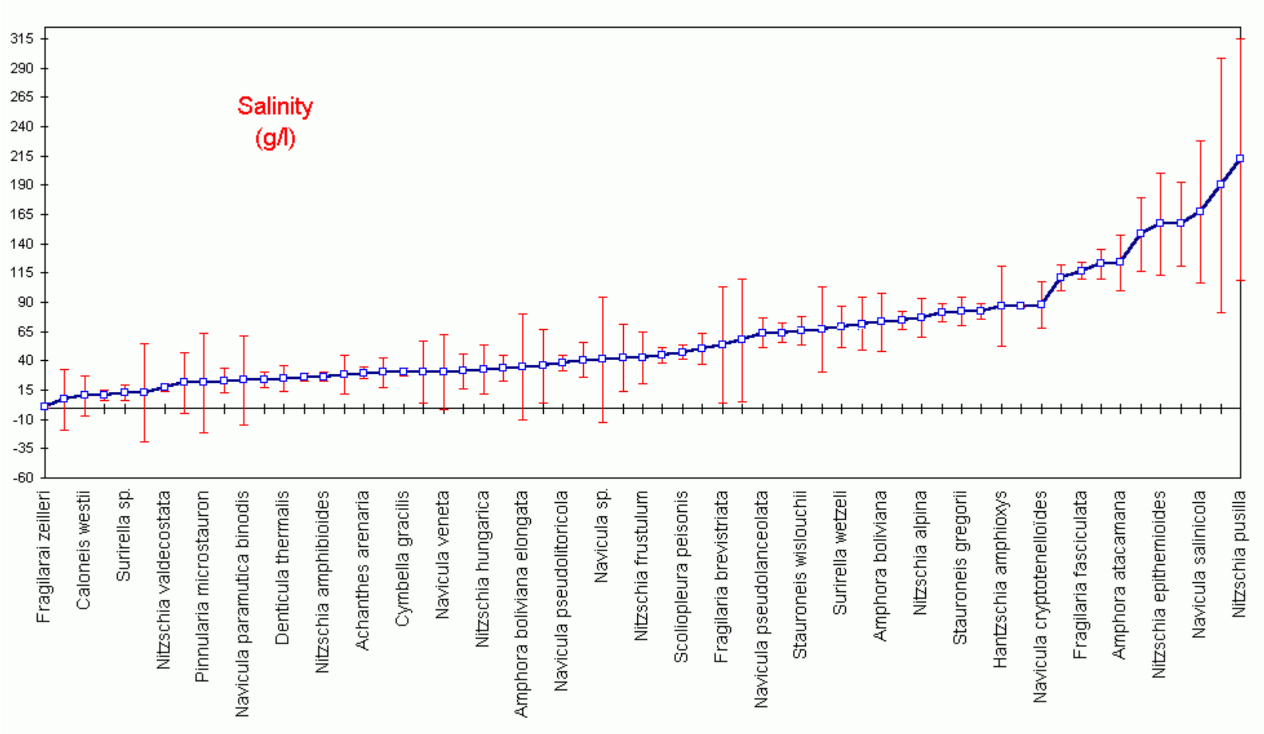


Figure 5A: WA method. Estimated optima and tolerances of 61 species to salinity (All with maximum abundance >3 and occurrence in three or more samples).

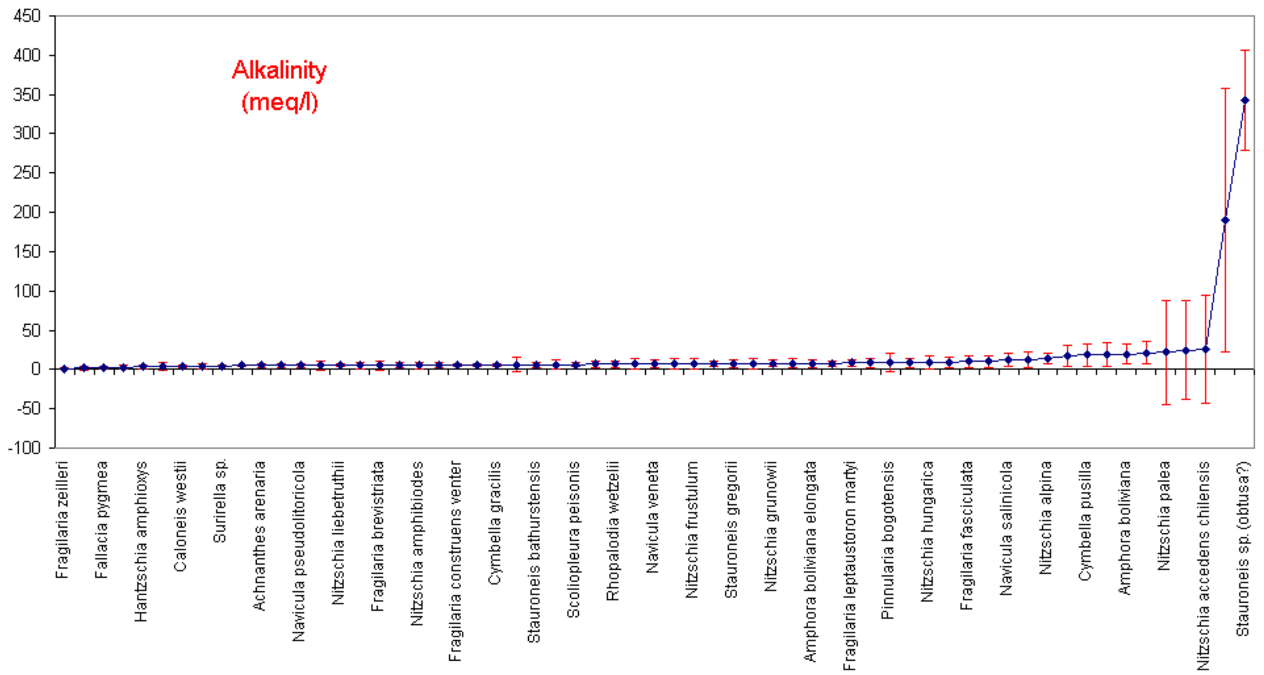


Figure 5B: WA method. Estimated optima and tolerances of 61 species to alkalinity (with maximum abundance > 3 and occurrence in three or more samples).

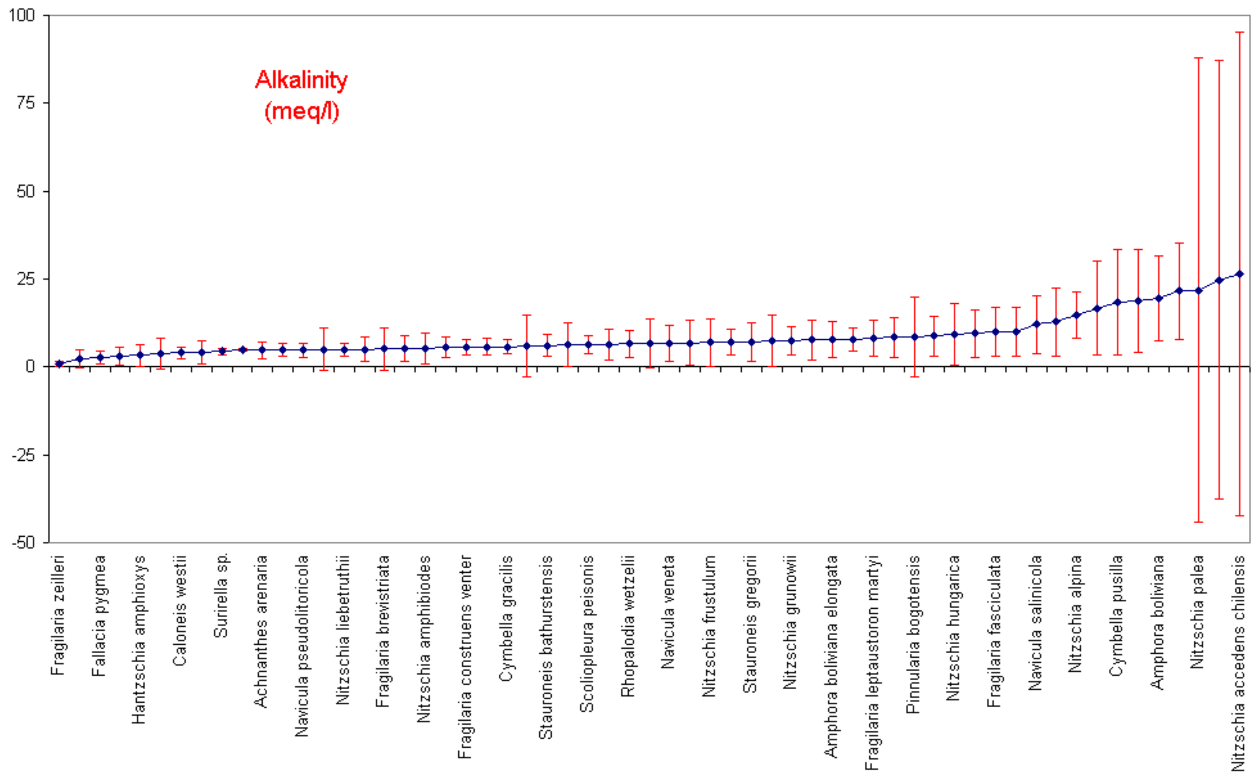


Figure 5C: WA method. Estimated optima and tolerances of 61 species to alkalinity (with maximum abundance > 3 and occurrence in three or more samples). In Figure 5C, the very high values of alkalinity were removed in order to show more clearly the optima and tolerances of species with low alkalinity values.

C. The diatom flora

In thirteen of these lakes the existing diatom flora (SERVANT-VILDARY, 1984; SERVANT-VILDARY & ROUX, 1990) was studied at the water/sediment interface (Table 2, Figure 2). Throughout the summer of 1978 samples of both water and sediments were collected by F. RISACHER at the same sites and at the same time. At Pastos Grandes, samples were collected from the margins toward the center, in order to relate changes in diatom assemblages to increases in salinity (Figure 3).

Diatom frustules are partially dissolved in the sediments collected (BADAUT, RISACHER *et alii*, 1979; BADAUT & RISACHER, 1983). But a comparison between living diatoms in the water and those in the water/sediment interface showed that this diagenesis is slight (ILTIS, RISACHER & SERVANT-VILDARY, 1984).

The diatom flora is diversified. The image data base is being prepared: 107 species are presented here. The list of images is in Table 3. It includes the abundant species (used in the transfer function calculations) and some rare ones. In columns 5 to 7 species previously published are indicated (SERVANT-VILDARY, 1984; SERVANT-VILDARY & BLANCO, 1984; SERVANT-VILDARY & ROUX, 1990).

Species identifications were based on a considerable number of recent works, not possible to cite here. On the other hand we would like to direct attention to publications that, although less well-known, are fundamental to this study because they concern areas close to southern Bolivia (FRENGUELLI, 1934, 1936, 1942).

D. Diatom ecology

Optima and tolerance of the species are obtained by the Weighted Averaging [WA] method and the Weighted Averaging Partial Least Squares regression [WA-PLS] (TER BRAAK & JUGGINS, 1993; TER BRAAK, JUGGINS *et alii*, 1993), programmed by M. ROUX and introduced in « Biomeco » for this study. All the sites were used, environmental data were not transformed. The 61 species selected from the total of 104 are those present at least in 3 samples. The values R, R^2 and that of SEP from WA are listed in Table 4.

The number of components selected for use in the WA-PLS method are deduced from « r » (correlation coefficient between observed and predicted value by the leave-one-out method). Values of R and R2 deduced from WA-PLS are listed in Table 4. Optima and tolerances of the species in relation to the ionic composition of the waters (anions and cations), alkalinity, salinity and pH estimated by WA leave-one-out method are listed in Table 4. Alkalinity and silica content are the parameters that can be most accurately estimated from the diatom flora (R = 0.94, R^2 = 0.88). Multiple correlation coefficients are up to 0.80 for sodium, sulfate, chlorine, salinity and pH. The accuracy of prediction for boron and lithium are relatively low, respectively 0.75 and 0.77. Figure 5A

