Bulk and clay mineralogy of stream sediments of the rivers Danube, Ebro and Elbe

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Introduction

This investigation is part of the EU-project "AQUATERRA - Integrated Modelling of the river-sediment-soil-groundwater system; advanced tools for the management of catchment areas and river basins in the context of global change". The intent of this project is to develop relationships between major soil properties concerning the filter and buffer function of soil and relatively low Quarternary terrace levels in different climatic regions in Europe. Therefore soil pedons (0 - 60 cm) were sampled in floodplains at Ebro (Spain), Elbe (Germany) and Danube (Austria). Sampling sites included a very young soil (frequently flooded), a soil under agricultural use (occasionally flooded) and a soil under agricultural use over long periods of time. To quantify the influence of soil management on soil development, additional sites presenting different managements, namely forest, grassland and arable land, were investigated in the Danube floodplain. Corollary relationships depicting soil development for the relatively young settings may provide a better understanding of pedogenesis and of the "evolution" of soil sorption capacity for organic and inorganic pollutants under a predominant climate.

Material and Methods

Research area

The investigated areas were the floodplains of the rivers Danube, Elbe and Ebro. Seven profiles were selected for mineralogical analysis. Both the bulk mineralogical and clay mineralogical composition of the samples were examined. The following profiles were chosen:

River Danube:

DA 1: "Paradeiser"-Island was selected due to the low age of less than 100 years
DA 9: A forest close to the village Orth an der Donau with an age of less than 600 years
DA 11: "Marchfeld"-Field with an age of less than 10 000 years

River Ebro:

EB 1: frequently flooded, Riparian forest (Salix)
EB 3: old arable land, orchard (peaches)

River Elbe:

EL 1: flushed sediment (~ 80 days/a), Riparian forest (Salix)
EL 3: arable land

Of all the profiles, the following depths were sampled and analyzed:
0 - 10 cm, 30 - 40 cm and 50 - 60 cm

Table 1: Bulk mineralogical assemblage of the soil profiles of the Danube, the Ebro and the Elbe

River	Profile	Depth	No.	Mica	Amph	Chl/Kao	Qu	K-Fsp	Plag	Calc	Dol	Pyr
		0 - 10 cm	**7478**	**	.	**	**	**	***	**	**	
Danube	DA1	30 - 40 cm	**7479**	**	*	**	**	*	**	*	***	
		50 - 60 cm	**7480**	**	*	**	**	.	**	*	**	.
		0 - 10 cm	**7481**	*	.	*	**	.	*	*	**	.
Danube	DA9	30 - 40 cm	**7482**	*	.	*	**	.	*	**	**	
		50 - 60 cm	**7483**	*		*	**	.	**	*	***	
		0 - 10 cm	**7484**	.		*	**	*	*	*	**	
Danube	DA11	30 - 40 cm	**7485**	*	.	*	**	*	**	*	**	.
		50 - 60 cm	**7486**	*		**	**	.	**	*	***	
		0 - 10 cm	**7487**	.		*	*	*	*	**	*	
Ebro	EB1	30 - 40 cm	**7488**	.	.	*	**	**	*	***	*	
		50 - 60 cm	**7489**	.		*	**	*	*	**	*	
		0 - 10 cm	**7490**	.		*	**	*	*	**	*	
Ebro	EB3	30 - 40 cm	**7491**	*		*	**	**	*	**	*	
		50 - 60 cm	**7492**	.		*	**	.	*	**	*	
		0 - 10 cm	**7493**	.		.	***	***	**			
Elbe	EL1	30 - 40 cm	**7494**	.		.	***	**	**			
		50 - 60 cm	**7495**	.		.	***	**	*			
		0 - 10 cm	**7496**	.		.	***	**	*			
Elbe	EL3	30 - 40 cm	**7497**	.		.	***	***	*			
		50 - 60 cm	**7498**	.		.	***	**	***			

