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Holocene sediments in the Cancosa Basin (Northern Chile): First results of diatom analyses

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INTRODUCTION

Fig. A. Location of the Cancosa Basin (from Schröder et al. 2000).

The Cancosa basin is situated at 19°30`S and 68°43`W in the North Chilenian Western Cordilliera next to Bolivia. The central basin area is 3950 m a.s.l. on average, whereas the surrounding Volcanoes reach their highest peaks at the Cerro Sillajhuay (5982 m) in the north and the Cerro Porquesa (5190 m) in the southwest. The study area, a high mountain-desert in a semi-arid environment is part of the *Desierto de Atacama* - the driest desert of the World (Abele 1987). The average rainfall is less then 200 mm·yr^{-1}. More than 90 % is summer precipetation caused by solar-heating of the Altiplano and the resulting convective processes.

This extraordinary climatic setting is caused by the comparetivly strong and slow-moving Southeast Pacific anticyclone in addition to the south-polar cold waters of the Humboldt-Current which cool off the Pacific air-masses and prevent evaporation and convection. These processes are strengthened by the blocking effect against moisture enriched air-masses from the Amazonas Basin through the Andes itself (Schmidt 1999). The position in the intersection between two atmospheric circulation belts, the Tropical Circulation in the north and the Westerlies in the south, makes the research area a very sensitiv archive for palaeoclimatic information. Shifts of one or even both of these circulation belts must have left traces in landscape development and paleaoecology.

In the last two decades a number of studies dealt with the topic of late pleistocene to holocene palaeoclimatic reconstruction, especially in the Chilenian winter rain region slightly south and the Peruvian-Bolivian altiplano slightly north of the study area in the Chilenian summer rain region where still only a few palaeoclimatic information are available (Messerli et al. 1992, Veit 1998, Schröder et al. 2000). This study is aiming to reconstruct lake-level changes and palaeo-ecological conditions by analyzing holocene limnic sediments in the Cancosa basin in order to close the gap of data between the winter rain region and the Peruvian-Bolivian altiplano.

MATERIAL & METHODS

Sedimentary and micropalaeontological studies of the lacustrine deposits feature a detailed reconstruction of the sedimentational environment in the basin and the essential paleohydrological changes in these present day semi-arid region. Lithostratigraphic and diatom analyses were carried out in two, so far not correlated stratigraphic sections in the former lacustrin system.

The outcrop “C1” located in the Rio Ocacucho valley is representing the northern marginal area of the ancient lake. The core of “C1” was taken at the base of the natural outcrop to reach the initial lacustrine deposites. So far undated organic rich material should provide information about timing and beginning of the lake accumulation. The core “CII” is from the deepest site of the basin next to the recent discharge. Here, the Rio Ocacucho and the Rio Saccaya unite to the Rio Cancosa which drained the complete basin.

Sedimentological analyses of grain size distribution, loss on ignition and the carbonate content according to Tucker (1996) were carried out to specify the sedimentational conditions of these deposites. The geochemical element distribution of aluminium, manganese, sulfur and iron was analysed by ICP-OES to identify paleaosoils or peat. The dithionit/oxalat iron ratio (Fe_d/Fe_o) was calcuated to proof the intensity of weathering processes and the pedogentic development in the sediments.

In addition, diatom analyses were carried out to underline and specify the results of the sedimentary record. The identification is based on Krammer & Lange-Bertalot (1986, 1988, 1991a, b), Krammer (2000), Rumrich et al. (2000), Metzeltin & Lange-Bertalot (1998), Metzeltin et al. (2005). Photomicrographs of diatoms were taken from each slide, these were identified and arranged to lay out a guide for counting. All species encountered in a number of transects across the prepared slides were identified and counted, until a minimum of 350 valves had been scored.The relative proportions of the species groups are used to determine the water quality. Classification of each species into ecological species groups were done according to Krammer & Lange-Betalot (1986 - 1991) and van Dam et al. (1994). The relative frequency of each taxon in each sample was calculated after the countings were completed. Diatom diversity H´ (Shannon diversity index) and evenness were calculated from the densities of the algae components according to Tremp (2005).

