

Chemical analyses of Rhaethian and Sinemurian clay of Northern Franconia

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Abstract

The Rhaetian clayey paleo-vertisol in the Großheirath pit according to carbon analyses proves to be vertically divided by an intercalated organic layer or soil horizon.

The Sinemurian shale in Lichtenfels-Kösten shows a saprolite cap representing a typical weathering front with enrichment of iron III oxide, heavy metals and loss of Ca/Sr carbonate.

Kurzfassung

Der rhätische Hauptton (Exter-Formation) ist in der Tongrube Großheirath als Paläo-Vertisol ausgebildet. Er wird durch eine 30 cm dicke dunkelgraue Lage zweigeteilt. Der organische Kohlenstoff dieser Lage ist in einer von zwei Messungen gegenüber dem liegenden und hangenden Ton deutlich erhöht. Er sollte also eine ehemalige organische Lage oder einen organischen Horizont repräsentieren.

Westlich Lichtenfels-Kösten war an der Neubaustrecke der Autobahn A73 die Obtususton-Formation erschlossen, sowohl unverwittert als auch durch einen Saprolit überprägt.

Analysen über die Saprolit-Untergrenze hinweg zeigen im Saprolit einen Schwund von zweiwertigem Eisen und Kalzium/Strontium-Karbonat, ferner eine Anreicherung von Eisen III-oxid und Schwermetallen. Der Saprolit erweist sich damit als Verwitterungshorizont unter dem Einfluss von Pflanzenbewuchs.

Rhaethian clay (Exter Formation, Hauptton layer)

In the clay pit GOTTFRIED in Grossheirath (Fig. 1) the Rhaetian Hauptton layer is exploited for ceramic materials. Within the 5.4 meter thick grey clay a thick paleo-vertisol developed, as mentioned first in SCHIRMER (2013: 237). This vertisol is subdivided in the pit by a darker grey band of 30 cm thickness into a thicker lower and smaller upper part. The band occurs throughout the entire pit. The question was, whether the dark grey colour of this intercalated band is an indication of an increased TOC content.

Location: Clay Pit R 4425590, H 5560850

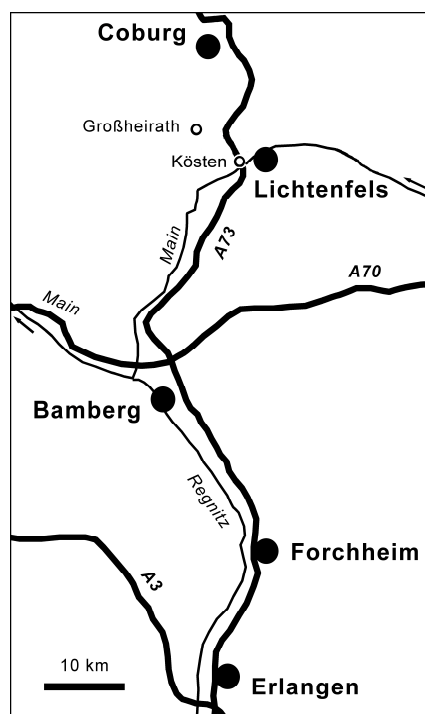


Fig. 1: Location of the Sites Großheirath and Lichtenfels-Kösten.

Two vertical ranks of each three samples were taken across the lower clay, the dark band and the upper clay. The analyses of total organic compounds TOC, total inorganic carbon TIC, total carbon TC and pH are shown in Tab 1.

Tab. 1: Carbon values from the Rhaetian clay (Hauptton) in Großheirath south of Coburg.

TOC = total organic carbon, TIC = total inorganic carbon, TC = total carbon.

	rank 1				rank 2			
Stratum	TOC	TIC	TC	pH	TOC	TIC	TC	pH
upper clay	0.18	n.d.	–	5.1	0.29	<0.1	0.29	6.6
dark band	0.57	0.25	0.82	6.6	0.16	0.12	0.28	6.9
lower clay	0.14	0.13	0.27	6.8	0.13	0.18	0.31	6.8
red spot	0.19	<0.1	0.19	6.8				

The absolute values of all measurements in Tab. 1 range between 0.13 and 0.57% TOC. These principally low values are considered normal owing to the strong oxidation properties of the Mesozoic deposits. Data rank 1 gives the information that the dark grey layer has twice to four times the TOC proportion than the lower and upper part of the clay. Likewise the TC proportion of the dark layer reflects this trend by a value three times higher than within the clay above and below.

Data rank 2 shows the dark grey layer with the same values as below and above. This may be due to strong turbation process within a vertisol.

The enhanced TOC value of the dark band in rank 1 points to higher TC and TOC rate in comparison to the clay above and below. Thus, it may be a soil horizon or an organic-rich deposit. Moreover, the fact that the organic carbon is prevailing the inorganic carbon points to soil formation at least in the background of the depositional setting as explained by SCHIRMER (2013: 237).