Fig. 6A

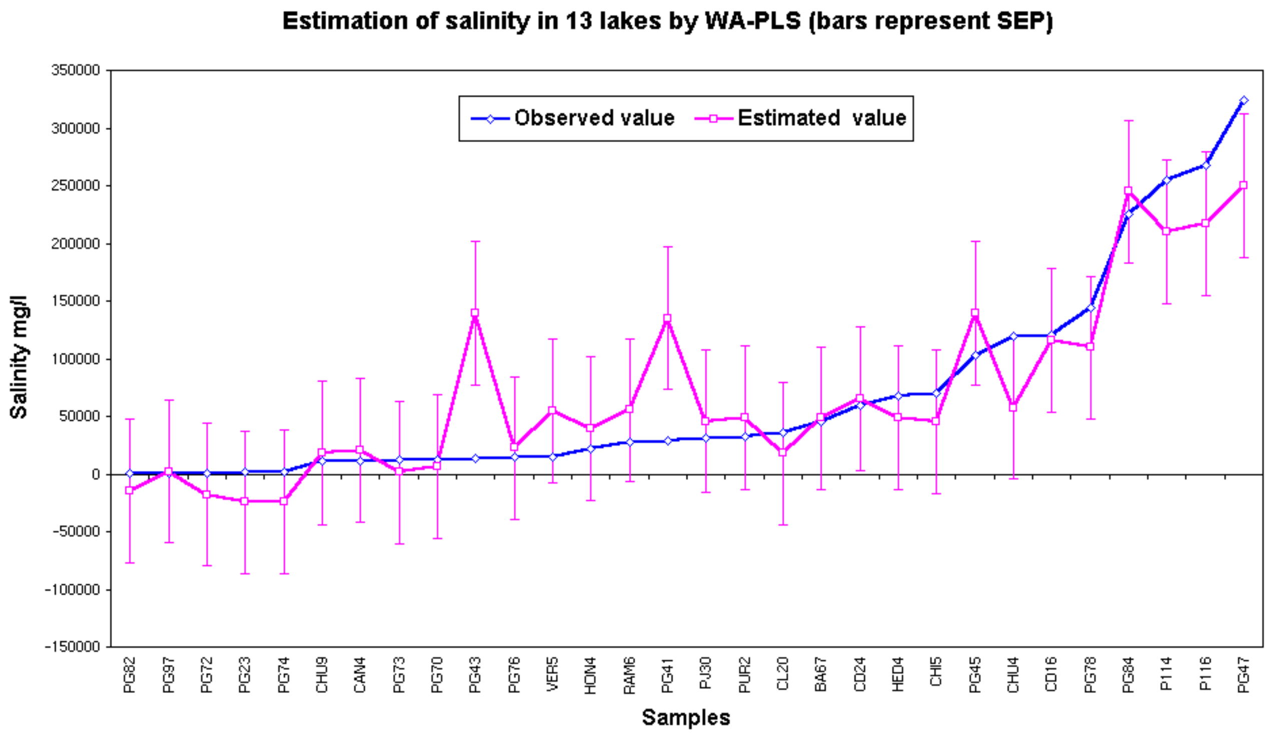
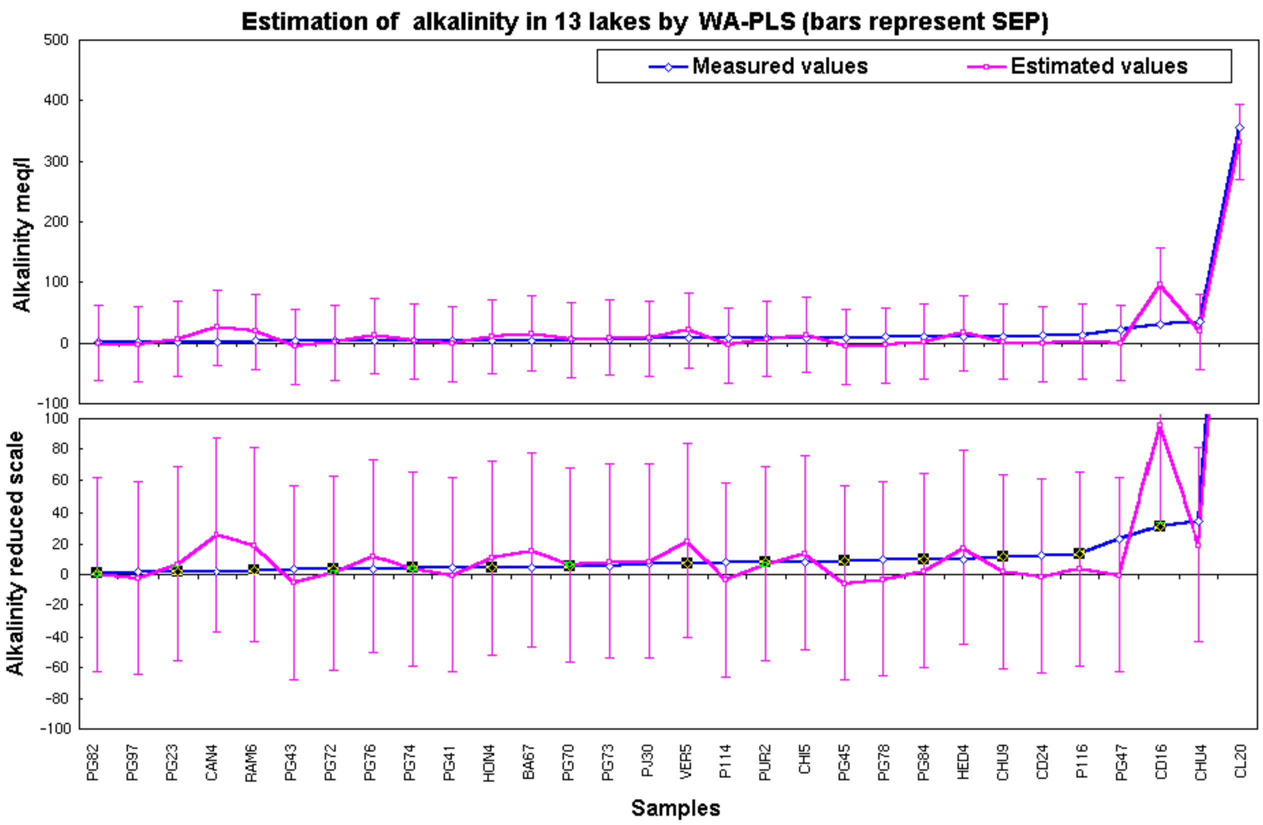


Fig. 6B



Figures 6A and 6B: WA-PLS method. The salinity and alkalinity of the lakes as inferred from modern diatom assemblages (calibration).

Figure 7: An example of the Lipez landscape: In the foreground a Quaternary glacis with a pebble cover. Note the absence of vegetation. In the background an Upper Cenozoic volcano.

Figure 8: Laguna Chiar Kkota in the foreground and Laguna Hedionda in the background. Salt deposits fringe the lakes.

Figure 9: Laguna Ballivián: Playa-type « salar », characterized by a very small watershed.

Figure 10: Laguna Ramaditas: In the background the threshold which separates Laguna Ramaditas from Laguna Ballivián. The two lakes were connected during the « Minchin » highstand phase.

Figure 11: Laguna Honda. 1: Past shorelines with bioherms, the top one is dated early Holocene (~ 11.800 cal yr BP) by U/Th, 2: Undated lacustrine deposits, 3: Diatomites representing the three main lacustrine phases (Minchin, Tauca and Coipasa).

Figure 12: Cachi Laguna salar: Unconfined aquifer salar.

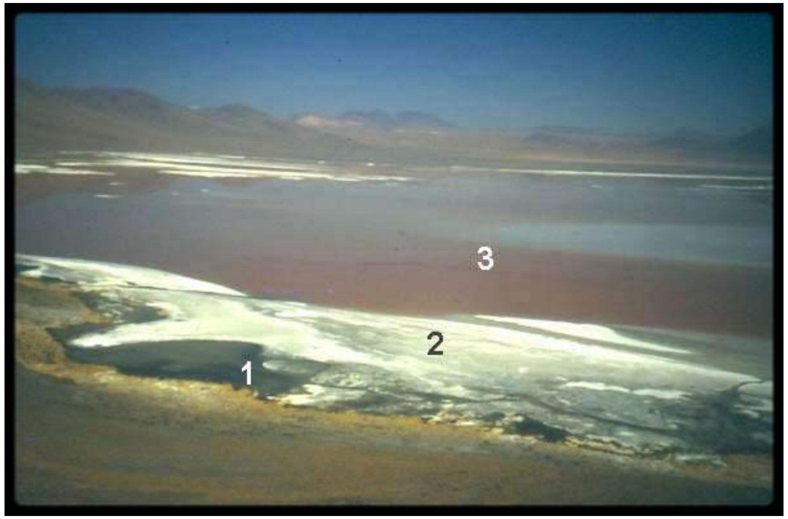


Figure 13: Laguna Colorada: 1: Springs at the foot of the slope, 2: Quaternary diatomites, 3: Open surface salt water.

Figure 14: Pastos Grandes salar: Fossil calcareous crust (undated).

Figure 15: Pastos Grandes salar: Calcareous pisoliths in shallow ephemeral pools fed by hot springs. Diatomites are common in the outer layers.

Figure 16: Laguna Ballivián: 1: Diatomites and bioherms of the highest water level, probably of the Minchin phase (Middle Glacial), 2: Diatomites presumably of the Tauca phase. Formations 1 and 2 are separated by an erosion surface, 3: Modern colluvions, 4: Halite efflorescences.

Figure 17: Laguna Ramaditas: Northern border. 1: Quaternary diatomites eroded by the wind during a Holocene dry phase, 2: Present-day halite efflorescences.

Appendices

Table 1 : Location of the lakes and data regarding water chemistry.

Table 2 : List of species and their abundance in 30 samples.

Table 3 : List of diatom pictures.

Table 4 :
WA method: Optima and tolerances of the species (in alphabetical order) to Na^+, Mg^{++}, $SO4^{--}$, Si, Li^+, salinity, pH, K^+, Ca^{++}, Cl^-, B and alkalinity. Estimation of environmental variables for each sample. SEP values are indicated at the end of the list of estimations for all samples. Optima and tolerances of species to salinity and alkalinity are illustrated in Figures 5A, 5B and 5C.
WA-PLS method. Values of r, R, R^2 and SEP listed in table 4 show that this method improves the predictions for all the environmental parameters. Calibration of salinity and alkalinity is illustrated in Figures 6A and 6B.

shows the ecological preferences of 61 species as regards salinity (g/l). Figures 5B and 5C show preferences of these species concerning alkalinity (meq/l) deduced from WA. Error bars represent the values the "tolerance" column of Table 4) above and below the optimum. Figures 6A and 6B show that the salinity and alkalinity of the 13 lakes can be estimated with reasonable accuracy from the diatom flora. Estimation of salinity is excellent except for PG43 and PG41 where measured salinity has mean values (28 and 13 g/l). Alkalinity is well estimated in all samples (except for Canapa and Laguna Colorada).

We cite here examples of the ecology of some species as deduced from these analyses:

- Optimum salinity for *Nitzschia liebetruthii* (**NILI**) est 28.4 ± 12 g/l. This species is very abundant at Ramaditas where the measured salinity is 27 g/l and the estimated salinity 30.8 g/l. This species seems to be a good indicator of average salinity in the range of salinities considered here.
- The optimum of *Navicula salinicola* (**NASA**) to lithium is 0.6 ± 0.5 g/l. This species is very abundant in Pastos Grandes 47 (measured lithium concentration 1.64 g/l) and estimated lithium concentration from the diatom flora is 0.5 g/l. This species is a good indicator of high concentrations of lithium.
- Concerning sulfates, *Surirella wetzeli* (**SUWE**) of which the optimum is 13.6 ± 11 g/l, is very abundant in Chulluncani 4 where measured sulfate concentration is 26.6 g/l and the estimated value is 11.5 g/l. This species is a good indicator of a high concentration of sulfates. We might cite *Mastoglia atacamae* (**MATA**) as an indicator of very low concentration.
- As an indicator for high alkalinity we cite *Stauroneis wislouchii* (**STAW**), its optimum is 190 ± 167 meq/l. It is abundant in Cachi Laguna 20, where measured alkalinity is 355 meq/l and the estimated value 211 meq/l. An indicator for low alkalinity could be *Amphora atacamana minor* (**AMPM**), for its optimum is 8.7 ± 5.7 meq/l and the measured alkalinity in the sample Pastos Grandes 78, where it is abundant, is 9.4 meq/l and the inferred alkalinity is 8.6 meq/l.
- As regards silicon, we can cite *Fragilaria zeilleri* (**FZ**). Its optimum is 0.020 ± 0.008 g/l, the measured value of silicon concentration being 0.015 g/l in Pastos Grandes sample 82 where this species is abundant and the inferred value is 0.02 g/l. *Stauroneis* sp. (**SSP**) on the contrary is a good indicator for a high concentration of silicon, for its optimum is 1.57 ± 0.02 g/l, and the measured value of silicon in Cachi Laguna 20 is 1.6 g/l and the inferred value 1.08 g/l.
- Concerning potassium, the optimum of *Nitzschia pusilla* (**NIPS**) is 7.7 ± 4.3 g/l. In Pastos Grandes sample 116 where it is abundant the measured concentration is 7.3 g/l and the inferred concentration is 4.6 g/l.
- As regards chlorine, the optimum of *Nitzschia accedens chilensis* (**NCHI**) is 86.4 ± 70 g/l. The values measured in Pastos Grandes sample 78 where this species is abundant is 85.9 g/l and the inferred value is 57.3 g/l.
- For sodium, we may cite *Fallacia pygmaea* (**NPYG**) which although rare in Pastos Grandes sample 43 is a good indicator for, its optimum is 3.3 g/l, whereas the measured concentration in the sample is 4.5 g/l and the inferred concentration 3.7 g/l.

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TABLEAU 1 : Localisation des lacs et données chimiques des eaux

TABLE 1: Lake locations and water chemistry data

Lacs	Lakes		Ballivian	Ramaditas	Laguna Verde	Hedionda	Pujio	Puripica	Honda	Chiar Kkota	Canapa
N° Ech.	N° Ech.		BA67	RAM6	VER5	HED4	PJ30	PUR2	HON4	CHI5	CAN4
Altitude	Altitude	(m)	4130	4120	4310	4121	4110	4393	4110	4110	4140
Longitude	Longitude		68°05'	68°05'	67°48'	68°04'	68°04'	67°30'	68°04'	68°04'	68°01'
Latitude	Latitude		21°38'	31°38'	22°48'	21°34'	21°37'	22°31'	21°37'	21°35'	21°
Na	Na	(mg/l)	13600	7590	4510	20400	10000	9550	6740	20700	3590
K	K	(mg/l)	1700	1030	308	2100	1020	1720	989	2500	212
Mg	Mg	(mg/l)	605	326	262	649	210	275	140	1140	34.0
Ca	Ca	(mg/l)	1200	1370	218	521	400	465	200	1340	65.0
SO4	SO4	(mg/l)	5700	3070	2300	17900	4320	4660	2600	4080	5070
Cl	Cl	(mg/l)	22000	13900	6460	24600	14500	15300	10300	38700	2250
Si	Si	(mg/l)	25.2	41.4	28.6	27.5	26.1	20.6	31.6	34.4	31.4
B	B	(mg/l)	150	77.0	125	235	145	238	57.0	250	13.0
Li	Li	(mg/l)	25.5	11.8	36.5	122	37.0	109	47.0	176	19.5
Alcalinité	Alkalinity	(mg/l)	4.88	2.93	7.25	10	7.22	7.8	4.4	8.05	2.15
Salinité	Salinity	(mg/l)	45335	27658	14716	67099	31139	32785	21392	69439	11440
Ions majeurs	Principal ions		NaCl	Na (Ca) Cl	NaCl (SO4)	NaCl (SO4)	NaCl (SO4)	NaCl (SO4)	NaCl	NaCl	NaCl (SO4)
pH	pH		8.18	8.15	8.72	8.5	8.85	8.52	9.05	8.28	9.18
Profondeur	Depth	(cm)	30	30	100	20	100	100	20	20	15
Température	Temperature	(°C)	5	1	2	8	1	4	6	8	6
Densité	Density		1.032	1.02	1.01	1.05	1.022	1.024	1.015	1.051	1.009