RESULTS

The grain-size distribution of “C1” is almost continuous with a maximum in the silt fraction (Fig. B). The high clay content and the restriction of grainsize < 2 mm indicate an inner-lacustrine location at the time of sedimentation. This is underlined by sediment-statistical evaluation. Only the stratas S3, S6, S12 and S32 of the outcrop show deposition of coarser material. They are enriched in aluminium and sulfur. The sedimentological record also point at a discontinuous change of lacustrine sediments with organic-rich depositions. The values of organic matter suggest even half-bog conditions in some stratas (Fig. C). These interbedded strata are interpreted as a variety of lake-level fluctuations, deepening vs. shallowing with temporary aggradation events. There is a good correlation between decreasing grain-size and increasing organic matter which points to a low-energetic sedimentary environment. The first results of the ICP-OES analyses and the Fe_d/Fe_o ratio shows a peak in S12 which correlates with a high organic content.

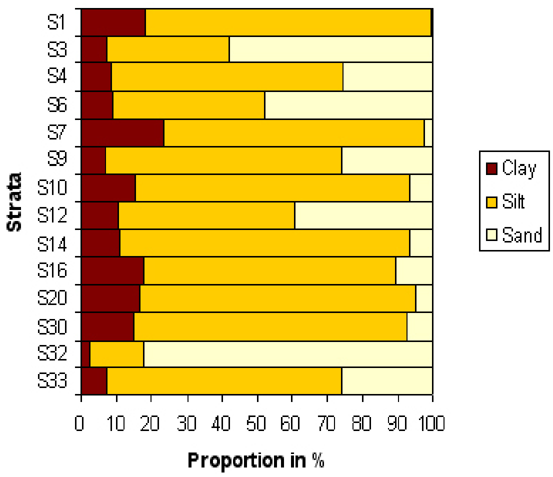

Fig. B. grainsize distribution in “C1”.

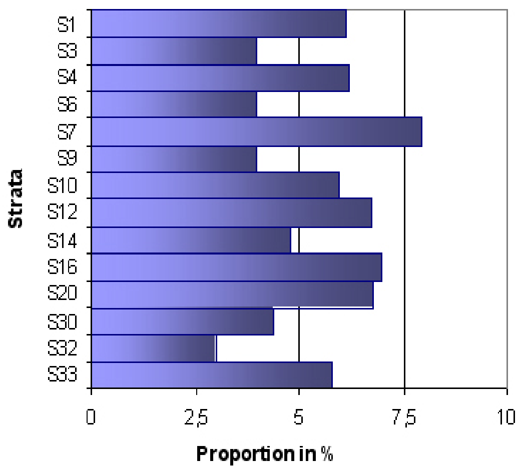

Fig. C. Content of organic matter in “C1”.

So far 10 samples of the "C1" section were analysed and a total of 98 taxa identified. *Achnanthes lanceolata* (Bréb.) Grunow, *Fragilaria capucina* Desm., *Naviculadicta chilensis* (Krasske) Lange-Bert., *Nitzschia palea* (Kütz.) W.Sm., *Luticola mutica* (Kütz.) D.G.Mann, and *Nitzschia chungara* U.Rumrich & Lange-Bert. were counted in every slide. *Achnanthes lanceolata* is the most abundant taxon throughout the sedimentological sequence followed by *Fragilaria capucina* and the endemic *Naviculadicta chilensis*. Seven other taxa were counted in 80 % of the samples, while *Fragilaria construens* f. *exigua* (W.Sm.) Hust. reaches abundances of about 20 % in stratas S3 and S4 which are the highest throughout the whole sedimentary record. Abundances of the most characteristic species are shown in Fig. E. 13 of the identified species (13.3 %) are currently known from the Andes only, e.g. *Nitzschia chungara*, *Pinnularia altiplanensis* Lange-Bert., Krammer & U.Rumrich and *Navicula lauca* U.Rumrich & Lange-Bertalot. Only few information is available about their ecological preferences which aggravates paleao-ecological interpretations. 87.6 % of the diatoms are well known cosmopolitan taxa from the Northern Hemisphere.

The samples of "C1" are dominated by mostly periphytic species. In samples with high organic content aerophilic species like *Hantzschia amphioxys* (Ehrenb.) Grunow and *Luticola mutica* have high abundances. The Shannon diversity index, calculated for every sample, shows only slight variability throughout the complete section (Fig. D). Only Stratas 3 and 4 reach a diversity of less than 3 %.

