

# Major and trace element geochemistry of superficial sediments and suspended particulate matter of shallow saline lakes in Eastern Austria

Anja Stojanovic<sup>a,\*</sup>, Daniel Kogelnig<sup>a</sup>, Barbara Mitteregger<sup>a</sup>, Dieter Mader<sup>b</sup>,  
Franz Jirsa<sup>a</sup>, Rudolf Krachler<sup>a</sup>, Regina Krachler<sup>a</sup>

<sup>a</sup>University of Vienna, Institute of Inorganic Chemistry, UZAH, Althanstrasse 14, 1090 Vienna, Austria

<sup>b</sup>University of Vienna, Department of Lithospheric Research, Austria

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## Abstract

General geochemical parameters of water, superficial sediments, and suspended particulate matter (SPM) were determined from small shallow saline lakes (soda ponds) as well as from lake Neusiedlersee in eastern Austria. Additionally, instrumental neutron activation analysis (INAA) was used to determine the distribution of major, rare earth and other trace elements in superficial sediments and SPM. Chemical results show remarkable differences in salinity and ionic strength between the investigated ponds. Anthropogenic effects, such as drawdown of ground water level and a loss of lake water due to drainage, are clearly reflected in obtained chemical and geological data. Due to a strong dependence of the complexation and scavenging behavior of the rare earth elements (REE) on ionic strength, a significant difference between REE concentrations in soda ponds with different anthropogenic impact was found. The content and composition of authigenic evaporitic minerals in superficial sediments and SPM clearly differ with a fluctuating water level and salt concentration. Furthermore, we determined the distribution of major and trace elements in superficial sediments of a nearby fluvial system. Our results show a clear correlation between REE superficial sediment concentrations in anthropogenically degraded soda ponds and fluvial system. Therefore, we assume that REE concentrations of sediments and SPM are suitable for the study of geochemical changes of inland saline lakes due to anthropogenic impacts on water balance.

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## 1. Introduction

The distribution of major and trace elements, including rare earth elements (REE) in different aquatic systems has extensively been analyzed and described, among others by Goldstein and Jacobsen (1988), Elderfield et al. (1990), Dupré et al. (1996), Bau et al.

(1997, 2006), Knappe et al. (2005), and Merten et al. (2005). Therefore, it is well known that rare earth elements show significant differences in their patterns according to their source rocks and are suitable for studying geochemical and sedimentary processes in different aquatic systems, highly depending on formation processes and bulk composition (e.g. McLennan, 1989). Due to the low solubility and relative immobility of REE, sediments in the upper crust inherit REE composition of their source rocks. Relative homogeneity

\*Corresponding author. Tel.: +43 1 4277 52625; fax: +43 1 4277 52620.  
E-mail address: [anja.stojanovic@univie.ac.at](mailto:anja.stojanovic@univie.ac.at) (A. Stojanovic).

of REE distribution patterns is generally interpreted as a consequence of mixing of different lanthanide patterns in the upper crust during weathering, erosion, transportation, and deposition (Taylor and McLennan, 1985). Nevertheless, there is also evidence of fractionation and mobilization during weathering, especially when geochemical reactions occurring in soils and river waters go along with changes in pH values. As the solutions get more basic the relatively insoluble REE can precipitate as hydroxides or carbonates, may replace  $H^+$  on accessible mineral exchange sites or can be adsorbed onto surfaces of minerals (Taylor and McLennan, 1985; Koeppenkastrup and De Carlo, 1993; Bau, 1999). A pH increase favors all three processes. The differential mobilization may result from mineralogical stabilities and the abundance of REE in minerals (Nesbitt, 1979; Goldstein and Jacobsen, 1988).

Rare earth elements comprise the lanthanide elements, La–Lu, as well as Y. Due to similarities in atomic structure, REE predominantly occur in trivalent state. There are two exception of this: under reducing conditions europium may occur in bivalent state ( $Eu^{2+}$ ) and oxidizing conditions allow Ce to become quadrivalent ( $Ce^{4+}$ ). The altered valence provokes different chemical and geochemical behavior, which leads to enrichment or depletion of these elements compared to other lanthanides. Relative abundances of these two elements are used to assess the redox behavior during geochemical processes. Europium shows an inflection in the REE patterns and is used as division point between two groups, the light rare earth elements (LREE, the elements from La to Sm) and the heavy rare earths (HREE, from Gd to Lu). The LREE/HREE fractionation (i.e. the ratio of the relative abundance of two groups) is evaluated by means of the La/Yb ratio. This ratio is particularly useful for studying sediment origin and REE mobility in the crust (McLennan, 1989).

In surface environments, the charge and radius-controlled (CHARAC) REE behavior (Bau, 1996) is overlapped by non-CHARAC behavior that prevails where complexation and competitive scavenging processes onto surfaces of suspended particulate matter take place in sea and river water. Complex building and adhesion processes are controlled by the electronic configurations of the involved ions, causing different chemical behavior for LREE and HREE. Furthermore, REE patterns allow a differentiation of aquatic environments by ionic strength (Wyndham et al., 2004).

Even though the distributions of rare earth and other trace elements in different marine, saline and fluvial sediments have already been discussed in the literature (e.g. Ross et al., 1995; Nyakairu and Koeberl, 2002; Oliveira et al., 2003; Moeller et al., 2003; Knappe et al., 2005; Bau et al., 2006), to our knowledge a direct comparison of REE patterns between fluvial and continental saline sediments is not yet available. In this work we compare REE distribution patterns and general chemical properties both of superficial sediments and suspended particulate matter (SPM) from Austrian waters bodies. For this purpose we chose sampling sites from waters of different salinity, ionic strength, and anthropogenic impact from the eastern part of Austria. The influence of main water parameters, sediment composition and grain size, as well as anthropogenic impact on the REE patterns in sediments and suspended particulate matter, will be discussed.

## 2. Study area

A schematic representation of the sampling areas is shown in Fig. 1. Both areas are located in eastern Austria. The Donaukanal ( $48^{\circ}10'N$ ,  $16^{\circ}28'O$ ), a fluvial system running through Vienna and an originally southern Danube arm, is now a regulated channel of



Fig. 1. Schematic map of the sample areas Donaukanal and Seewinkel in eastern Austria.

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