Cachi Laguna	Chulluncani		Laguna Colorada		Pastos Grandes										
CL20	**CHU4**	**CHU9**	**CD24**	**CD16**	**PG70**	**PG23**	**PG41**	**PG43**	**PG45**	**PG47**	**PG72**	**PG73**	**PG76**	**PG74**	**PG78**
4495	4430	4430	4278	4278	4400	4400	4400	4400	4400	4400	4400	4400	4400	4400	4400
67°57'	67°53'	67°53'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'	67°47'
21°43'	21°32'	21°32'	22°11'	22°11'	21°39'	21°39'	21°39'	21°39'	21°39'	21°39'	21°39'	21°39'	21°39'	21°39'	21°39'
10600	30100	2320	19900	40700	4000	451	9270	4510	34000	103000	80.0	3910	4510	350	46000
2850	12800	1800	2110	4260	532	43.0	1020	500	3950	14200	16.5	399	579	48.1	5000
0.146	1900	53.0	382	914	89.9	11.0	265	132	110	3470	20.2	138	132	55.4	1200
2.49	730	200	103	260	200	24.5	360	200	1100	3100	50.9	190	200	32.7	1500
3710	26600	4360	5980	6440	265	72.0	465	250	1270	2460	105	302	305	130	2920
4540	44000	1970	29500	65000	7240	699	16700	8060	61400	194000	90.2	6750	8310	600	85900
161	21.9	18.7	32.5	45.6	36.4	38.4	31.6	17.3	20.5	31.4	37.2	58.8	32.2	30.2	34.2
143	959	147	263	612	29.9	3.49	60.0	28.4	290	944	0.995	25.5	32.0	2.92	320
54.1	22.5	2.75	86.8	196	42.5	4.80	117	52.5	500	1640	0.507	42.5	57.5	3.89	600
355	35	11.4	12.9	31.5	5.09	1.51	4.25	3.21	9.08	22.9	3.3	5.13	3.85	4.2	9.42
36285	119261	11377	59166	120357	12787	1475	28564	13961	103267	324141	644	12189	14421	1542	144099
NaCO3 (Cl)	NaCl (SO4)	NaCl (SO4)	NaCl	NaCl	NaCl	NaCl	NaCl	NaCl	NaCl	NaCl	Na (Ca) CO3 (Cl)	NaCl	NaCl	Na (Ca) Cl (CO3)	NaCl
10.38	8.8	10.2	8.52	8.4	8.42	9.35	8.52	8.05	7.4	7.2	6.95	8.15	8.35	7.85	7.91
50	15	15	20	20	20	100	20	100	100	100	20	20	20	20	20
21	5	8	10	6	5	1	4	6	5	5	10	1	10	1	10
1.029	1.087	1.008	1.04	1.081	1.009	1.001	1.02	1.01	1.073	1.211	1	1.009	1.01	1.001	1.098

Pastos Grandes

PG82	PG84	PG97	P114	P116
4400	4400	4400	4400	4400
67°47'	67°47'	67°47'	67°47'	67°47'
21°39'	21°39'	21°39'	21°39'	21°39'
41.9	77100	85.1	81000	92000
4.42	6450	12.6	9810	7390
3.21	1250	7.41	2550	2080
6.10	1650	12.5	2380	2500
14.0	3370	4.99	3240	3180
63.2	134000	150	154000	158000
15.9	33.0	22.4	16.8	31.4
0.703	404	1.08	545	520
0.347	675	1.18	1160	861
0.523	9.7	1.36	7.68	13.1
195	225344	402	255230	267366
Na (Ca) Cl (CO3)	NaCl	Na (Ca) Cl (CO3)	NaCl	NaCl
9.62	7.46	8.92	6.95	7.5
20	100	20	100	100
10	15	10	10	7
1	1.147	1	1.167	1.171

TABLEAU 2 : Liste des espèces et abondance dans 30 échantillons

TABLE 2: List of species and their abundance in 30 samples

Codes / Codes	Genres / Genera	Espèces / Species	Ballivian BA67	Ramaditas RAM6	Laguna Verde VER5	Hedionda HED4	Pujio PJ30	Puripica PUR2	Honda HON4	Chiar kkota CHI5	Chulluncani CHU4	Chulluncani CHU9	Canapa CAN4
ACAR	*Achnanthes*	*arenaria*	2.29	0.50	0.50	0.00	0.00	0.00	12.52	0.00	0.00	0.00	0.00
AD	*Achnanthes*	*delicatula*	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00
ASPE	*Achnanthes*	*speciosa*	3.99	0.10	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
AMPA	*Amphora*	*atacamana*	0.00	0.00	0.00	0.73	3.41	1.89	0.99	0.00	0.00	0.00	1.71
AMPM	*Amphora*	*atacamana minor*	0.00	0.00	0.00	0.00	0.00	0.30	0.00	1.30	0.00	0.00	0.00
ABOL	*Amphora*	*boliviana*	1.00	0.00	0.40	0.00	0.00	0.00	0.20	0.00	0.00	0.98	0.00
ABEL	*Amphora*	*boliviana elongata*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00
AMCJ	*Amphora*	*carvajaliana*	2.29	0.00	0.00	77.24	54.32	63.01	70.07	83.50	9.60	0.00	0.00
ANSA	*Anomoeoneis*	*sphaerophora angusta*	0.00	0.00	0.00	0.18	0.20	0.00	0.00	0.00	0.70	0.98	0.00
CSP	*Caloneis*	*silicula minuta*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.98	0.00
CAW	*Caloneis*	*westii*	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CP	*Cocconeis*	*placentula*	0.00	0.99	3.70	0.00	0.40	0.00	0.00	0.00	0.00	0.98	0.00
CYL	*Cymbella*	*gracilis*	4.39	0.50	0.00	0.00	11.85	0.00	2.49	1.30	0.00	0.00	0.00
CYMP	*Cymbella*	*pusilla*	0.30	0.50	0.00	0.00	0.00	0.00	0.80	0.00	0.90	0.00	0.00
DETH	*Denticula*	*thermalis*	0.60	0.60	0.10	0.00	0.00	0.00	0.20	0.00	0.00	0.98	0.00
DE	*Denticula*	*elegans*	4.69	2.29	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
DEV	*Denticula*	*valida*	0.00	0.70	14.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FB	*Fragilaria*	*brevistriata*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	4.01
FRCV	*Fragilaria*	*construens venter*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FE	*Fragilaria*	*fasciculata*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OM	*Fragilaria*	*leptaustoron martyi*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FP	*Fragilaria*	*pinnata*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	1.71
FZ	*Fragilaria*	*zeilleri*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HA	*Hantzschia*	*amphioxys*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HN	*Hantzschia*	*novsp*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00
MATA	*Mastoglia*	*atacamae*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NCA	*Navicula*	*cariocincta*	0.00	0.00	0.00	0.00	0.00	0.30	0.00	1.60	0.00	0.00	9.23
NCI	*Navicula*	*cincta*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
NC	*Navicula*	*veneta*	0.00	0.00	0.00	2.20	0.00	0.60	0.00	0.00	0.70	14.71	0.00
NHN	*Navicula*	*nivalis*	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
NPB	*Navicula*	*paramutica binodis*	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	2.30	2.50	0.00
NAO	*Navicula*	*cryptotenelloïdes*	1.60	0.50	0.20	0.36	1.20	8.87	1.19	0.10	0.00	0.00	6.32
NLA	*Navicula*	*pseudolanceolata*	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	49.40	9.75	26.08
NLI	*Navicula*	*pseudolitoricola*	0.30	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
NPYG	*Fallacia*	*pygmeae*	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
NDC	*Navicula*	*erifuga*	0.60	0.30	0.40	0.00	3.82	7.88	3.78	0.00	0.00	0.00	0.00
NASA	*Navicula*	*salinicola*	0.30	0.50	0.00	0.00	5.92	1.60	1.49	0.00	0.00	0.00	0.00
NS	*Navicula*	sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NILI	*Nitzschia*	*liebetruthii*	62.70	80.40	70.10	0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00
NCHI	*Nitzschia*	*accedens chilensis*	0.00	0.00	1.40	0.00	0.00	0.00	0.20	2.60	0.00	0.00	0.00
NIAL	*Nitzschia*	*alpina*	1.40	1.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ND	*Nitzschia*	*amphibiodes*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	2.31
NICC	*Nitzschia*	*compressa compressa*	0.00	0.50	0.20	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00
NIEP	*Nitzschia*	*epithemioides epithemioides*	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
NF	*Nitzschia*	*frustulum*	1.20	0.10	0.00	0.00	0.00	0.00	0.00	0.50	1.80	3.92	0.00
NGRU	*Nitzschia*	*grunowii*	0.60	0.60	0.20	0.00	2.41	0.00	0.00	0.10	0.00	0.80	0.00
NIH	*Nitzschia*	*hantzschiana*	1.30	1.39	0.00	0.00	1.91	6.58	0.70	0.00	1.50	0.00	0.00
NIHU	*Nitzschia*	*hungarica*	0.00	0.00	0.00	0.36	0.00	2.89	0.00	0.00	4.70	25.49	15.05
NPA	*Nitzschia*	*palea*	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
NIPS	*Nitzschia*	*pusilla*	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	5.50	0.00
NIVA	*Nitzschia*	*valdecostata*	0.00	0.00	0.00	0.00	0.80	1.89	0.00	0.00	0.00	0.00	8.02
PB	*Pinnularia*	*bogotensis*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00
PIMI	*Pinnularia*	*microstauron*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00
RHWE	*Rhopalodia*	*wetzelii*	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00
SCPE	*Scoliopleura*	*peisonis*	0.00	0.99	0.00	1.72	2.01	0.60	1.29	2.60	0.00	0.00	0.00
SG	*Stauroneis*	*gregorii*	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
SB	*Stauroneis*	*bathurstensis*	0.00	0.00	0.00	3.00	1.61	1.30	1.19	0.30	0.00	0.00	3.41
SSP	*Stauroneis*	*species (obtusa?)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STAW	*Stauroneis*	*wislouchii*	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.30	0.70	0.00	12.34
SO	*Surirella*	*oregonica*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUSE	*Surirella*	*sella*	5.98	2.98	1.90	0.00	4.82	0.00	1.89	1.00	0.10	0.00	0.00
SUSP	*Surirella*	sp.	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUWE	*Surirella*	*wetzelii*	0.00	0.00	0.00	13.78	0.40	1.99	0.10	0.10	22.10	3.92	4.81

TABLEAU 2 : Liste des espèces et abondance dans 30 échantillons

TABLE 2: List of species and their abundance in 30 samples

Codes / Codes	Genres / Genera	Espèces / Species	Cachi Laguna	Laguna Colorada		Pastos Grandes						
			CL20	CD24	CD16	PG70	PG23	PG41	PG43	PG45	PG47	PG72
ACAR	*Achnanthes*	*arenaria*	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AD	*Achnanthes*	*delicatula*	0.00	0.00	0.09	0.00	0.89	1.48	4.50	1.37	0.00	0.00
ASPE	*Achnanthes*	*speciosa*	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00
AMPA	*Amphora*	*atacamana*	0.00	0.00	2.94	0.72	0.00	5.43	6.70	8.40	4.94	0.00
AMPM	*Amphora*	*atacamana minor*	0.00	0.00	0.00	0.00	0.00	5.55	4.50	0.00	2.22	0.00
ABOL	*Amphora*	*boliviana*	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ABEL	*Amphora*	*boliviana elongata*	0.00	0.00	0.00	2.80	0.80	0.00	0.00	0.68	1.31	0.00
AMCJ	*Amphora*	*carvajaliana*	0.00	1.00	6.08	0.00	0.00	2.50	3.90	2.73	0.40	0.50
ANSA	*Anomoeoneis*	*sphaerophora angusta*	0.00	2.00	0.09	0.72	0.00	0.00	0.00	0.00	0.00	0.00
CSP	*Caloneis*	*silicula minuta*	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.50
CAW	*Caloneis*	*westii*	0.00	0.00	0.00	2.38	2.78	0.00	0.00	0.00	0.00	0.00
CP	*Cocconeis*	*placentula*	0.00	1.30	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
CYL	*Cymbella*	*gracilis*	0.00	0.00	0.09	1.04	0.20	0.00	0.00	0.68	0.00	0.00
CYMP	*Cymbella*	*pusilla*	0.00	0.00	1.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
DETH	*Denticula*	*thermalis*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DE	*Denticula*	*elegans*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEV	*Denticula*	*valida*	0.00	0.00	0.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00
FB	*Fragilaria*	*brevistriata*	0.00	0.00	0.00	35.82	73.06	10.23	7.30	10.00	9.49	0.00
FRCV	*Fragilaria*	*construens venter*	0.00	0.00	0.00	0.00	0.00	5.80	0.00	3.65	0.00	0.00
FE	*Fragilaria*	*fasciculata*	0.00	0.00	0.00	0.00	0.00	1.85	0.00	0.00	5.85	0.00
OM	*Fragilaria*	*leptaustoron martyi*	0.00	3.00	0.00	0.00	1.89	0.00	0.00	0.46	0.00	0.00
FP	*Fragilaria*	*pinnata*	0.00	0.00	0.00	0.72	0.00	1.85	0.00	2.73	1.31	0.00
FZ	*Fragilaria*	*zeilleri*	0.00	0.00	0.00	0.00	9.94	0.00	0.60	0.00	0.00	0.00
HA	*Hantzschia*	*amphioxys*	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
HN	*Hantzschia*	*novsp*	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.06
MATA	*Mastoglia*	*atacamae*	0.00	0.00	0.00	1.97	0.50	0.00	0.00	1.37	0.00	0.00
NCA	*Navicula*	*cariocincta*	0.00	0.00	0.09	0.00	0.10	0.74	0.60	0.00	0.40	50.25
NCI	*Navicula*	*cincta*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NC	*Navicula*	*veneta*	0.00	21.00	0.95	2.38	0.10	0.00	0.60	0.00	0.91	0.00
NHN	*Navicula*	*nivalis*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
NPB	*Navicula*	*paramutica binodis*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.56
NAO	*Navicula*	*cryptotenelloïdes*	0.00	1.00	4.84	1.55	0.80	10.97	7.30	5.40	8.58	0.00
NLA	*Navicula*	*pseudolanceolata*	0.00	12.00	0.00	7.25	0.00	12.70	12.90	0.00	0.00	0.00
NLI	*Navicula*	*pseudolitoricola*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NPYG	*Fallacia*	*pygmeae*	0.00	0.00	0.00	0.31	1.19	0.00	0.60	0.00	0.00	0.00
NDC	*Navicula*	*erifuga*	0.00	0.00	5.22	0.00	0.00	0.00	0.00	17.70	2.72	1.51
NASA	*Navicula*	*salinicola*	0.00	7.00	21.65	2.07	0.00	14.92	21.40	19.20	25.73	0.00
NS	*Navicula*	sp.	0.00	0.00	0.00	0.00	1.09	0.37	1.60	0.00	0.40	0.00
NILI	*Nitzschia*	*liebetruthii*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NCHI	*Nitzschia*	*accedens chilensis*	2.30	0.00	5.89	0.31	0.10	5.70	8.50	1.37	7.37	0.00
NIAL	*Nitzschia*	*alpina*	0.00	35.00	4.56	0.00	0.10	0.00	0.00	0.00	2.22	0.00
ND	*Nitzschia*	*amphibiodes*	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NICC	*Nitzschia*	*compressa compressa*	0.00	0.00	0.00	1.04	0.10	0.37	0.00	0.00	0.00	0.00
NIEP	*Nitzschia*	*epithemioides epithemioides*	0.00	0.00	1.61	0.00	0.00	3.45	10.10	6.60	5.45	0.00
NF	*Nitzschia*	*frustulum*	0.00	0.00	0.00	3.62	0.00	1.85	0.00	1.80	0.00	0.00
NGRU	*Nitzschia*	*grunowii*	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIH	*Nitzschia*	*hantzschiana*	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.59
NIHU	*Nitzschia*	*hungarica*	0.00	2.00	1.23	0.00	0.50	0.00	1.10	1.37	0.40	0.00
NPA	*Nitzschia*	*palea*	0.30	0.00	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.00
NIPS	*Nitzschia*	*pusilla*	2.30	3.00	0.00	0.00	0.00	1.48	1.10	2.73	14.63	0.00
NIVA	*Nitzschia*	*valdecostata*	0.00	1.00	0.00	2.07	0.00	0.00	0.00	0.00	0.00	3.02
PB	*Pinnularia*	*bogotensis*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PIMI	*Pinnularia*	*microstauron*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RHWE	*Rhopalodia*	*wetzelii*	0.00	0.00	0.00	1.55	0.00	0.74	2.20	4.10	0.40	0.00
SCPE	*Scoliopleura*	*peisonis*	0.00	0.00	0.00	1.04	0.00	0.00	1.10	1.37	0.00	0.00
SG	*Stauroneis*	*gregorii*	0.00	0.00	0.00	2.07	0.00	2.71	0.00	1.37	1.82	0.00
SB	*Stauroneis*	*bathurstensis*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SSP	*Stauroneis*	*species (obtusa?)*	19.60	0.00	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.00
STAW	*Stauroneis*	*wislouchii*	75.80	5.00	40.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO	*Surirella*	*oregonica*	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.40	0.00
SUSE	*Surirella*	*sella*	0.00	2.00	0.09	9.32	0.10	0.00	0.10	0.91	0.10	0.00
SUSP	*Surirella*	sp.	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.00
SUWE	*Surirella*	*wetzelii*	0.00	0.00	0.00	3.62	0.10	0.37	0.60	4.10	0.20	0.00

