

**Table 4** Hydrophysical data and oxygen and nutrient concentrations of all measured samples (*n.d.* not determined; *0* = below detection limit of the method)

Sample	Depth (m)	Temp (°C)	pH	Cond. (mS cm <sup>-1</sup> )	SM (mg l <sup>-1</sup> )	TDS (mg l <sup>-1</sup> )	O <sub>2</sub> (μmol l <sup>-1</sup> )	Si (μmol l <sup>-1</sup> )	NO <sub>2</sub> <sup>-</sup> (μmol l <sup>-1</sup> )	NO <sub>3</sub> <sup>-</sup> (μmol l <sup>-1</sup> )	PO <sub>4</sub> <sup>3-</sup> (μmol l <sup>-1</sup> )	NH <sub>4</sub> <sup>+</sup> (μmol l <sup>-1</sup> )	N/P
Al 1	0	19.8	8.89	13.39	2.0	8853	203	17.1	0.22	3.71	0.63	0	6.23
Al 2	10	18.3	8.89	13.28	2.6	8828	213	5.3	0.65	0.97	1.58	0	1.03
Al 3	20	15.3	8.89	13.28	2.8	8782	97	5.0	1.74	3.23	0.00	0	<i>n.d.</i>
Al 4	26	14.8	8.88	13.38	3.2	8766	41	3.6	1.74	5.00	0.53	0	12.71
Al 5	30	14.6	8.88	13.36	3.0	8637	41	10.7	1.09	14.68	1.79	0	8.81
Al 6	40	14.1	8.88	13.37	1.8	8784	16	20.3	0.00	10.48	1.05	0	9.98
Al 7	50	14.0	8.87	13.37	3.8	8733	6	29.3	0.00	3.39	3.05	5.7	2.99
Al 8	60	13.8	8.87	13.37	1.9	8720	22	51.6	0.00	7.10	5.16	15	4.28
Al 9 - seepage	0	25.4	7.30	2.1	<i>n.d.</i>	668	<i>n.d.</i>	694.3	0.22	0.16	0.53	0	0.71
Atexcac	0	23.1	8.22	11.7	6.9	6086	<i>n.d.</i>	950.7	1.74	43.22	4.42	291	76.0

NO<sub>2</sub> and NH<sub>4</sub> data of Alchichica water column are those measured in the field, while the seepage water and Atexcac samples were measured by IC in the lab. PO<sub>4</sub> and NO<sub>3</sub> data were measured by IC. *SM* Suspended matter

Hydrophysical data and oxygen and nutrient concentrations vary noticeable with depth. These values are given in Table 4. The profiles are plotted in Fig. 4b, c.

The hydrochemical data were used to calculate carbonate, phosphate, and SiO<sub>2</sub> mineral saturation indices and CO<sub>2</sub>-pressure (*PCO*<sub>2</sub>) with PHREEQC (Table 5) and with the WATEQ4F constants (Table 6) (Parkhurst et al. 1990). The saturation index (SI) is defined as the decadic logarithm of the quotient of the ion activity product and the mass balance constant, for example (for calcite):

$$SI_{\text{calcite}} = \log\left(\frac{[Ca^{2+}] * [CO_3^{2-}]}{K_{\text{Calcite}}}\right)$$

Thus, positive values denote supersaturation, zero is saturation, and negative values represent undersaturation with regard to the respective mineral.

#### Discussion of hydrochemistry

Alchichica and Atexcac are crater lakes without any surface water tributaries and without any surface outlets. Their water balance is determined by precipitation and evaporation. In addition, they receive groundwater seeping out of the porous tephra of their respective volcanic edifices and they may lose lake water into the deeper ground water body; thus, they are essentially groundwater outcrops. Their water levels are altered by climatic variation and (potentially) by groundwater extraction. In the case of Alchichica, a terrace surrounds the present lake, which indicates that the ground water level used to be higher. This once higher level correlates with the water body that was responsible for precipitating the stromatolites that ring the present lake. Thus, the hydrochemical conditions of the

present lake must not necessarily reflect the conditions that caused the growth of the exposed stromatolite generations. Nevertheless, the study of the present lake will give us clues about the nature of the former lake.

The two lakes sampled are both brackish (i.e., >5,000 mg/l) in salinity: for Alchichica the sum of the total dissolved solids (TDS) amounts to 8,763 ± 67.6 mg l<sup>-1</sup>, for Atexcac it is 6,086 mg/l. On the contrary, the seepage water sample amounted to only 668 mg l<sup>-1</sup>. Thus, the groundwater that contributes to the lakes is less mineralized, and evaporation must be the mechanism, that increases TDS in the lake. The factor of enrichment for Alchichica Lake is 13 (i.e., 8,763/668), at least with respect to the one seepage sample available.

When we sampled the lake in June 2007, the lake was well mixed with respect to its main ions. However, seasonal heating had established a warmer, ca. 15-m-thick surface layer (Table 4) above a cooler (about 14°C) bottom layer. The amount of TDS listed in Table 4 suggests that the ion concentration decreases with increasing depth, and that the difference amounts to about 1.5% of total TDS. This small difference is, however, within analytical scatter and may not be significant. Should it be significant, then density decrease caused by the concentration decrease is counterbalanced by the higher temperature in the surface layer causing a density increase downwards. The conductivity measurements are also inconclusive, and do not show a clear trend. In any case, we must conclude that water column stability in the lake is low, and that the lake must have mixed during the cooler time of the year prior to sampling.

Main ion concentrations of the lakes and of the seepage water are compared in Table 4. They reveal the main differences between the lakes and the seepage water. In Alchichica