Geochemistry of four sediment cores from the Carlos Anwandter Sanctuary, Los Lagos region, Chile

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Abstract. The Carlos Anwandter Sanctuary is an international Ramsar site that comprises a vast area of wetland with a major truncating river system, which suffered dramatic environmental changes during 2004. From two of several river tributaries, Cruces and Pichoy rivers, four sediment cores were analyzed for major and trace element geochemistry and mineralogy, with the aim to evaluate natural variability versus potential anomalies registered in the sedimentary record. Besides the study of statistical distributions, factor analysis and artificial neuronal network analyses were developed from the overall database. The results evidenced a rather uniform high-metal content within the entire sedimentary columns, which involved the chronostratigraphic horizon of the year 2004, according geochronological models supported by 210Pb down core data. Both, major and trace element compositions can be explained by the influence of the lithology of the bedrock in the study area of the Carlos Anwandter wetland site. The herewith presented geochemical and mineralogical data set of the four analyzed sediment cores clearly points to a rather natural source influence on the studied sediment variability.

Keywords: Carlos Anwandter Sanctuary, geochemistry, geostatistics

1 Introduction

The Carlos Anwandter Natural Sanctuary, province of Valdivia, 10th Region of Los Lagos in southern Chile, originated by subsidence and flooding of mainly agricultural areas during the earthquake of 1960 (Schlatter and Manzilla, 1998). The area of the Sanctuary represents about 4,877 hectares with elevation of less than 3 m a.s.l. and a water column varying between 0.25 and 5 m (Reinhardt et al., 2010). The study area is classified as belonging to the Valdivian ecosystem with a high biodiversity, an annual precipitation of 2349 mm and an average temperature of 11.9 °C (Hauenstein and Ramirez, 1986). The most important lithology in the area are schist, metapelites and others metal-rich Paleozoic metamorphic rocks, together with clay-rich Cenozoic marine sediments (Sernageomin, 2003).

The herewith presented work will contribute to the knowledge of the geochemical and mineralogical characteristics on 4 sediment cores taken from the main tributaries of the Carlos Anwandter Sanctuary, Cruces and Pichoy rivers (Fig. 1). Furthermore, the undertaken geostatistical data interpretation pretends to evaluate possible sources for their obtained characteristics.

2 Method and data presentation

2.1 Methods

For the geochemical analytical work a total of 165 sediment samples were extracted from 4 sediment cores. Sample density was about each 0.5 to 1 cm in the first 10 to 20 cm of each core. Sample density decreased to every 2 cm in the deeper core sections. The core length varied from 25 to 40 cm in all four cores. Major and trace elements were undertaken by the ICP-OES (Perkin Elmer, Optima 7300V) at the Geochemistry Laboratory of the Geology Department, University of Chile. Mineralogical characterizations of the same samples used in the geochemical study were undertaken by the Fourier Transformation Infrared Spectrometer (FTIR; Perkin Elmer, Spectrum 100) of the same Geology Department. Peak quantification was performed by the use of MatLab software calculations, according to the quantitative method for mineral determination of Bertaux et al. (1998). Geochronological models were determined from each sediment core from the recognition of stratigraphic horizons associated to the tsunami impact in the area that followed the 1960 Valdivia earthquake, according Reinhardt et al. (2010), supported by 210Pb results. During 2004 the Carlos Anwandter Natural Sanctuary in the Cruces River suffered from dramatic changes that involved a large mass mortality of the vegetation, particularly the Brazilian elodea (Egeria densa), which is the main food source of many water birds. These changes occurred after the opening and during the following year of a large pulp mill located upstream along the Cruces river. To evaluate possible records associated to these changes, the chronostratigraphic horizon linked to the year 2004, is indicated.

2.2 Data presentation

FTIR analyses on the 4 studied sediment cores indicate that the mineral occurrence is very uniform, with a high
variability in mineral-content with respect to mean values
or tendencies. These are composed mainly by varying
amounts of lithics which can be summarized as quartz,
albite, bytownite, biotite and amphibole and clay minerals
such as illite and montmorillonite (Figs. 2 and 3).

Major and trace element (As, Ba, Cd, Cr, Cu, Li, Mo, Ni,
Pb, Sc, V, Y, Zn, S, Cl) variations along each sediment core
are characteristic and vary mainly comparing the three
Cruces river sediment cores with the single Pichoy river
core. A nearly constant element concentration throughout
each core length is characteristic for Li.