TABLEAU 2 : Liste des espèces et abondance dans 30 échantillons

TABLE 2: List of species and their abundance in 30 samples

Codes / Codes	Genres / Genera	Espèces / Species	Pastos Grandes								
			PG73	PG76	PG74	PG78	PG82	PG84	PG97	P114	P116
ACAR	*Achnanthes*	*arenaria*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
AD	*Achnanthes*	*delicatula*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00
ASPE	*Achnanthes*	*speciosa*	1.46	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AMPA	*Amphora*	*atacamana*	0.00	2.90	0.00	10.59	0.68	7.75	0.00	3.70	1.79
AMPM	*Amphora*	*atacamana minor*	0.00	0.00	0.00	5.34	0.00	0.00	0.00	0.00	3.79
ABOL	*Amphora*	*boliviana*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ABEL	*Amphora*	*boliviana elongata*	3.11	1.90	3.67	0.00	0.00	0.18	0.00	0.00	0.00
AMCJ	*Amphora*	*carvajaliana*	0.00	0.00	0.00	1.31	1.07	1.25	0.00	0.00	0.00
ANSA	*Anomoeoneis*	*sphaerophora angusta*	0.29	0.00	0.00	0.00	0.19	0.00	0.56	0.00	0.00
CSP	*Caloneis*	*silicula minuta*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAW	*Caloneis*	*westii*	3.02	0.00	3.10	0.00	0.19	0.18	0.00	0.00	0.00
CP	*Cocconeis*	*placentula*	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00
CYL	*Cymbella*	*gracilis*	9.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYMP	*Cymbella*	*pusilla*	0.00	3.53	7.53	2.62	0.20	0.00	0.00	0.00	0.00
DETH	*Denticula*	*thermalis*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DE	*Denticula*	*elegans*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEV	*Denticula*	*valida*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FB	*Fragilaria*	*brevistriata*	6.42	0.00	5.27	1.31	0.00	0.00	0.00	11.26	5.18
FRCV	*Fragilaria*	*construens venter*	0.00	0.00	1.32	1.71	0.00	1.51	0.00	1.95	0.00
FE	*Fragilaria*	*fasciculata*	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OM	*Fragilaria*	*leptaustoron martyi*	0.00	0.00	0.00	0.00	0.00	1.07	0.74	0.32	0.30
FP	*Fragilaria*	*pinnata*	0.00	0.00	0.00	1.70	11.99	0.00	0.00	0.00	8.97
FZ	*Fragilaria*	*zeilleri*	0.00	0.00	1.69	0.00	41.52	0.00	0.00	0.00	0.00
HA	*Hantzschia*	*amphioxys*	0.00	0.00	0.00	0.00	0.19	0.00	0.56	0.43	0.00
HN	*Hantzschia*	*novsp*	0.00	0.00	0.56	0.00	0.19	0.00	13.30	0.43	0.00
MATA	*Mastoglia*	*atacamae*	15.18	7.40	16.65	1.30	0.19	0.71	1.12	0.00	0.60
NCA	*Navicula*	*cariocincta*	0.00	0.00	0.00	0.80	0.20	5.79	4.80	3.40	2.20
NCI	*Navicula*	*cincta*	2.00	0.00	0.00	0.00	4.30	1.06	0.00	6.90	0.00
NC	*Navicula*	*veneta*	7.50	5.90	17.78	0.81	19.10	1.07	3.72	3.68	2.19
NHN	*Navicula*	*nivalis*	0.00	0.00	0.00	0.00	0.19	0.00	5.03	0.00	0.30
NPB	*Navicula*	*paramutica binodis*	0.00	0.00	0.00	0.00	0.19	0.53	10.90	0.43	0.60
NAO	*Navicula*	*cryptotenelloïdes*	0.00	4.40	1.13	11.40	3.10	2.40	28.80	8.30	6.70
NLA	*Navicula*	*pseudolanceolata*	15.66	24.30	5.27	31.37	0.20	0.00	0.00	0.00	10.97
NLI	*Navicula*	*pseudolitoricola*	0.00	1.94	0.00	0.40	0.00	0.00	0.00	0.00	0.00
NPYG	*Fallacia*	*pygmeae*	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00
NDC	*Navicula*	*erifuga*	0.00	0.00	0.00	0.00	0.00	0.00	5.59	6.49	0.00
NASA	*Navicula*	*salinicola*	0.00	2.90	0.00	12.30	1.85	35.65	0.00	30.40	22.90
NS	*Navicula*	sp.	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
NILI	*Nitzschia*	*liebetruthii*	1.95	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00
NCHI	*Nitzschia*	*accedens chilensis*	0.00	0.42	0.00	2.22	0.88	6.32	0.00	1.95	8.18
NIAL	*Nitzschia*	*alpina*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ND	*Nitzschia*	*amphibiodes*	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NICC	*Nitzschia*	*compressa compressa*	5.84	2.40	0.38	0.40	0.19	0.89	0.00	0.00	0.60
NIEP	*Nitzschia*	*epithemioides epithemioides*	0.00	0.00	0.00	1.70	0.68	8.01	0.00	4.44	7.28
NF	*Nitzschia*	*frustulum*	5.00	10.90	0.38	1.31	1.56	1.25	0.00	1.41	0.00
NGRU	*Nitzschia*	*grunowii*	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIH	*Nitzschia*	*hantzschiana*	4.96	0.00	0.40	1.30	1.36	0.00	0.00	0.00	0.00
NIHU	*Nitzschia*	*hungarica*	2.24	3.90	0.56	1.31	3.31	0.53	4.66	0.43	0.60
NPA	*Nitzschia*	*palea*	0.00	0.00	0.00	0.00	0.00	6.23	0.00	0.00	0.30
NIPS	*Nitzschia*	*pusilla*	0.00	0.00	0.00	0.00	0.00	9.70	0.00	11.47	13.86
NIVA	*Nitzschia*	*valdecostata*	0.00	0.00	0.40	0.00	1.17	0.00	0.00	0.00	0.00
PB	*Pinnularia*	*bogotensis*	1.07	0.00	1.69	0.00	0.39	0.18	0.56	0.00	0.00
PIMI	*Pinnularia*	*microstauron*	0.00	0.00	1.89	0.00	0.40	0.00	0.60	0.00	0.30
RHWE	*Rhopalodia*	*wetzelii*	0.00	3.20	0.00	0.40	0.19	0.98	0.56	0.43	0.30
SCPE	*Scoliopleura*	*peisonis*	1.75	2.90	0.00	1.71	0.19	0.00	0.00	0.00	0.00
SG	*Stauroneis*	*gregorii*	0.00	0.00	0.40	0.00	0.88	0.36	0.00	0.00	0.00
SB	*Stauroneis*	*bathurstensis*	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00
SSP	*Stauroneis*	*species (obtusa?)*	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STAW	*Stauroneis*	*wislouchii*	0.00	4.90	0.00	0.00	0.00	3.74	0.56	0.87	1.50
SO	*Surirella*	*oregonica*	0.70	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUSE	*Surirella*	*sella*	0.00	1.46	9.78	0.40	0.10	0.00	0.56	0.00	0.00
SUSP	*Surirella*	sp.	1.90	1.20	0.40	0.00	0.00	0.00	0.00	0.00	0.00
SUWE	*Surirella*	*wetzelii*	3.79	1.56	3.29	0.10	0.10	0.18	0.00	0.43	0.00

TABLEAU 3 : Liste des images de diatomées

TABLE 3: List of diatom pictures

Genres *Genera*	Espèces *Species*		Images Pictures		SERVANT-VILDARY & ROUX (1990)	SERVANT-VILDARY & BLANCO (1984)	SERVANT-VILDARY (1984)
Achnanthes	*arenaria*	Amossé	CG2001_M01_SSV-FR-MR_Photo_001	d2-80	Fig. 42-43		
Achnanthes	*brevipes intermedia*	Kützing	CG2001_M01_SSV-FR-MR_Photo_002	d1-73			
Achnanthes	*chilensis*	Hustedt			Fig. 31-32		
Achnanthes	*delicatula*	(Kütz) Grunow			Fig. 33	Pl. IV, fig. 1-2	
Achnanthes	*speciosa*	Hustedt	CG2001_M01_SSV-FR-MR_Photo_003	d2-101		Pl. I, fig. 19; Pl. VIII, fig. 4	
Amphora	*atacamana*	Frenguelli	CG2001_M01_SSV-FR-MR_Photo_004	d1-09a	Fig. 11		
Amphora	*atacamana minor*		CG2001_M01_SSV-FR-MR_Photo_005	d2-29	Fig. 12b & c		
Amphora	*boliviana*	Patrick	CG2001_M01_SSV-FR-MR_Photo_006, CG2001_M01_SSV-FR-MR_Photo_007	d2-53, d2-17	Fig. 10		
Amphora	*boliviana elongata*		CG2001_M01_SSV-FR-MR_Photo_008	d2-12	Fig. 13		
Amphora	*carvajaliana*	Patrick	CG2001_M01_SSV-FR-MR_Photo_009	d1-71	Fig. 9, 14		
Amphora	*coffaeformis*	Agardh	CG2001_M01_SSV-FR-MR_Photo_010	d2-99		Pl. IV, fig. 9	
Amphora	*lineolata*	Ehrenberg	CG2001_M01_SSV-FR-MR_Photo_011	d2-52a	Fig. 47-48		
Amphora	*lybica*	Ehrenberg	CG2001_M01_SSV-FR-MR_Photo_012	d1-06	Fig. 44		
Amphora	*platensis*	Frenguelli	CG2001_M01_SSV-FR-MR_Photo_013	d2-65		Pl. II, fig. 25	
Anomoeoneis	*sphaerophora angusta*	Frenguelli	CG2001_M01_SSV-FR-MR_Photo_014	d2-11		Pl. II , fig. 16-17	
Anomoeoneis	*sphaerophora navicularis*	(Ehr.) O. Muller	CG2001_M01_SSV-FR-MR_Photo_015	d4-05		Pl. II , fig. 12-13	
Anomoeoneis	*sphaeroprophora platensis*	Frenguelli	CG2001_M01_SSV-FR-MR_Photo_016	d2-09	Fig. 49		
Brachysira	*aponina*	Kutzing	CG2001_M01_SSV-FR-MR_Photo_017	d2-23	Fig. 25		
Caloneis	*silicula minuta*	(Grun) Mills	CG2001_M01_SSV-FR-MR_Photo_018	d1-57			
Caloneis	*westii*	(W. Smith) Hendey	CG2001_M01_SSV-FR-MR_Photo_019	d1-02	Fig. 50	Pl. I, fig. 7	
Cocconeis	*placentula euglypta*	(Ehr) Cleve	CG2001_M01_SSV-FR-MR_Photo_020	d1-37			
Cymbella	*cymbiformis*	(Agardh Kütz) Van Heurck	CG2001_M01_SSV-FR-MR_Photo_021	d2-83			
Cymbella	*pusilla*	Grunow	CG2001_M01_SSV-FR-MR_Photo_022	d1-81	Fig. 14		
Denticula	*elegans*	Kützing	CG2001_M01_SSV-FR-MR_Photo_023	d2-24	Fig. 51		
Denticula	*eximia*	Krammer & Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_024	d2-57			
Denticula	*kuetzingii*	Grunow	CG2001_M01_SSV-FR-MR_Photo_025	d2-43			
Denticula	*subtilis*	Grunow	CG2001_M01_SSV-FR-MR_Photo_026	d1-18			
Denticula	*tenuis* var.?	Kützing	CG2001_M01_SSV-FR-MR_Photo_027	d2-22	Fig. 36		
Denticula	*thermalis*	Kützing	CG2001_M01_SSV-FR-MR_Photo_028	d3-60			
Denticula	*valida*	(Pedicino) Grunow	CG2001_M01_SSV-FR-MR_Photo_029	d2-60	Fig. 35		
Entomoneis	*paludosa*	(W. Smith) Reimer	CG2001_M01_SSV-FR-MR_Photo_030	d3-75		Pl. IV, fig. 10	
Fallacia	*pygmeae*	Kützing	CG2001_M01_SSV-FR-MR_Photo_031	d2-100	Fig. 38	Pl. II, fig. 23	
Fragilaria	*brevistriata*		CG2001_M01_SSV-FR-MR_Photo_032	d2-98 (PAG 70)			
Fragilaria	*brevistriata*		CG2001_M01_SSV-FR-MR_Photo_033	d2-07a (PAG 73)	Fig. 27		
Fragilaria	*brevistriata*		CG2001_M01_SSV-FR-MR_Photo_034	d1-41 (PAG 23)			
Fragilaria	*brevistriata elliptica*	Héribaud	CG2001_M01_SSV-FR-MR_Photo_035	d1-45 (PAG 41)			
Fragilaria	*construens binodis*	(Ehrenberg) Husted	CG2001_M01_SSV-FR-MR_Photo_036	d2-86			
Fragilaria	*construens* f. *subsalina*	Hustedt	CG2001_M01_SSV-FR-MR_Photo_037	d1-43			
Fragilaria	*fasciculata*	(Agardh) Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_038	d1-44			
Fragilaria	*pinnata*	Ehrenberg				Pl. III, fig. 2	