Amph .....Amphibole
Chl/Kao .....Chlorite/Kaolinite
Qu .....Quartz
K-Fsp .....K-Feldspar
Plag .....Plagioclase feldspar
Calc .....Calcite
Dol .....Dolomite
Pyr .....Pyrite

*** high amounts
** medium amounts
* small amounts
. traces

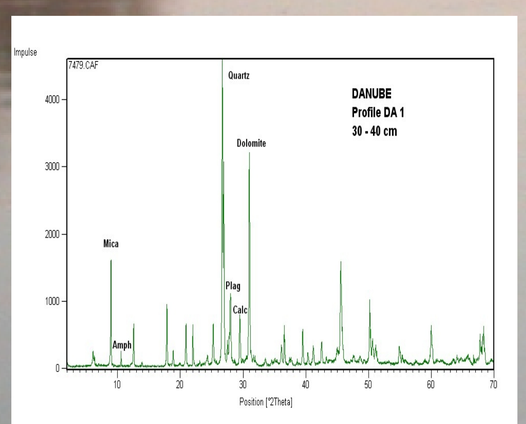

Fig.1: X-ray diffractogram of the bulk mineralogical assemblage of the Danube profile (30 - 40 cm)

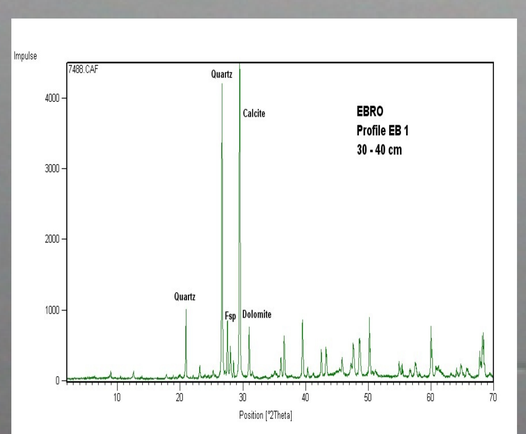

Fig.2: X-ray diffractogram of the bulk mineralogical assemblage of the Ebro profile (30 - 40 cm)

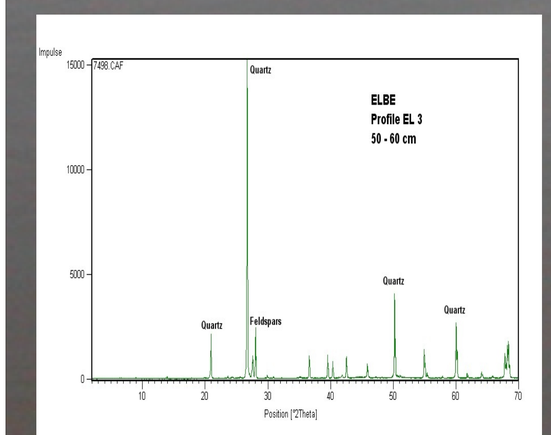

Fig.3: X-ray diffractogram of the bulk mineralogical assemblage of the Elbe profile (50 - 60 cm)

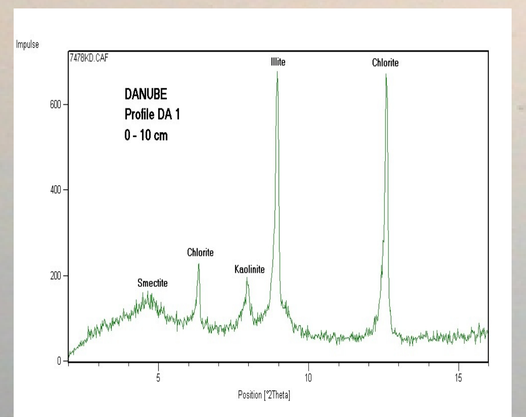

Fig. 4: X-ray diffractogram of the clay mineral assemblage of profile DA 1 (0 - 10 cm) treated with K and DMSO.