The calculated mean of the grain size distribution increase
in general from the upper level of year 1986 depth to the
top of the representative 223G (Cruces river) and 213G
(Pichoy river) sediment cores.

The illite and montmorillonite portions, the magnetic
susceptibility, Fe, Mn and Al are decreasing at the lower
estimate of the 2004 horizon of core 223G to the top. On
the other hand, Si, quartz+feldspar+amphibole+biotite are
slightly increasing from the lower estimated 2004 horizon
of the same core. The 1986 estimated horizons indicate
general variations which are visible throughout the cores
but major changes are not recognized.

Mn, Fe, magnetic susceptibility and the finer portion of
sediment core 213G are slightly decreasing from the
estimated upper 1986 horizon to the top. In contrast, Si,
montmorillonite and the lithic mineral components are
slightly increasing from the same horizon to the top. At the
2004 horizons no remarkable changes are visible, still, Si,
amphibole and montmorillonite are somewhat indicating a
stronger increase to the top compared to the rest of the
core.

3. Discussion

3.1 Principal component analyses (PCA)

The principal component analysis (PCA) is a multivariate
and statistical technique used to examine data variability
(Reid and Spencer, 2009). With this technique samples
will be grouped when geochemical and mineralogical
variability behaves very similar. The resulting first factor
explains most of the total variance, the second most of the
remaining variance and so on (Schaefer and Einax, 2010).

Through the PCA it is possible to distinguish three main
groups of elements in all sediment cores of the study area.
The four cores are mainly characterized by groups 1-to-3.
Core 221G (Cruces river) combines two additional groups,
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Group 1 is associated with felsic components; group 2
comprises mainly metals that are usually associated with
clay minerals. Group 3 is related to Cl and S indicating an
influence of the saltwater system (estuary). Group 4 joints
groups 1 and 2 without making a difference between them.
Finally group 5 links S and Pb indicating a relation to
sulfates and/or sulfides or blend minerals.

3.2 Artificial neuronal networks (ANN)

The Artificial Neural Network (ANN) can be defined as a
network of individual processors (“neurons”) that have the
ability to store a small amount of local memory. These
units are interconnected by communication channels which
usually carry numerical data (Lacassie et al., 2004). A
multivariate data analysis of geochemical data of
sediments was undertaken using GCS (Growing Cell
Structure), a specific type of ANN that uses to visualize
geochemical similarities and differences between the four
herewith studied sedimentary cores.

The GCS analysis of the dataset resulted in a neural map
composed of six interconnected nodes, each associated
with a group of sediment samples that presents similar
geochemical characteristics. The distribution of the
sample-node associations shows that there is a close
relationship between the sampling sites and the
geochemical signature of the studied sediments.

The six nodes are summarizing the following geochemical
elements characteristics; node 1: K, Al, Fe, Y, Li, Zn, Mn,
Pb, Ba, Pb; node 2: P, Cu; node 3: Si, Na, Mg, Ca, Ti;
node 4: Cr, V, Ba, Cl, Cu, Sc, Ti, K; node 5: Ti, Ni, V, Ba,
K, Cu (Mulet, 2011).

Each of the four sediment cores indicates their own
association to one or more different nodes. The only
exception is sample core 222G (Cruces river) which shows
a single affinity to node 2. 223G (Cruces river) is
characterized by nodes 4 and 5, 213G (Pichoy river) by
nodes 1 and 6 and 221G (Cruces river) by a combination
of nodes 3, 4 and 5.

4. Conclusion

The herewith presented geochemical and mineralogical
data-set of the four analyzed sediment cores clearly points
to a rather natural source influence on the studied sediment
variability which could be related to local climatic changes
(changes in the precipitation and erosion rates in the
watershed). Both, major and trace element compositions
can be explained by the influence of the lithology of the
bedrock in the study area of the Carlos Anwandter wetland
site.

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References


Figure 1. Location of sediment cores obtained from the Carlos Anwandter Sanctuary area close to Valdivia city.

Figure 2. Grain size distribution, FTIR mineralogy and some major elements from sediment core 22G3, Cruces river. The grey zone and dotted lines indicate the probable chronstratigraphic horizons associated to the years 2004 and 1986.

Figure 3. Grain size distribution, FTIR mineralogy and some major elements from sediment core 213G, Pichoy river. The grey zone and dotted lines indicate the probable chronstratigraphic horizons associated to the years 2004 and 1986.