TABLEAU 3 : Liste des images de diatomées

TABLE 3: List of diatom pictures

Genres / *Genera*	Espèces / *Species*		Images / Pictures		SERVANT-VILDARY & ROUX (1990)	SERVANT-VILDARY & BLANCO (1984)	SERVANT-VILDARY (1984)
Fragilaria	*zeilleri*	Héribaud	CG2001_M01_SSV-FR-MR_Photo_039	d4-08	Fig. 29		
Hantzschia	*amphioxys*	(Ehrenberg) Grunow	CG2001_M01_SSV-FR-MR_Photo_040	d1-10		Pl. V, fig. 12-13	
Hantzschia	*amphioxys* var. *maior*	Grunow	CG2001_M01_SSV-FR-MR_Photo_041	d2-93		Pl. V, fig. 1-11	
Hantzschia	sp.		CG2001_M01_SSV-FR-MR_Photo_042	d2-89			
Hippodonta	*hungarica*	(Grun) Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_043	d2-06			
Mastoglia	*atacamae*	Frenguelli					
Mastoglia	*smithii lacustris*	Grunow	CG2001_M01_SSV-FR-MR_Photo_044, CG2001_M01_SSV-FR-MR_Photo_045	d2-25, d2-47	Fig. 53		
			CG2001_M01_SSV-FR-MR_Photo_046	d2-14			
Navicula	*arctotenelloides*	Lange-Bertalot & Metzeltin	CG2001_M01_SSV-FR-MR_Photo_047	d2-95 (Pag 72)			
Navicula	*cariocincta*	Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_048	d2-103			
Navicula	cf. *muticopsis*	Van Heurck	CG2001_M01_SSV-FR-MR_Photo_049	d2-103			
Navicula	cf. *paramutica binodis*	Bock	CG2001_M01_SSV-FR-MR_Photo_050	d2-04 (ag 116)	Fig. 39	Pl. II, fig. 20	
Navicula	*cincta*	Ehrenberg	CG2001_M01_SSV-FR-MR_Photo_051	d2-37			
Navicula	*cryptotenelloides*	Hustedt	CG2001_M01_SSV-FR-MR_Photo_052	d1-09c			
Navicula	*digitoradiata minor*	Krasske			Fig. 54		
Navicula	*erifuga*	Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_053, CG2001_M01_SSV-FR-MR_Photo_054	d1-36, d1-27	Fig. 34		
			CG2001_M01_SSV-FR-MR_Photo_055	d2-05 (Pag 73)			
Navicula	*incertata*	Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_056	d4-11			
Navicula	*nivalis*	Ehrenberg	CG2001_M01_SSV-FR-MR_Photo_057	d1-35		Pl. II, fig. 21	
Navicula	*novadecipiens*	Hustedt	CG2001_M01_SSV-FR-MR_Photo_058	d2-18 (Can 4)			
Navicula	*phyllepta*	Kützing	CG2001_M01_SSV-FR-MR_Photo_059	d1-31			
Navicula	*podzorskii*	Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_060	d2-55 (Bal 67)			
Navicula	*pseudolitoricola*	Häkansson	CG2001_M01_SSV-FR-MR_Photo_061	d2-15 (Pag 84)			
Navicula	*salinicola*		CG2001_M01_SSV-FR-MR_Photo_062	d2-32	Fig. 22, 23		
Navicula	sp.		CG2001_M01_SSV-FR-MR_Photo_063	d1-98			
Navicula	*tripunctata*	(O.F. Muller) Bory	CG2001_M01_SSV-FR-MR_Photo_064	d2-07b (Pag 73)			
Navicula	*veneta*	Kützing	CG2001_M01_SSV-FR-MR_Photo_065	d2-85	Fig. 45		
Neidium	*bisulcatum subampliatum*	Krammer	CG2001_M01_SSV-FR-MR_Photo_066	d2-84			
Neidium	*koslowii*	Mereschkowski	CG2001_M01_SSV-FR-MR_Photo_067	d3-72			
Nitzschia	*accedens chilensis*	Patrick	CG2001_M01_SSV-FR-MR_Photo_068	d1-08			Pl. I, Fig. 1-5
Nitzschia	aff. *valdecostata*		CG2001_M01_SSV-FR-MR_Photo_069	d2-59 (Cl20)			Pl. IV, Fig. 4-11
Nitzschia	*amphibia*	Grunow	CG2001_M01_SSV-FR-MR_Photo_070	d2-21 (Can 4)			
Nitzschia	cf. *amphibioides*	Hustedt	CG2001_M01_SSV-FR-MR_Photo_071	d3-62			
Nitzschia	*compressa compressa*	Lange-Bertalot					Pl. I, Fig. 26
Nitzschia	*epithemioides epithemioides*	Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_072, CG2001_M01_SSV-FR-MR_Photo_073	d2-13, d1-89			Pl. I, Fig. 12-15
			CG2001_M01_SSV-FR-MR_Photo_074	d1-86 (Pag 84)			
Nitzschia	*frustulum (modesta)*	(Kützing) Grunow	CG2001_M01_SSV-FR-MR_Photo_075	d2-46 (Bal)			Pl. I, Fig. 16-17
Nitzschia	*grunowii*	(Cleve) Hasle	CG2001_M01_SSV-FR-MR_Photo_076	d2-94 (Pag 72)			Pl. II, Fig. 13-16
Nitzschia	*hantzschiana (modesta)*	Rabenhorst					

TABLEAU 3 : Liste des images de diatomées

TABLE 3: List of diatom pictures

Genres *Genera*	Espèces *Species*		Images *Pictures*		SERVANT-VILDARY & ROUX (1990)	SERVANT-VILDARY & BLANCO (1984)	SERVANT-VILDARY (1984)
			CG2001_M01_SSV-FR-MR_Photo_077	d1-49			
Nitzschia	*hungarica*	Grunow					Pl. II, Fig. 1-9
Nitzschia	*liebetruthii*	Lange-Bertalot	CG2001_M01_SSV-FR-MR_Photo_078, CG2001_M01_SSV-FR-MR_Photo_079	d2-20, d2-58			Pl. IV, Fig. 19-25
			CG2001_M01_SSV-FR-MR_Photo_080	d1-40 (CLD 16)			
Nitzschia	*alpina*	Hustedt					Pl. I, Fig. 6-9
			CG2001_M01_SSV-FR-MR_Photo_081	d2-36 (Can)			
Nitzschia	*palea*	(Kützing) W. Smith					Pl. III, Fig. 6-7
			CG2001_M01_SSV-FR-MR_Photo_082	d1-48 (Pag 23)			
Nitzschia	*palea*	(Kützing) W. Smith					
			CG2001_M01_SSV-FR-MR_Photo_083	d4-16			
Nitzschia	*pusilla*	Grunow					
			CG2001_M01_SSV-FR-MR_Photo_084	d1-54			
Nitzschia	*valdecostata*	Lange-Bertalot & Simonsen					Pl. IV, Fig. 1-3
			CG2001_M01_SSV-FR-MR_Photo_085	d2-38			
Nitzschia	*valdestriata*	Aleem & Hustedt					
			CG2001_M01_SSV-FR-MR_Photo_086	d2-92			
Pinnularia	*borealis* f. *ovalis*	Boye Petersen					
			CG2001_M01_SSV-FR-MR_Photo_087	d2-90			
Pinnularia	*microstauron*	Ehrenberg Cleve					
			CG2001_M01_SSV-FR-MR_Photo_088	d2-48 (Pur 2)			
Placoneis	aff. *elginensis*	(Greg) Cox var elginensis					
			CG2001_M01_SSV-FR-MR_Photo_089	d4-10			
Rhopalodia	*sculpta*	Krammer					
			CG2001_M01_SSV-FR-MR_Photo_090	d2-34			
Rhopalodia	*wetzelii*	Hustedt			Fig. 15-17		
			CG2001_M01_SSV-FR-MR_Photo_091	d3-64			
Scoliopleura	*peisonis*	Grunow			Fig. 52		
			CG2001_M01_SSV-FR-MR_Photo_092	d2-16			
Stauroneis	*anceps*	Ehrenberg					
			CG2001_M01_SSV-FR-MR_Photo_093	d2-50			
Stauroneis	*bathurstensis*	Giffen			Fig. 34		
			CG2001_M01_SSV-FR-MR_Photo_094	d2-68,			
Stauroneis	*elata*	Hustedt					
			CG2001_M01_SSV-FR-MR_Photo_095	d1-46			
Stauroneis	*gregorii*	Ralfs			Fig. 55		
			CG2001_M01_SSV-FR-MR_Photo_096	d3-76			
Stauroneis	*gregorii densestriata*	Hustedt					
			CG2001_M01_SSV-FR-MR_Photo_097	d2-19			
Stauroneis	*gregorii var linearis*	Hustedt					
			CG2001_M01_SSV-FR-MR_Photo_098	d1-26			
Stauroneis	*legleri*	Hustedt			Fig. 40		
			CG2001_M01_SSV-FR-MR_Photo_099	d2-40			
Stauroneis	sp. *(obtusa?)*				Fig. 37		
Stauroneis	*wislouchii*	Poretsky & Anisimova	CG2001_M01_SSV-FR-MR_Photo_100, CG2001_M01_SSV-FR-MR_Photo_101	d4-02, d2-49	Fig. 41		
			CG2001_M01_SSV-FR-MR_Photo_102	d1-05			
Surirella	*chilensis*	Janish			Fig. 56		
			CG2001_M01_SSV-FR-MR_Photo_103	d1-12			
Surirella	*dubia*	Frenguelli					
			CG2001_M01_SSV-FR-MR_Photo_104	d1-70			
Surirella	*oregonica*	Ehrenberg				Pl. I, fig. 17; Pl. VIII, fig. 1-2	
			CG2001_M01_SSV-FR-MR_Photo_105	d2-27			
Surirella	*ovata utahensis*	Grunow			Fig. 26	Pl. VIII, fig. 8-9; Pl. II, fig. 6	
Surirella	*peisonis*	Hustedt				Pl. II, fig. 5 & 10	
Surirella	*sella*	Hustedt	CG2001_M01_SSV-FR-MR_Photo_106	d1-13	Fig. 19	Pl. II, fig. 7; Pl. VII, fig. 3-7	
Surirella	*wetzelii*	Hustedt			Fig. 20		
			CG2001_M01_SSV-FR-MR_Photo_107	d1-73a			
Chiar Kkota							
			CG2001_M01_SSV-FR-MR_Photo_038	d1-44			
Pastos Grandes 23							
Pastos Grandes 84			CG2001_M01_SSV-FR-MR_Photo_063, CG2001_M01_SSV-FR-MR_Photo_108	d1-98, d1-09			

TABLEAU 4 : Optima et tolérances estimées des espèces

TABLE 4: Optima and tolerances of the species

Weighted Averaging (WA) method. Results: R, R², Standard error of prediction (SEP).
Weighted Averaging Plus Least Squares regression (WA-PLS). Results: number of components, r, R, R² and S

Genres	Espèces	Codes	Na+ (mg/l)			
Genera	Species	Samples	codes	OPTIMUM	TOLERANCE	FREQUENCE
Achnanthes	*arenaria*	ACAR		9440.02	11850.67	6
Achnanthes	*delicatula*	AD		13217.75	17837.34	7
Achnanthes	*speciosa*	ASPE		9437.31	4670.60	6
Amphora	*atacamana*	AMPA		40443.13	32684.07	17
Amphora	*atacamana minor*	AMPM		40196.09	36663.85	7
Amphora	*boliviana*	ABOL		23994.03	17053.50	5
Amphora	*boliviana elongata*	ABEL		10787.01	25830.84	9
Amphora	*carvajaliana*	AMCJ		15297.68	11510.65	21
Anomoeoneis	*sphaerophora angusta*	ANSA		13427.04	10983.83	9
Caloneis	*silicula minuta*	CSP		16067.21	14089.92	4
Caloneis	*westii*	CAW		3332.06	9349.22	8
Cocconeis	*placentula*	CP		7358.88	6013.96	7
Cymbella	*gracilis*	CYL		9520.02	10816.22	13
Cymbella	*pusilla*	CYMP		21344.87	15054.82	7
Denticula	*thermalis*	DETH		6761.96	4415.52	5
Fragilaria	*brevistriata*	FB		17235.64	33302.23	11
Fragilaria	*construens venter*	FRCV		26823.29	29188.60	5
Fragilaria	*fasciculata*	FE		37721.56	34753.68	5
Fragilaria	*leptaustoron martyi*	OM		27283.28	29857.10	7
Fragilaria	*pinnata*	FP		37365.34	41497.84	9
Fragilaria	*zeilleri*	FZ		177.13	488.35	4
Hantzschia	*amphioxys*	HA		27347.08	38222.20	4
Hantzschia	nov. sp.	HN		2085.29	10485.98	7
Mastoglia	*atacamae*	MATA		6873.58	15864.44	11
Navicula	*cariocincta*	NCA		22097.43	34459.92	14
Navicula	*cincta*	NCI		50355.07	38808.34	4
Navicula	*veneta*	NC		9779.83	20579.58	20
Navicula	*nivalis*	NHN		4366.02	18936.03	5
Navicula	*paramutica binodis*	NPB		6935.49	19702.86	9
Navicula	*cryptotenelloïdes*	NAO		28421.04	34981.70	25
Navicula	*pseudolanceolata*	NLA		16821.11	12651.41	7
Navicula	*pseudolitoricola*	NLI		12031.41	14350.63	5
Fallacia	*pygmeae*	NPYG		3339.75	4620.82	7
Navicula	*erifuga*	NDC		28247.65	28971.50	19
Navicula	*salinicola*	NASA		55122.24	34786.00	18
Navicula	sp.	NS		13124.38	30099.34	5
Nitzschia	*liebetruthii*	NILI		8307.35	3635.29	6
Nitzschia	*accedens chilensis*	NCHI		48925.66	38497.14	17
Nitzschia	*alpina*	NIAL		25431.24	19047.58	7
Nitzschia	*amphibiodes*	ND		8500.04	7345.89	4
Nitzschia	*compressa compressa*	NICC		14086.18	24500.73	13
Nitzschia	*epithemioides epithemioides*	NIEP		52051.10	37543.32	12
Nitzschia	*frustulum*	NF		13205.34	20836.79	16
Nitzschia	*grunowii*	NGRU		9150.83	5819.79	8
Nitzschia	*hantzschiana*	NIH		6869.44	10104.02	12
Nitzschia	*hungarica*	NIHU		9519.94	17046.45	20
Nitzschia	*palea*	NPA		64909.73	28127.99	6
Nitzschia	*pusilla*	NIPS		69579.49	35585.78	11
Nitzschia	*valdecostata*	NIVA		5422.61	4662.80	7
Pinnularia	*bogotensis*	PB		8636.53	17258.04	6
Pinnularia	*microstauron*	PIMI		6689.21	22072.75	5
Rhopalodia	*wetzelii*	RHWE		24527.57	27391.25	14
Scoliopleura	*peisonis*	SCPE		14800.99	13101.88	13
Stauroneis	*gregorii*	SG		26378.85	30284.68	13
Stauroneis	*bathurstensis*	SB		10397.72	6982.38	7
Stauroneis	*species (obtusa?)*	SSP		10391.23	1275.46	4
Stauroneis	*wislouchii*	STAW		21298.95	18691.32	13
Surirella	*oregonica*	SO		18356.95	35103.41	4
Surirella	*sella*	SUSE		7995.52	9242.72	19
Surirella	sp.	SUSP		4010.54	1994.34	6
Surirella	*wetzelii*	SUWE		19125.02	14219.46	21