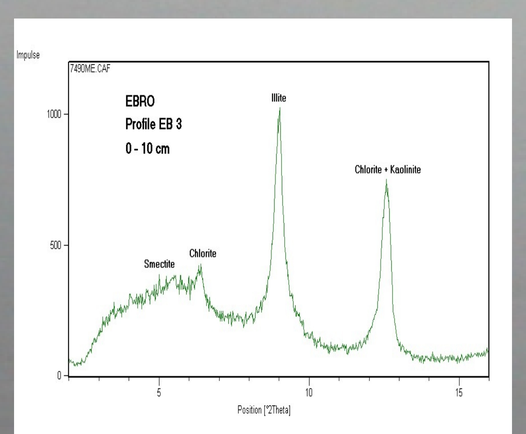

Fig. 5: X-ray diffractogram of the clay mineral assemblage of profile EB 3 (0 - 10 cm) treated with Mg and ethylene glycol.

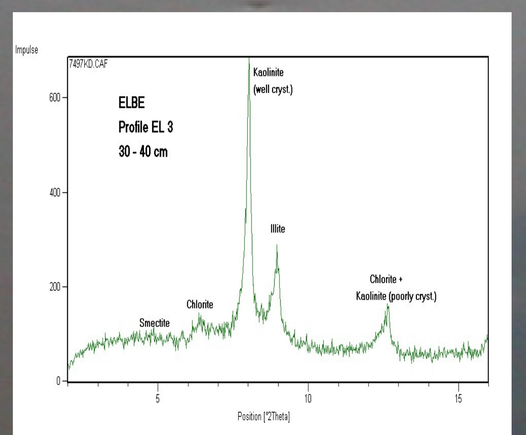

Fig. 6: X-ray diffractogram of the clay mineral assemblage of profile EL 3 (30 - 40 cm) treated with K and DMSO.

Table 2: Semiquantitative results of the clay mineral analyses; values in %

River	Profile	Depth	No.	Sm	Vc	Ill	Kao	Chl	ML
		0 - 10 cm	**7478**	13	tr	52	5	30	tr
Danube	DA1	30 - 40 cm	**7479**	10	tr	57	5	28	tr
		50 - 60 cm	**7480**	15	tr	53	4	28	tr
		0 - 10 cm	**7481**	14	tr	61	5	20	tr
Danube	DA9	30 - 40 cm	**7482**	17	tr	60	5	18	tr
		50 - 60 cm	**7483**	16	tr	54	7	22	tr
		0 - 10 cm	**7484**	7	tr	64	4	24	tr
Danube	DA11	30 - 40 cm	**7485**	10	tr	64	4	22	tr
		50 - 60 cm	**7486**	15	tr	54	4	26	tr
		0 - 10 cm	**7487**	13		63	7	16	tr
Ebro	EB1	30 - 40 cm	**7488**	15		64	6	15	tr
		50 - 60 cm	**7489**	10		66	5	18	tr
		0 - 10 cm	**7490**	11		67	5	16	tr
Ebro	EB3	30 - 40 cm	**7491**	14		63	6	17	tr
		50 - 60 cm	**7492**	16		66	5	14	tr
		0 - 10 cm	**7493**	11	tr	45	36	8	tr
Elbe	EL1	30 - 40 cm	**7494**	17	tr	41	37	5	tr
		50 - 60 cm	**7495**	20	tr	44	28	8	tr
		0 - 10 cm	**7496**	7	tr	42	44	7	tr
Elbe	EL3	30 - 40 cm	**7497**	6	tr	38	49	7	tr
		50 - 60 cm	**7498**	3	tr	51	38	7	tr