The lower part of the clay respectively palaeosol presents red spotlike anomalies of some decimeters in diameter as result of a palaeo gleyic vertisol, named Tiefenroth Soil in Schirmer (2013: 223). Carbon data of one of these anomalies (Tab. 1) compared with those of the lower clay show insignificant differences.

Sinemurian shale (Obtususton Formation, former Lias β)

During the construction of the Autobahn A 73 between Bamberg and Coburg the clayey shale of the Obtususton Formation was exposed. It showed in various places both the unweathered shale and an overlying saprolitic zone (SCHIRMER 2013: 236). The differences between both strata was studied by sampling across the boundary.

Location (Fig. 1): A73, construction km 67, R: 4430786 H: 5557446, 750 m western of Lichtenfels-Kösten.

Three samples LIF 1–3 mark the unweathered clay (LIF 1), its transition zone to the saprolite (LIF 2), and the saprolite (LIF 3). They were analysed by RFA (Tab. 2).

In addition two samples of siderite nodules were analysed, one from the unweathered shale of the Obtususton Formation (LIF 4), another one from the top of the Numismalismergel Formation nearby (L11).

From unweathered clay to saprolite the data in Tab. 2 show a clear increase of trivalent iron oxide, and of select heavy metals, such as As, Ba, Co, Ni, and Zi; conversely, a decrease of CaO, MgO, Sr, bivalent iron, MnO and La.

As a typical result of weathering bivalent iron is oxidated to trivalent iron, whereas calcium, and strontium carbonate dissolves. The increase of heavy metals indicate long plant growth at the relic surface of the saprolite dating far back in geologic time. Plants gather heavy metals from the soil and accumulate them in the soil horizons in which they root.

By the way it is of interest that MgO concentrations are comparatively higher than CaO. In the Altdorf region, 80 km southward, it was noticed that within the Obtususton Formation the MgO concentration is approximately half of the CaO content (SALGER & SCHMIDT-KALER 1973: 163). However, the informations of both areas are based on one single measurement.

The samples LIF 4 and 11 represent siderite nodules unaffected by saprolite. They show similar dimensions among themselves. Contrasting to the shale their much higher CaO content than MgO content is remarkable. The high concentrations of Fe₂O₃ are within the expected ranges.

Tab. 2: RFA element analyses from Liassic shale (Obtususton Formation) in Kösten western of Lichtenfels. MAC = mass absorption coefficient.

parameter	measuring unit	LIF 01	LIF 02	LIF 03	LIF 04	LIF 11
Al ₂ O ₃	%	19,16	19,12	19,39	4,95	5,18
As	ppm	6	3	14	15	<2
Ba	ppm	296	269	343	148	102
Bi	ppm	4,7	1	0,9	1,7	0,7
CaO	%	1,66	2,89	0,76	25,24	28,17
Cd	ppm	<0,1	<0,1	<0,1	0,2	0,2
Ce	ppm	95	93	104	95	107
Co	ppm	20	19	29	12	6
Cr	ppm	114	111	116	28	20
Cs	ppm	14	5	6	<5	<5
Cu	ppm	30	26	32	15	12
Fe ₂ O ₃ difference	%	2,32	4,28	5,47	2,25	1,71
Fe ₂ O ₃ total	%	5,59	5,45	5,93	16,47	15
FeO titr	%	2,94	1,05	0,41	12,8	11,96
Ga	ppm	22	20	19	<10	<10
K ₂ O	%	3,26	3,12	3,28	0,78	0,78
La	ppm	64	50	57	46	93
MgO	%	2,51	1,73	1,7	2,81	2,97
MnO	%	0,115	0,034	0,172	0,348	0,452
Na ₂ O	%	0,19	0,2	0,2	0,11	0,13
Nb	ppm	14	41	17	23	19
Nd	ppm	43	37	45	67	51
Ni	ppm	60	58	81	27	45
P ₂ O ₅	%	0,15	0,17	0,16	1,38	1,4
Pb	ppm	8	32	22	23	18
Rb	ppm	151	141	154	37	35
Sb	ppm	4,1	6	5,4	<0,5	<0,5
SiO ₂	%	58,63	58,28	61,72	17,85	14,04
Sn	ppm	5	7	7	<2	<2
Sr	ppm	114	104	105	220	498
Ta	ppm	6,8	3,9	<1	9,5	5,3
Th	ppm	17	24	16	9	8
TiO ₂	%	0,99	1,03	1,01	0,27	0,21
Tl	ppm	1,8	<1	2,1	<1	<1
U	ppm	3	<1	4	<1	<1
V	ppm	170	162	175	129	55
W	ppm	7,2	6	8,1	8,2	3,7
Y	ppm	35	34	36	53	32
Zn	ppm	61	60	98	22	101
Zr	ppm	248	277	265	100	65
ignition loss 1050	%	8,86	9,03	6,96	29,59	32,18
loss on drying	%	7,23	9,82	9,68	0,32	0,36
Total	%	100,94	101,08	101,38	98,47	99,32
MAC	nb	47,5	48,1	48,2	78,9	78,3

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Contribution of authors

T. P. cared for the analytical part, W.S. provided field work, sampling and the text.