Samples	*Observed values*	*Estimated values*	*Residus*
BA67	13600.000	9850.410	3749.590
RAM6	7590.000	9189.363	-1599.363
VER5	4510.000	10314.528	-5804.528
HED4	20400.000	15766.853	4633.147
PJ30	10000.000	17438.639	-7438.639
PUR2	9550.000	17764.068	-8214.068
HON4	6740.000	15732.725	-8992.725
CHI5	20700.000	16570.824	4129.176
CAN4	3590.000	17847.662	-14257.662
CHU4	30100.000	16336.339	13763.661
CHU9	2320.000	15377.588	-13057.588
CL20	10600.000	21038.520	-10438.520
CD24	19900.000	22094.158	-2194.158
CD16	40700.000	31594.473	9105.527
PG70	4000.000	17107.711	-13107.711
PG23	451.000	15642.589	-15191.589
PG41	9270.000	33827.559	-24557.559
PG43	4510.000	37911.148	-33401.148
PG45	34000.000	36413.168	-2413.168
PG47	103000.000	43389.824	59610.176
PG72	80.000	8339.988	-8259.988
PG73	3910.000	12262.317	-8352.317
PG76	4510.000	19992.775	-15482.775
PG74	350.000	11090.177	-10740.177
PG78	46000.000	31939.594	14060.406
PG82	41.900	15822.397	-15780.497
PG84	77100.000	47132.605	29967.395
PG97	85.100	16681.498	-16596.398
P114	81000.000	41826.746	39173.254
P116	92000.000	43336.016	48663.984
	WA: Coefficient de correlation multiple		**R = 0.8117**
			R^2 = 0.66
	Variance de la variable Na à expliquer		**8.31E+08**
	Variance des résidus		**4.25E+08**
	Ecart-type des résidus = SEP Standard error of prediction		**20614.64**
	WA-PLS : 2 components, SEP = 19442		**R = 0.89**
			R^2 = 0.80
			r = 0.7428

K+ (mg/l)				Salinity (mg/l)			
codes	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*	*codes*	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*
	1207.12	925.77	6		29884.19	34429.63	6
	1511.25	2143.75	7		40795.95	55567.99	7
	1166.47	600.42	6		31176.80	15906.11	6
	4426.33	3845.48	17		123735.41	99822.04	17
	4257.09	4103.14	7		122779.11	110397.41	7
	2860.24	1447.47	5		72972.30	48567.10	5
	1825.20	3406.29	9		34962.11	80398.52	9
	2077.72	2147.55	21		50363.23	37055.72	21
	2897.28	3823.70	9		44776.31	38354.55	9
	6951.01	5887.35	4		64038.06	55436.06	4
	350.89	795.83	8		10419.22	27379.88	8
	923.81	743.64	7		23819.22	17230.23	7
	1071.23	1196.17	13		30254.42	33905.07	13
	4631.94	4764.32	7		71689.87	48995.69	7
	1464.69	419.25	5		24453.56	13426.39	5
	2142.83	4228.09	11		53828.97	103370.23	11
	2866.36	3155.15	5		82480.13	89476.72	5
	4810.78	4884.37	5		116897.13	109656.84	5
	2635.38	2740.90	7		81122.17	88503.35	7
	3477.70	3933.59	9		110897.58	122287.35	9
	18.46	53.66	4		627.79	1512.63	4
	3312.03	4629.13	4		86242.18	120386.45	4
	288.91	1278.51	7		6799.33	32799.58	7
	705.25	1446.05	11		21127.10	46977.82	11
	2131.09	3435.69	14		66718.63	103268.48	14
	5849.73	4612.14	4		157232.81	121336.81	4
	1264.47	2378.74	20		30542.75	62613.84	20
	369.78	1523.23	5		12920.90	54997.88	5
	1541.78	3682.57	9		23503.87	61560.73	9
	3238.18	4138.50	25		87662.23	107368.46	25
	6070.26	5953.59	7		63646.28	50895.54	7
	1407.68	1534.89	5		38474.49	44953.49	5
	400.11	569.66	7		10917.80	15497.66	7
	3065.24	3031.91	19		86752.94	87606.20	19
	5914.08	4163.34	18		167355.16	106348.25	18
	1732.16	4169.37	5		41231.30	94724.01	5
	983.03	547.96	6		28432.38	12116.65	6
	5219.24	4429.53	17		148070.84	116343.82	17
	2867.35	2681.80	7		76748.71	59978.92	7
	856.53	866.66	4		26391.02	22403.08	4
	1313.88	2022.91	13		42439.33	71431.60	13
	5416.01	4283.07	12		157145.11	113644.09	12
	2049.83	3191.30	16		42566.63	64692.72	16
	1249.43	614.71	8		29977.37	17128.71	8
	1199.49	2455.08	12		23025.32	33768.41	12
	2176.01	3286.98	20		32533.97	53575.68	20
	5508.15	2199.18	6		190057.30	81420.38	6
	7761.39	4335.74	11		212075.11	108571.73	11
	586.82	652.96	7		17276.65	14251.57	7
	2315.01	4612.97	6		30407.47	57011.78	6
	1085.02	1823.82	5		21220.58	63804.37	5
	2710.03	3007.51	14		74965.75	82850.99	14
	1708.77	1435.23	13		47373.04	40977.83	13
	3107.44	3915.96	13		82300.65	94715.86	13
	1148.16	801.92	7		33961.54	23164.52	7
	2769.21	435.99	4		35521.27	4497.50	4
	3094.82	1616.26	13		65771.20	53788.02	13
	2472.09	4863.69	4		57857.84	110435.44	4
	972.41	1242.84	19		25807.73	28999.84	19
	461.16	249.10	6		12834.27	6515.62	6
	5394.96	5449.09	21		69143.63	51302.73	21

Observed values	Estimated values	RESIDUS	Observed values	Estimated values	RESIDUS
1700.000	1190.587	509.413	45335.000	32671.533	12663.467
1030.000	1100.207	-70.207	27658.000	30878.086	-3220.086
308.000	1204.500	-896.500	14716.000	34239.449	-19523.449
2100.000	2508.819	-408.819	67099.000	52600.191	14498.809
1020.000	2161.026	-1141.026	31139.000	55710.945	-24571.945
1720.000	2335.447	-615.447	32785.000	57165.410	-24380.410
989.000	2062.277	-1073.277	21392.000	50968.250	-29576.250
2500.000	2163.798	336.202	69439.000	53829.586	15609.414
212.000	3499.940	-3287.940	11440.000	59072.313	-47632.313
12800.000	4922.541	7877.459	119261.000	59508.641	59752.359
1800.000	2976.847	-1176.847	11377.000	50853.691	-39476.691
2850.000	3194.134	-344.134	36285.000	65473.848	-29188.848
2110.000	3085.000	-975.000	59166.000	68947.984	-9781.984
4260.000	3810.768	449.232	120357.000	96830.477	23526.523
532.000	2218.201	-1686.201	12787.000	54032.887	-41245.887
43.000	1913.913	-1870.913	1475.000	48721.523	-47246.523
1020.000	3764.239	-2744.239	28564.000	103717.336	-75153.336
500.000	4202.771	-3702.771	13961.000	115942.891	-101981.891
3950.000	4206.625	-256.625	103267.000	111875.195	-8608.195
14200.000	4819.732	9380.268	324141.000	132470.984	191670.016
16.500	1244.068	-1227.568	644.000	26697.957	-26053.957
399.000	2304.313	-1905.313	12189.000	40753.777	-28564.777
579.000	2433.364	-1854.364	14421.000	62155.457	-47734.457
48.100	1482.448	-1434.349	1542.000	35173.887	-33631.887
5000.000	3514.777	1485.223	144099.000	97949.422	46149.578
4.420	1703.133	-1698.713	195.000	48293.891	-48098.891
6450.000	5043.687	1406.313	225344.000	142971.688	82372.313
12.600	2056.703	-2044.103	402.000	51884.598	-51482.598
9810.000	4639.320	5170.680	255230.000	127894.984	127335.016
7390.000	4677.638	2712.362	267366.000	131722.109	135643.891
WA: Coefficient de correlation multiple		**R = 0.7559**	*WA: Coefficient de correlation multiple*		**R = 0.8022**
		R^2 = 0.57			**R^2 = 0.57**
Variance de la variable K à expliquer		**1.37E+07**	*Variance de la variable Salinité à expliquer*		**7.69E+09**
Variance des résidus		**8377185**	*Variance des résidus*		**4.07E+09**
Ecart-type des résidus = SEP Standard error of prediction		**2894.337**	*Ecart-type des résidus = SEP Standard error of prediction*		**63814.21**
WA-PLS : 1 component			*WA-PLS : 2 components, SEP = 62130*		**R = 0.8849**
					R^2 = 0.78
					r = 0.71

Alkalinity meq/l				Mg++ (mg/l)			
codes	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*	*codes*	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*
	4.83	2.42	6		255.58	302.83	6
	4.96	3.53	7		259.71	498.06	7
	4.81	0.48	6		393.67	236.63	6
	9.55	6.85	17		934.53	1001.13	17
	8.77	5.79	7		1114.11	1031.01	7
	19.57	12.10	5		609.18	351.06	5
	7.83	5.10	9		310.19	837.84	9
	8.45	5.60	21		559.31	507.79	21
	12.83	9.73	9		436.95	583.08	9
	21.54	13.74	4		976.78	925.04	4
	4.00	1.65	8		96.89	159.22	8
	7.93	3.34	7		251.37	105.36	7
	5.76	2.04	13		279.62	315.07	13
	18.34	14.90	7		811.12	681.13	7
	7.05	3.65	5		267.74	218.89	5
	5.14	6.02	11		526.02	1045.61	11
	5.67	2.19	5		699.55	774.64	5
	9.92	6.88	5		787.64	1328.67	5
	8.16	5.01	7		515.12	666.24	7
	6.86	6.51	9		848.94	1063.83	9
	0.85	0.76	4		7.73	16.18	4
	3.37	3.08	4		863.02	1201.80	4
	3.02	2.67	7		67.10	316.65	7
	4.85	1.77	11		170.92	316.38	11
	3.82	4.47	14		519.20	852.05	14
	5.22	3.57	4		1485.00	1200.18	4
	6.80	5.04	20		261.44	571.33	20
	2.24	2.49	5		105.26	426.55	5
	6.04	8.87	9		260.79	643.18	9
	7.45	7.39	25		759.29	1050.31	25
	18.84	14.61	7		901.39	884.16	7
	4.86	2.03	5		375.59	403.90	5
	2.69	1.74	7		126.12	239.36	7
	7.77	5.70	19		662.75	805.69	19
	12.08	8.31	18		1351.85	1118.83	18
	4.95	6.07	5		434.87	1015.02	5
	4.95	1.81	6		382.49	145.35	6
	26.48	68.77	17		1251.83	1133.28	17
	14.67	6.52	7		592.65	676.83	7
	5.26	4.32	4		203.84	283.87	4
	5.70	2.34	13		325.96	480.09	13
	9.98	7.00	12		1212.33	1150.28	12
	6.96	6.71	16		376.29	624.60	16
	7.45	4.09	8		274.68	214.97	8
	6.25	6.17	12		235.63	394.34	12
	9.22	8.70	20		287.81	596.76	20
	21.86	66.12	6		1081.25	490.77	6
	24.73	62.45	11		1840.32	1214.60	11
	4.14	3.21	7		101.32	112.42	7
	8.67	11.32	6		392.05	680.48	6
	6.50	4.37	5		171.03	493.83	5
	6.55	3.88	14		451.37	747.87	14
	6.41	2.45	13		427.65	422.44	13
	7.24	5.49	13		703.45	958.14	13
	6.11	3.14	7		293.92	281.30	7
	343.05	63.68	4		4.85	30.72	4
	190.15	167.55	13		353.31	500.26	13
	6.71	6.78	4		609.79	1186.10	4
	5.62	3.01	19		253.96	304.65	19
	4.34	0.92	6		137.36	63.04	6
	16.68	13.32	21		854.15	817.65	21