Sm .....Smectite
Vc.....Vermiculite
Ill .....Illite
Kao.....Kaolinite
Chl .....Chlorite
ML .....Mixed Layer Minerals

tr.....traces

Results - Bulk mineralogy

Danube

The bulk mineralogical analyses show that the soil profiles of the Danube are dominated by carbonates (calcite and dolomite). Furthermore, quartz, K-feldspar, plagioclase, chlorite, kaolinite and mica occur in low to medium amounts (see Table 1 and Fig.1). In the youngest profile (DA 1) the highest amounts of mica of all the three profiles can be found as well as low amounts of amphibole. The occurrence of amphibole stresses the low age of this profile, as amphibole is sensitive to weathering processes. In the oldest profile (DA 11), amphibole can just be found in one horizon in traces. The highest contents in feldspars can be found in the uppermost layers of the youngest profile, which is remarkable. This can be due to flooding events, which deliver fresh, unweathered material. The carbonates are dominated by dolomite, which is due to the dolomitic bedrock in the Alps (Hauptdolomit facies).

Ebro

In comparison, the Ebro profiles are dominated by calcite, the dolomite shows lower contents compared to the Danube profiles (see Table 1 and Fig.2). The other minerals occur in more or less comparable amounts. Amphiboles were detected in traces in only one horizon.

Elbe

The Elbe sediments are completely different from the other profiles concerning the bulk mineralogical assemblage. Quartz, K-feldspar and plagioclase dominate both soil profiles (see Table 1 and Fig. 3). Mica and chlorite can only be found in traces. Carbonates (calcite and dolomite) are completely absent in both profiles.

Results - Clay mineralogy

Danube

The clay mineralogical assemblage of the Danube profiles is dominated by illite with contents between 52 and 64 % (Table 2 and Fig. 4). There is a weak trend towards higher illite contents in the older profiles (DA 9 and DA 11). Chlorite shows the second highest contents with values between 18 and 30 %. The highest amounts can be found in the youngest profile which is due to the transportation of fresh, unweathered material. Smectite is present in low amounts with values between 7 and 17 %. The differences are due to the different smectite contents of the material which was eroded during flood events. Kaolinite is only present in low amounts with values between 4 and 7 %. In all samples from the Danube River, vermiculite and mixed layer minerals can only be found in traces.

Ebro

Like the Danube profiles, the Ebro profiles are also dominated by illite, but show the highest values of all the analyzed profiles. In most samples the illite even amounts up to 2/3 of the clay mineral assemblage (Table 2 and Fig. 5). The chlorite values are lower than in the Danube profiles, with values between 14 and 18 %. Smectite and kaolinite are also present in low amounts with values between 10 and 16 % and 5 and 7 %, respectively. However, vermiculite is completely absent in all the Ebro samples.

Elbe

The kaolinite values of the Elbe profiles are the most outstanding feature of the Elbe profiles. This stresses the differences of these profiles in comparison with the Danube and Ebro profiles already found in the bulk mineralogical analyses (Table 2 and Fig. 6). The kaolinite shows values of up 49 %. This is due to the parent material in the hinterland of River Elbe, which is mostly the Bohemian Massif. Feldspars are major constituents in the granites and gneisses found in the Bohemian Massif. The kaolinites of River Elbe derive from the weathering of the feldspars to kaolinite. Apart from kaolinite, the profiles of river Elbe also show high contents of illite. Chlorite is present in the lowest amounts of all profiles with values between 5 and 7 %. The smectite contents are different in both profiles. In EL 1 the smectite shows values up to 20 %, whereas the contents in EL 3 are lower with a maximum of 7 %. In all samples from the Elbe River, vermiculite and mixed layer minerals can only be found in traces.

Summary

The bulk and clay mineralogical analyses for this project aimed at a better understanding of the different pedogenetical processes in the three investigated river basins. Summarizing it can be said, that the soil profiles of the Danube and the Ebro show comparable bulk and clay mineralogical assemblages, whereas the Elbe profiles are completely different. The reason for this are the different parent materials in the hinterland of these rivers.