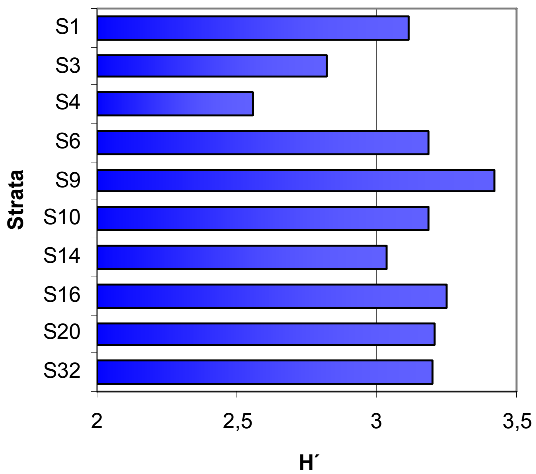

Fig. D. Diatom-Diversity in "C1"

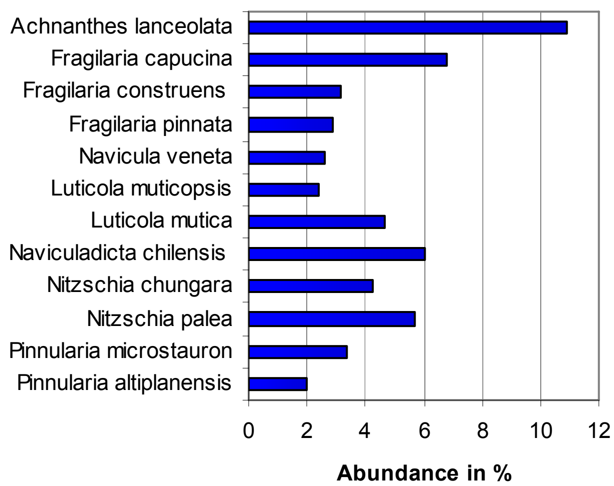

Fig. E. Abundance of most charakteristic taxa in "C1" – average of all counted samples

DISCUSSION

The sedimentary record represents relative stable inner-lacustrine sedimentary conditions throughout the whole limnic deposition. Only stratas S3, S6, S12 and S32 show a more marginal lake setup. The correlation between grain size and content of aluminium and sulfur in these stratas is interpreted as changes in erosion and entry from the surrounding area and indicate a fluvial impact on the deposits. The high percentage of sand in S32 is interpreted as a single high run-off event and clearly shows fluvial effects on the lacustrine sytem. This is underlined by the distribution of aluminium and sulfur which are reaching peaks in S32 and the low organic content. The Fe_d/Fe_o ratio and the high organic content gives evidences for a intensive aggradation event with inicial soil development in S12.

The high abundance of periphytic diatoms suggests the dominance of a low energy sedimentary environment and underlines the results of the grain size analysis but even in times when sediments suggest open water conditions, the lake was shallow. *Fragilaria*-dominated biofacies (*Fragilaria capucina*, *Fragilaria construens* (Ehrenb.) Grunow, *Fragilaria pinnata* Ehrenb., *Fragilaria inflata* (Heiden) Hust.) as well as the absence of planktonic diatoms, point to the predominance of shallow lacustrine conditions only a few metres in depth. The proportion of epiphytes indicates palustine conditions with an abundance of macrophytes. The most abundant species, *Achnanthes lanceolata,* is a widespread, periphytic taxon with ecological focus on circumneutral, eutrophic waters with only little salinity (van Dam et al. 1994).

Aerophilic species like *Hantzschia amphioxys*, *Luticola mutica* and *Pinnularia divergentissima* (Grunow) Cleve in samples with high organic content also indicate palustrine conditions with changes in moisture. There seems to be a correlation between content of organic matter, Fe_d/Fe_o ratio and abundance of aerophilic taxa which points to complete aggradation of the lacustrine system (e.g. S12). But this has to be proven further.

The stratas S3 and S4 are exeptions. Lower diversity here is caused by the massiv appearance of *Fragilaria construens* f. *exigua*. Together with the planktonic *Surirella tenera* W.Greg. this could be an evidence for a greater water colum at that time.

The high abundance of eutrophic taxa like *Fragilaria capucina* var. *vaucheriae* (Kütz.) Lange-Bert., *Fragilaria capucina* var. *perminuta* (Grunow) Lange-Bert. and *Nitzschia palea* in some strata may be caused by the influence of the surrounding volcanic material. Other stratas are dominated by more meso- to oligotrophic taxa which maybe showing a decrease in volcanic activity. The relation and correlation between volcanic activity (with focus on sulfur and sulfate) and the change of eutrophic to oligotrophic conditions implied by diatom composition has to be studied further.