Observed values	*Estimated values*	*RESIDUS*	*Observed values*	*Estimated values*	*RESIDUS*
4.880	5.629	-0.749	605.000	386.463	218.537
2.930	5.367	-2.437	326.000	385.820	-59.820
7.250	5.943	1.307	262.000	416.459	-154.459
10.000	9.825	0.175	649.000	585.043	63.957
7.220	7.909	-0.689	210.000	542.507	-332.507
7.800	8.281	-0.481	275.000	568.564	-293.564
4.400	7.968	-3.568	140.000	525.182	-385.182
8.050	9.280	-1.230	1140.000	570.364	569.636
2.150	33.674	-31.524	34.000	577.680	-543.680
35.000	17.005	17.995	1900.000	772.366	1127.634
11.400	11.218	0.182	53.000	506.815	-453.815
355.000	211.978	143.022	0.146	342.099	-341.953
12.900	21.075	-8.175	382.000	593.984	-211.984
31.500	85.025	-53.525	914.000	721.933	192.067
5.090	6.856	-1.766	89.900	506.458	-416.558
1.510	5.726	-4.216	11.000	459.126	-448.126
4.250	15.215	-10.965	265.000	856.742	-591.742
3.210	10.760	-7.550	132.000	933.127	-801.127
9.080	10.065	-0.985	110.000	883.374	-773.374
22.900	12.948	9.952	3470.000	1097.798	2372.202
3.300	6.202	-2.902	20.200	246.155	-225.955
5.130	9.467	-4.337	138.000	427.681	-289.681
3.850	17.223	-13.373	132.000	497.498	-365.498
4.200	6.356	-2.156	55.400	320.698	-265.298
9.420	8.664	0.756	1200.000	793.382	406.618
0.523	4.055	-3.532	3.210	398.847	-395.637
9.700	20.107	-10.407	1250.000	1129.245	120.755
1.360	7.315	-5.955	7.410	446.102	-438.692
7.680	12.414	-4.734	2550.000	1071.368	1478.632
13.100	15.249	-2.149	2080.000	1080.861	999.139
WA: Coefficient de correlation multiple		**R = 0.9460**	*WA: Coefficient de correlation multiple*		**R = 0.7260**
		R^2 = 0.89			**R^2 = 0.53**
Variance de la variable Alcalinité à expliquer		**3929.396**	*Variance de la variable Mg à expliquer*		**724201.7**
Variance des résidus		**847.3527**	*Variance des résidus*		**478831.7**
Ecart-type des résidus = SEP Standard error of prediction		**29.10932**	*Ecart-type des résidus = SEP Standard error of prediction*		**691.9767**
WA-PLS : 2 components, SEP = 62.26		**R = 0.9661**	*WA-PLS : 2 components, SEP = 857*		**R = 0.8437**
		R^2 = 0.93			**R^2 = 0.71**
		r = 0.29			**r = 0.43**

Ca++ (mg/l)				pH			
codes	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*	*codes*	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*
	420.70	482.06	6		8.86	0.38	6
	450.58	515.59	7		8.20	0.59	7
	768.25	499.24	6		8.22	0.10	6
	1137.33	899.67	17		7.93	0.60	17
	1267.27	1008.59	7		7.98	0.42	7
	425.29	380.82	5		8.75	0.73	5
	391.49	746.98	9		8.70	1.04	9
	618.80	470.62	21		8.57	0.34	21
	224.58	217.28	9		8.92	0.63	9
	444.63	289.77	4		8.89	1.01	4
	149.26	253.17	8		8.42	0.59	8
	347.14	401.19	7		8.84	0.58	7
	452.72	458.50	13		8.34	0.42	13
	559.39	447.41	7		8.67	0.41	7
	724.62	544.64	5		9.07	0.95	5
	533.64	965.21	11		8.63	0.81	11
	803.03	755.73	5		8.13	0.55	5
	1193.96	1020.58	5		7.62	0.40	5
	533.20	800.76	7		8.44	0.74	7
	1065.66	1146.64	9		8.50	1.00	9
	12.50	21.53	4		9.50	0.35	4
	809.48	1118.84	4		8.40	1.06	4
	73.82	289.37	7		8.06	1.02	7
	243.75	422.97	11		8.08	0.32	11
	591.31	906.16	14		8.80	0.93	14
	1428.50	1117.31	4		7.98	1.25	4
	244.79	552.35	20		7.94	1.02	20
	134.18	511.41	5		8.59	0.76	5
	211.87	503.34	9		8.12	1.12	9
	840.19	1005.36	25		8.27	0.70	25
	388.21	304.07	7		8.89	0.51	7
	570.76	548.83	5		8.26	0.16	5
	231.90	395.92	7		8.83	0.61	7
	871.76	823.57	19		8.05	0.51	19
	1445.32	1030.71	18		7.73	0.58	18
	434.01	895.48	5		8.33	0.69	5
	927.70	514.60	6		8.35	0.27	6
	1300.92	1111.42	17		7.97	0.74	17
	341.29	691.18	7		8.42	0.30	7
	185.37	311.36	4		8.80	0.39	4
	474.54	610.27	13		8.24	0.39	13
	1419.81	1033.84	12		7.71	0.56	12
	464.34	570.43	16		8.34	0.84	16
	573.43	428.60	8		8.84	0.66	8
	296.95	389.41	12		7.81	0.82	12
	292.24	448.64	20		9.25	0.84	20
	1428.95	617.70	6		7.80	0.79	6
	1917.29	1060.52	11		7.75	1.00	11
	147.19	147.26	7		8.93	0.41	7
	233.75	375.63	6		8.33	0.58	6
	238.36	590.28	5		8.89	1.08	5
	788.48	737.93	14		7.96	0.53	14
	648.31	518.15	13		8.32	0.41	13
	858.91	897.79	13		8.20	0.63	13
	329.35	257.23	7		8.79	0.35	7
	8.93	41.58	4		10.32	0.34	4
	181.14	400.04	13		9.44	1.01	13
	603.60	1036.06	4		8.24	0.55	4
	459.95	507.47	19		8.31	0.39	19
	235.36	266.56	6		8.26	0.29	6
	523.62	367.16	21		8.61	0.60	21

Observed values	*Estimated values*	*RESIDUS*
1200.000	809.649	390.351
1370.000	870.791	499.209
218.000	903.878	-685.878
521.000	591.004	-70.004
400.000	655.317	-255.317
465.000	636.018	-171.018
200.000	609.795	-409.795
1340.000	639.713	700.287
65.000	430.164	-365.164
730.000	433.077	296.923
200.000	440.114	-240.114
2.490	216.707	-214.217
103.000	447.579	-344.579
260.000	684.664	-424.664
200.000	569.280	-369.280
24.500	479.207	-454.707
360.000	971.286	-611.286
200.000	1084.233	-884.233
1100.000	1053.445	46.555
3100.000	1202.642	1897.358
50.900	247.577	-196.677
190.000	411.541	-221.541
200.000	610.692	-410.692
32.700	383.106	-350.406
1500.000	944.818	555.182
6.100	451.328	-445.228
1650.000	1237.152	412.848
12.500	489.792	-477.292
2380.000	1147.982	1232.018
2500.000	1192.603	1307.397
WA: Coefficient de correlation multiple		**R = 0.7652**
		R^2 = 0.58
Variance de la variable Ca à expliquer		**679352.3**
Variance des résidus		**395522.8**
Ecart-type des résidus = SEP Standard error of prediction		**628.906**
WA-PLS : 2 components, SEP = 723		**R = 0.8873**
		R^2 = 0.78
		r = 0.60

Observed values	*Estimated values*	*RESIDUS*
8.180	8.358	-0.178
8.150	8.352	-0.202
8.720	8.359	0.361
8.500	8.563	-0.063
8.850	8.416	0.434
8.520	8.450	0.070
9.050	8.548	0.502
8.280	8.536	-0.256
9.180	8.889	0.291
8.800	8.755	0.045
10.200	8.663	1.537
10.380	9.532	0.848
8.520	8.380	0.140
8.400	8.632	-0.232
8.420	8.452	-0.032
9.350	8.683	0.667
8.520	8.138	0.382
8.050	7.988	0.062
7.400	7.983	-0.583
7.200	7.991	-0.791
6.950	7.984	-1.034
8.150	8.374	-0.224
8.350	8.269	0.081
7.850	8.273	-0.423
7.910	8.078	-0.168
9.620	8.939	0.681
7.460	7.972	-0.512
8.920	8.305	0.615
6.950	8.025	-1.075
7.500	8.033	-0.533
WA: Coefficient de correlation multiple		**R = 0.8598**
		R^2 = 0.74
Variance de la variable pH à expliquer		**0.6853808**
Variance des résidus		**0.3132309**
Ecart-type des résidus = SEP Standard error of prediction		**0.5596703**
WA-PLS : 5 components, SEP = 0.5		**R = 0.9910**
		R^2 = 0.98
		r = 0.71

Water Depth (cm)				SO4-- (mg/l)			
codes	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*	*codes*	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*
	25.67	17.34	6		3076.92	1110.96	6
	87.37	29.17	7		1086.05	1485.76	7
	26.11	7.40	6		3344.37	2655.90	6
	67.16	39.49	17		2597.65	2315.38	17
	57.59	39.93	7		1891.93	1392.47	7
	27.21	21.68	5		5429.08	1346.65	5
	30.23	28.93	9		1630.14	1850.29	9
	45.72	37.44	21		6809.94	6514.59	21
	21.36	15.29	9		7057.99	8108.55	9
	16.13	2.09	4		14551.30	12160.47	4
	40.15	34.56	8		305.49	687.34	8
	64.47	39.29	7		3305.58	1521.19	7
	43.53	35.40	13		2286.84	2091.15	13
	23.03	13.65	7		9398.68	9766.64	7
	26.08	16.73	5		4148.31	1100.49	5
	69.60	39.02	11		1008.27	2799.18	11
	36.56	32.41	5		1276.23	1276.24	5
	92.14	23.81	5		1168.87	773.41	5
	61.50	39.97	7		3118.10	2558.73	7
	53.22	39.73	9		1688.03	2099.76	9
	35.69	31.76	4		31.01	37.12	4
	53.12	39.40	4		1100.61	1524.19	4
	21.08	9.86	7		433.10	1332.44	7
	25.40	20.08	11		413.01	682.88	11
	39.88	35.71	14		1972.44	2097.02	14
	69.70	39.02	4		2235.71	1622.06	4
	24.70	20.03	20		2131.15	3533.38	20
	23.56	16.49	5		238.03	770.94	5
	23.35	18.01	9		2616.59	7012.43	9
	51.25	39.16	25		2074.23	2163.68	25
	16.24	2.16	7		13831.40	11352.57	7
	21.40	3.47	5		1473.46	1854.03	5
	75.99	35.93	7		616.91	1375.98	7
	51.35	39.00	19		1853.26	1681.74	19
	77.21	36.07	18		2854.64	1770.38	18
	81.46	33.76	5		425.92	687.68	5
	53.12	33.05	6		3561.97	1428.39	6
	71.78	37.41	17		2617.36	1841.58	17
	25.12	18.42	7		5723.60	986.38	7
	17.46	2.50	4		4223.57	2051.06	4
	39.06	33.72	13		1241.51	1528.46	13
	85.37	31.13	12		2249.66	1569.41	12
	28.60	25.54	16		2425.68	5523.68	16
	62.55	38.67	8		4066.46	1230.23	8
	36.40	31.84	12		2703.45	5066.40	12
	25.50	25.97	20		5042.76	6079.36	20
	96.22	14.93	6		3008.68	1053.60	6
	85.99	30.13	11		3096.90	1026.16	11
	31.44	31.72	7		3878.28	2092.21	7
	22.34	15.71	6		4307.58	9477.35	6
	23.34	19.95	5		1708.62	2017.53	5
	62.35	39.77	14		1219.75	1320.91	14
	41.56	34.99	13		3528.86	4783.96	13
	45.42	37.20	13		1283.33	1244.81	13
	39.24	36.04	7		7900.61	6144.05	7
	49.76	6.80	4		3593.35	622.02	4
	38.05	19.86	13		4569.58	2230.61	13
	40.39	34.87	4		594.93	776.31	4
	36.60	30.16	19		2281.74	2523.52	19
	24.39	17.26	6		417.85	605.88	6
	27.40	27.15	21		13693.55	11044.40	21

Observed values	*Estimated values*	*RESIDUS*	*Observed values*	*Estimated values*	*RESIDUS*
30.000	48.048	-18.048	5700.000	3467.345	2232.655
30.000	51.388	-21.388	3070.000	3516.977	-446.977
100.000	53.718	46.282	2300.000	3491.296	-1191.296
20.000	42.499	-22.499	17900.000	7575.381	10324.619
100.000	48.317	51.683	4320.000	5001.739	-681.739
100.000	45.509	54.491	4660.000	5550.414	-890.414
20.000	43.393	-23.393	2600.000	5734.399	-3134.399
20.000	46.190	-26.190	4080.000	6263.509	-2183.509
15.000	32.839	-17.839	5070.000	6937.772	-1867.772
15.000	23.971	-8.971	26600.000	11548.886	15051.114
15.000	29.545	-14.545	4360.000	5405.575	-1045.575
50.000	42.387	7.613	3710.000	4295.603	-585.603
20.000	32.489	-12.489	5980.000	5253.148	726.852
20.000	50.686	-30.686	6440.000	3957.202	2482.798
20.000	51.707	-31.707	265.000	2787.123	-2522.123
100.000	63.598	36.402	72.000	1061.000	-989.000
20.000	58.745	-38.745	465.000	2484.437	-2019.437
100.000	67.860	32.140	250.000	2533.728	-2283.728
100.000	64.911	35.089	1270.000	2736.314	-1466.314
100.000	70.009	29.991	2460.000	2559.531	-99.531
20.000	26.840	-6.840	105.000	2165.341	-2060.341
20.000	33.344	-13.344	302.000	4186.065	-3884.065
20.000	41.007	-21.007	305.000	2404.631	-2099.631
20.000	34.938	-14.938	130.000	2193.485	-2063.485
20.000	55.110	-35.110	2920.000	2207.240	712.760
20.000	41.971	-21.971	14.000	1402.441	-1388.441
100.000	70.063	29.937	3370.000	2777.558	592.442
20.000	36.766	-16.766	4.990	1957.775	-1952.785
100.000	66.741	33.259	3240.000	2404.016	835.984
100.000	66.259	33.741	3180.000	2383.299	796.701
WA: Coefficient de correlation multiple		**R = 0.7413**	*WA: Coefficient de correlation multiple*		**R = 0.8500**
		R^2 = 0.55			**R^2 = 0.72**
Variance de la variable Tranche d'eau à expliquer		**1397.806**	*Variance de la variable SO4 à expliquer*		**2.94E+07**
Variance des résidus		**836.4213**	*Variance des résidus*		**1.41E+07**
Ecart-type des résidus = SEP Standard error of prediction		**28.92095**	*Ecart-type des résidus = SEP Standard error of prediction*		**3750.238**
WA-PLS : 2 components, SEP = 41		**R = 0.8648**	*WA-PLS : 5 components, SEP = 3537*		**R = 0.9917**
		R^2 = 0.74			**R^2 = 0.98**
		r = 0.41			**r = 0.76**

Cl- (mg/l)				Lithium (mg/l)			
codes	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*	*codes*	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*
	14993.11	20451.81	6		58.45	111.05	6
	23639.56	33514.01	7		166.63	262.07	7
	15569.22	7225.07	6		34.52	11.72	6
	72787.46	60379.97	17		490.04	456.92	17
	72700.10	65890.75	7		489.38	481.26	7
	37967.34	27712.32	5		107.90	88.53	5
	19267.58	48614.77	9		147.96	406.09	9
	24130.00	20875.09	21		117.22	153.79	21
	19628.20	16419.76	9		48.22	42.67	9
	23215.80	20889.64	4		15.76	12.78	4
	5807.30	16248.26	8		31.95	81.62	8
	10938.92	9193.09	7		36.21	26.45	7
	16042.57	20076.66	13		77.18	144.18	13
	33282.25	23423.09	7		70.51	76.11	7
	10540.70	8016.47	5		15.35	13.76	5
	31637.72	61943.40	11		231.40	479.69	11
	49128.13	53852.89	5		329.55	366.88	5
	69660.26	65760.14	5		574.26	562.33	5
	46050.76	53391.00	7		238.19	328.66	7
	65349.60	72704.67	9		403.86	455.04	9
	286.94	864.62	4		1.86	5.67	4
	51973.35	72683.44	4		391.45	547.51	4
	3568.51	19498.65	7		21.70	142.62	7
	12221.71	27972.67	11		78.36	169.18	11
	38783.57	62138.53	14		234.57	392.79	14
	94506.10	73370.53	4		684.15	545.30	4
	16210.28	37029.64	20		87.80	254.26	20
	7456.06	32517.56	5		40.63	177.12	5
	11373.54	34209.47	9		48.48	199.27	9
	51249.82	64592.64	25		354.27	488.55	25
	23962.93	19259.33	7		29.68	21.89	7
	22025.46	26822.35	5		133.68	191.39	5
	5919.56	8371.95	7		27.65	36.36	7
	50956.84	52497.13	19		343.67	366.05	19
	98857.86	64366.08	18		643.94	510.25	18
	24428.40	56771.34	5		197.62	482.28	5
	13756.07	6121.92	6		24.21	10.55	6
	86499.48	70530.56	17		549.66	537.87	17
	40356.13	36909.32	7		170.07	337.54	7
	11904.31	12867.56	4		52.48	42.71	4
	24349.91	42594.55	13		131.35	230.65	13
	93201.18	68176.38	12		613.43	500.96	12
	23300.64	38014.12	16		139.97	261.14	16
	13999.22	9801.08	8		33.29	33.36	8
	11111.16	17226.60	12		50.05	105.49	12
	14437.85	30423.25	20		70.78	201.00	20
	112249.90	49845.83	6		568.25	252.74	6
	125270.74	67082.82	11		860.92	551.53	11
	6736.76	7800.39	7		37.07	33.10	7
	13728.14	28535.13	6		41.14	128.41	6
	10814.46	38052.54	5		56.56	207.94	5
	44325.84	49602.85	14		309.45	356.24	14
	25510.28	24406.43	13		152.19	183.42	13
	48898.94	56756.38	13		362.75	457.35	13
	13299.95	9791.01	7		66.50	48.26	7
	4654.01	1288.13	4		54.07	8.05	4
	27943.74	35632.36	13		122.35	156.06	13
	34312.12	66225.71	4		279.98	563.92	4
	13291.57	16382.25	19		52.33	118.69	19
	7145.56	3654.46	6		43.42	24.42	6
	28007.31	24131.16	21		92.79	173.32	21

Observed values	*Estimated values*	*RESIDUS*	*Observed values*	*ESTIMATIONS*	*and RESIDUS*
22000.000	16382.306	5617.694	25.500	49.242	-23.742
13900.000	15258.410	-1358.410	11.800	37.755	-25.955
6460.000	17306.295	-10846.295	36.500	52.718	-16.218
24600.000	24605.609	-5.609	122.000	115.566	6.434
14500.000	29036.055	-14536.055	37.000	158.964	-121.964
15300.000	29399.520	-14099.520	109.000	164.771	-55.771
10300.000	25460.934	-15160.934	47.000	129.877	-82.877
38700.000	26699.959	12000.041	176.000	137.293	38.707
2250.000	27770.922	-25520.922	19.500	130.516	-111.016
44000.000	24015.320	19984.680	22.500	61.906	-39.406
1970.000	25116.932	-23146.932	2.750	130.094	-127.344
4540.000	27219.348	-22679.348	54.100	137.076	-82.976
29500.000	35892.352	-6392.352	86.800	175.138	-88.338
65000.000	51764.414	13235.586	196.000	301.824	-105.824
7240.000	30018.563	-22778.563	42.500	192.471	-149.971
699.000	28448.877	-27749.877	4.800	202.218	-197.418
16700.000	60321.617	-43621.617	117.000	399.189	-282.189
8060.000	67867.867	-59807.867	52.500	453.979	-401.479
61400.000	65206.918	-3806.918	500.000	442.065	57.935
194000.000	77789.156	116210.844	1640.000	522.698	1117.302
90.200	13854.553	-13764.353	0.507	72.611	-72.104
6750.000	20275.330	-13525.330	42.500	101.736	-59.236
8310.000	34917.531	-26607.531	57.500	221.704	-164.204
600.000	19036.701	-18436.701	3.890	111.431	-107.541
85900.000	57354.555	28545.445	600.000	381.853	218.147
63.200	27945.895	-27882.695	0.347	176.855	-176.508
134000.000	83734.867	50265.133	675.000	536.504	138.496
150.000	29453.436	-29303.436	1.180	190.823	-189.643
154000.000	75271.078	78728.922	1160.000	503.956	656.044
158000.000	77381.148	80618.852	861.000	509.584	351.416
WA: Coefficient de correlation multiple		**R= 0.8132**	*WA: Coefficient de correlation multiple*		**R = 0.77**
		R^2 = 0.66			**R^2 = 0.59**
Variance de la variable Cl à expliquer		**2.80E+09**	*Variance de la variable Li à expliquer*		**149337.2**
Variance des résidus		**1.42E+09**	*Variance des résidus*		**79096.27**
Ecart-type des résidus = SEP Standard error of prediction		**37698.6**	*Ecart-type des résidus = SEP Standard error of prediction*		**281.2406**
WA-PLS : 2 components, SEP = 35726		**R = 0.8823**	*WA-PLS : 2 components, SEP = 266*		**R = 0.8739**
		R^2 = 0.79			**R^2 = 0.76**
					r = 0.68

Boron (mg/l)				Si (mg/l)			
codes	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*	*codes*	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*
	84.66	79.84	6		30.98	3.13	6
	108.74	139.96	7		23.06	7.45	7
	96.98	59.88	6		34.23	13.01	6
	309.41	252.11	17		28.32	7.54	17
	288.37	276.56	7		29.37	6.22	7
	374.34	237.75	5		34.65	11.35	5
	128.41	227.70	9		32.39	13.05	9
	208.90	166.22	21		28.86	5.78	21
	265.04	285.04	9		27.54	7.02	9
	523.20	439.22	4		24.42	6.88	4
	22.06	50.54	8		40.50	11.41	8
	141.29	62.67	7		29.33	6.44	7
	96.48	92.71	13		35.18	12.38	13
	422.29	375.90	7		33.12	10.08	7
	122.73	35.56	5		27.18	8.94	5
	135.42	272.93	11		35.71	7.47	11
	169.76	182.32	5		30.16	4.95	5
	330.69	324.31	5		23.93	8.64	5
	217.52	171.69	7		31.63	6.02	7
	241.04	271.12	9		24.72	7.73	9
	1.60	3.06	4		20.53	8.87	4
	184.32	256.95	4		20.77	5.84	4
	22.74	84.07	7		28.97	7.48	7
	45.66	97.59	11		39.74	13.48	11
	136.34	213.21	14		23.63	7.74	14
	328.98	256.78	4		18.42	5.28	4
	107.12	171.49	20		33.42	9.42	20
	25.78	107.02	5		25.09	5.73	5
	111.57	268.04	9		28.51	7.73	9
	231.93	275.46	25		26.87	7.25	25
	465.68	440.31	7		30.04	12.48	7
	94.53	105.20	5		32.15	2.98	5
	30.12	53.74	7		31.05	9.75	7
	218.55	207.91	19		28.89	7.11	19
	416.32	267.21	18		28.74	8.61	18
	112.65	277.83	5		27.55	8.81	5
	113.56	31.92	6		32.60	7.49	6
	382.55	300.96	17		35.51	27.28	17
	321.62	183.27	7		33.82	4.47	7
	87.60	109.44	4		32.01	0.79	4
	94.87	135.43	13		42.62	13.73	13
	363.02	282.07	12		26.53	7.73	12
	139.56	222.38	16		32.68	11.94	16
	141.03	75.15	8		29.13	9.85	8
	114.33	193.31	12		34.67	11.24	12
	174.68	247.15	20		25.35	8.96	20
	347.25	140.06	6		38.52	24.37	6
	509.18	272.62	11		31.86	25.16	11
	65.00	92.58	7		29.33	5.77	7
	169.14	343.71	6		33.55	14.67	6
	83.02	131.40	5		24.26	5.81	5
	183.99	198.35	14		26.58	7.08	14
	144.36	111.20	13		32.49	10.28	13
	203.25	259.98	13		35.19	11.17	13
	128.32	100.06	7		28.40	3.60	7
	139.13	21.03	4		157.05	21.14	4
	275.44	228.50	13		100.98	61.14	13
	160.96	324.66	4		39.52	11.43	4
	90.54	104.74	19		31.12	5.17	19
	28.32	16.29	6		45.05	13.00	6
	421.25	397.04	21		27.18	9.22	21

Observed values	*Estimated values*	*RESIDUS*	*Observed values*	*Estimated values*	*RESIDUS*
150.000	123.807	26.193	25.200	32.419	-7.219
77.000	120.656	-43.656	41.400	32.550	8.850
125.000	128.298	-3.298	28.600	32.431	-3.831
235.000	233.375	1.625	27.500	28.893	-1.393
145.000	194.662	-49.662	26.100	30.078	-3.978
238.000	209.196	28.804	20.600	28.957	-8.357
57.000	192.644	-135.644	31.600	29.424	2.176
250.000	208.042	41.958	34.400	29.419	4.981
13.000	271.104	-258.104	31.400	37.281	-5.881
959.000	384.899	574.101	21.900	29.686	-7.786
147.000	228.941	-81.941	18.700	29.181	-10.481
143.000	256.833	-113.833	161.000	108.663	52.337
263.000	274.761	-11.761	32.500	35.529	-3.029
612.000	307.855	304.145	45.600	58.906	-13.306
29.900	164.081	-134.181	36.400	32.689	3.711
3.490	123.997	-120.507	38.400	34.046	4.354
60.000	265.911	-205.911	31.600	31.744	-0.144
28.400	298.557	-270.157	17.300	28.375	-11.075
290.000	297.368	-7.368	20.500	28.086	-7.586
944.000	336.567	607.433	31.400	30.057	1.343
0.995	103.283	-102.288	37.200	32.256	4.944
25.500	175.538	-150.038	58.800	34.981	23.819
32.000	179.071	-147.071	32.200	35.390	-3.190
2.920	114.049	-111.129	30.200	33.632	-3.432
320.000	248.693	71.307	34.200	29.630	4.570
0.703	115.891	-115.188	15.900	23.444	-7.544
404.000	349.545	54.455	33.000	32.587	0.413
1.080	149.260	-148.180	22.400	28.209	-5.809
545.000	314.913	230.087	16.800	29.672	-12.872
520.000	324.056	195.944	31.400	30.689	0.711
WA: Coefficient de correlation multiple		**R = 0.7577**	*WA: Coefficient de correlation multiple*		**R = 0.9411**
		R² = 0.57			**R² = 0.88**
Variance de la variable B à expliquer		**66730.07**	*Variance de la variable Si à expliquer*		**633.5131**
Variance des résidus		**41769.64**	*Variance des résidus*		**149.972**
Ecart-type des résidus = SEP Standard error of prediction		**204.3762**	*Ecart-type des résidus = SEP Standard error of prediction*		**12.24631**
WA-PLS : 1 component			*WA-PLS : 3 components, SEP = 16.95*		**R = 0.9812**
					R² = 0.96
					r = 0.75

Density

codes	*OPTIMUM*	*TOLERANCE*	*FREQUENCE*
	1.02	0.02	6
	1.03	0.04	7
	1.02	0.01	6
	1.08	0.06	17
	1.08	0.07	7
	1.05	0.03	5
	1.02	0.05	9
	1.04	0.03	21
	1.03	0.03	9
	1.05	0.04	4
	1.01	0.02	8
	1.02	0.01	7
	1.02	0.02	13
	1.05	0.03	7
	1.02	0.01	5
	1.04	0.07	11
	1.06	0.06	5
	1.08	0.07	5
	1.05	0.06	7
	1.07	0.08	9
	1.00	0.00	4
	1.06	0.08	4
	1.00	0.02	7
	1.01	0.03	11
	1.04	0.07	14
	1.10	0.08	4
	1.02	0.04	20
	1.01	0.04	5
	1.02	0.04	9
	1.06	0.07	25
	1.05	0.04	7
	1.03	0.03	5
	1.01	0.01	7
	1.06	0.06	19
	1.11	0.07	18
	1.03	0.06	5
	1.02	0.01	6
	1.10	0.07	17
	1.05	0.04	7
	1.02	0.02	4
	1.03	0.05	13
	1.10	0.07	12
	1.03	0.04	16
	1.02	0.01	8
	1.02	0.02	12
	1.02	0.04	20
	1.12	0.05	6
	1.14	0.07	11
	1.01	0.01	7
	1.02	0.04	6
	1.01	0.04	5
	1.05	0.05	14
	1.03	0.03	13
	1.06	0.06	13
	1.03	0.02	7
	1.03	0.00	4
	1.05	0.03	13
	1.04	0.07	4
	1.02	0.02	19
	1.01	0.00	6
	1.05	0.04	21

Observed values	*Estimated values*	*RESIDUS*
1.032	1.023	0.009
1.020	1.022	-0.002
1.010	1.024	-0.014
1.050	1.038	0.012
1.022	1.039	-0.017
1.024	1.040	-0.016
1.015	1.036	-0.021
1.051	1.038	0.013
1.009	1.041	-0.032
1.087	1.043	0.044
1.008	1.035	-0.027
1.029	1.046	-0.017
1.040	1.047	-0.007
1.081	1.065	0.016
1.009	1.037	-0.028
1.001	1.032	-0.031
1.020	1.069	-0.049
1.010	1.077	-0.067
1.073	1.075	-0.002
1.211	1.087	0.124
1.000	1.018	-0.018
1.009	1.028	-0.019
1.010	1.042	-0.032
1.001	1.024	-0.023
1.098	1.065	0.033
1.000	1.032	-0.032
1.147	1.094	0.053
1.000	1.035	-0.035
1.167	1.084	0.083
1.171	1.087	0.084
WA: Coefficient de correlation multiple		**R = 0.8003**
		R^2 = 0.64
Variance de la variable Densité à expliquer		**3.25E+00**
Variance des résidus		**1.7**
Ecart-type des résidus = SEP Standard error of prediction		**4.1**
WA-PLS : 2 components, SEP = 0.04		**R = 0.8827**
		R^2 = 0.78
		r = 0.70