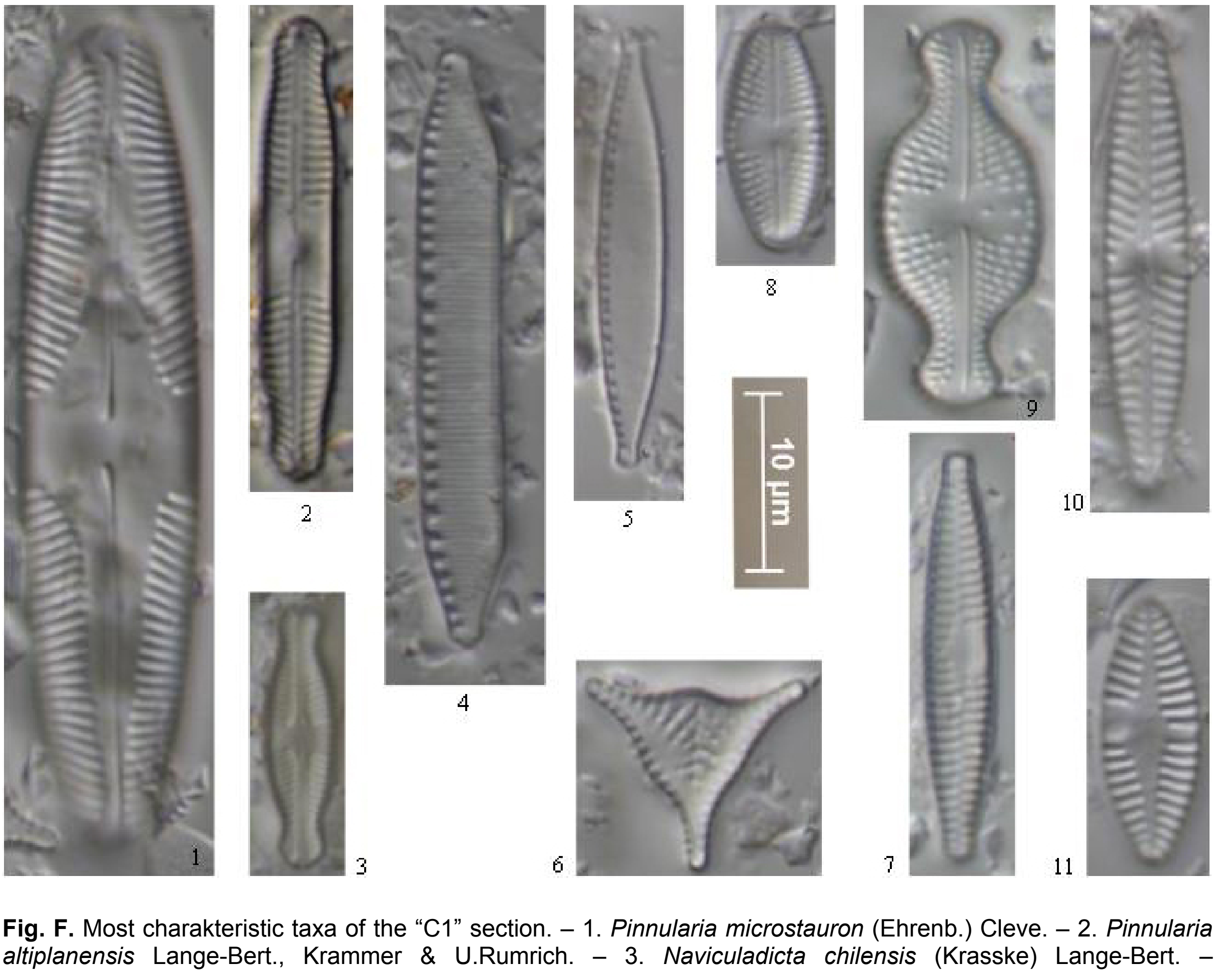

Fig. F. Most charakteristic taxa of the "C1" section. – 1. *Pinnularia microstauron* (Ehrenb.) Cleve. – 2. *Pinnularia altiplanensis* Lange-Bert., Krammer & U.Rumrich. – 3. *Naviculadicta chilensis* (Krasske) Lange-Bert. – 4. *Nitzschia chungara* U.Rumrich & Lange-Bert. – 5. *Nitzschia palea* (Kütz.) W.Sm. – 6. *Fragilaria construens* f. *exigua* (W.Sm.) Hust. – 7. *Fragilaria capucina* Desm. – 8. *Luticola mutica* (Kütz.) D.G.Mann. – 9. *Luticola muticopsis* (Van Heurck) D.G.Mann. – 10. *Navicula lauca* U.Rumrich & Lange-Bert. – 11. *Achnanthes lanceolata* (Bréb.) Grunow.

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