Alternative Buffer Materials Project

Comparison of the available buffer materials: advantages and disadvantages related to their hydraulic, mechanical and geochemical performance

This presentation

- Objectives of the experiment
- Experiment design
- Results from measurements in field (Test 1)
- Termination of test package 1
- Chemical-mineralogical characterization
- Summary of observations
- Outlook

Participants

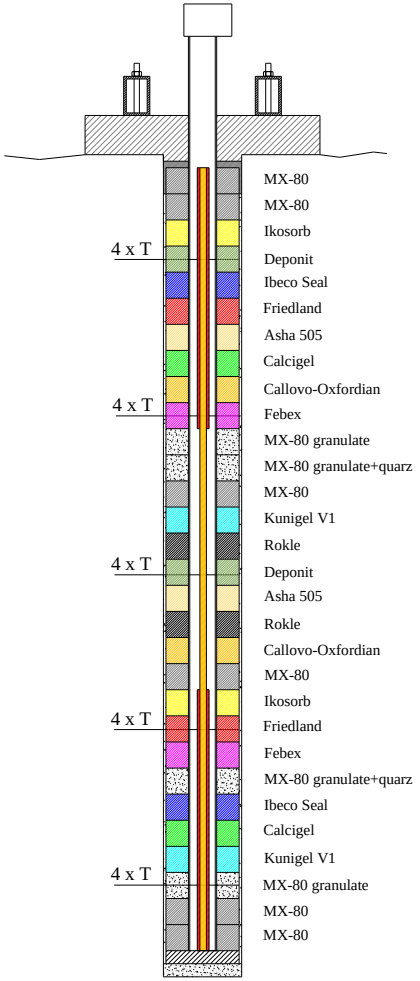
- SKB
- BGR
- Clay Technology
- Posiva
- Nagra/University of Bern
- ANDRA
- RAWRA
- JAEA
- AECL
- BRIUG
- KIT

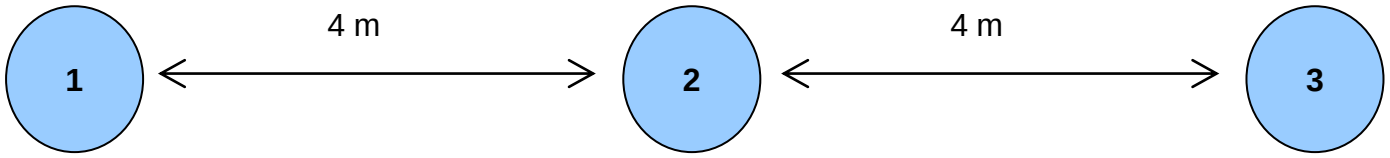
Objectives of the project

- Detect and describe differences between different clay materials regarding:
  - Manufacturing and handling of blocks
  - Mineral stability
  - Physical properties
- Additional objectives:
  - Study of iron-clay interaction
  - Comparison of analytical methods
  - Diffusion of major cations

Experiment design

- Experiment design based on LOT with some modifications:
  - Different materials are tested
  - Less instrumentation
  - Shorter deposit holes (3m)
  - Complete package length heated
  - Central tube made of steel
  - No inserts or tracers





Short-term (1-2 years).
Heated from start.
Artificial saturation from start.

Medium-term(2-4 years).
Heating started when buffer was saturated.
Artificial saturation from start.

Long-term (≥ 5 years).
Heated from start.
No artificial saturation.

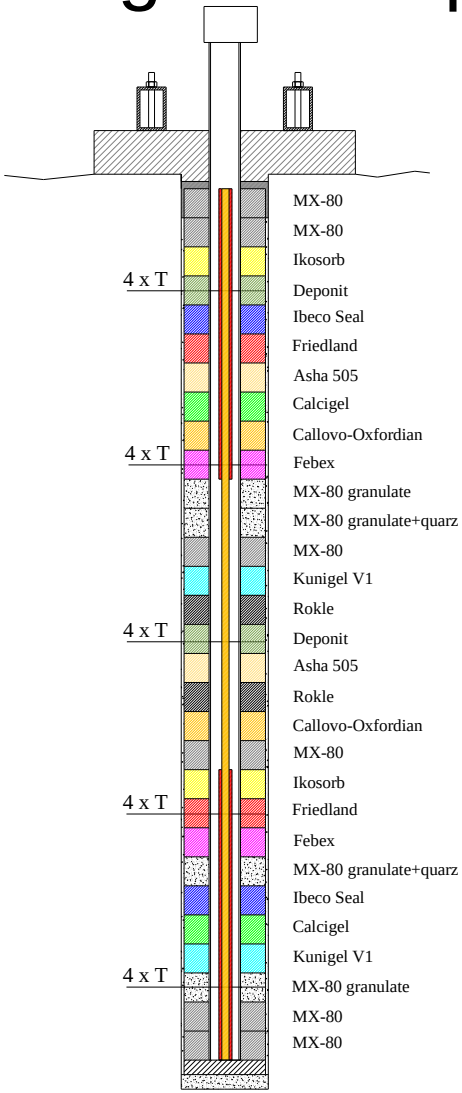
Materials

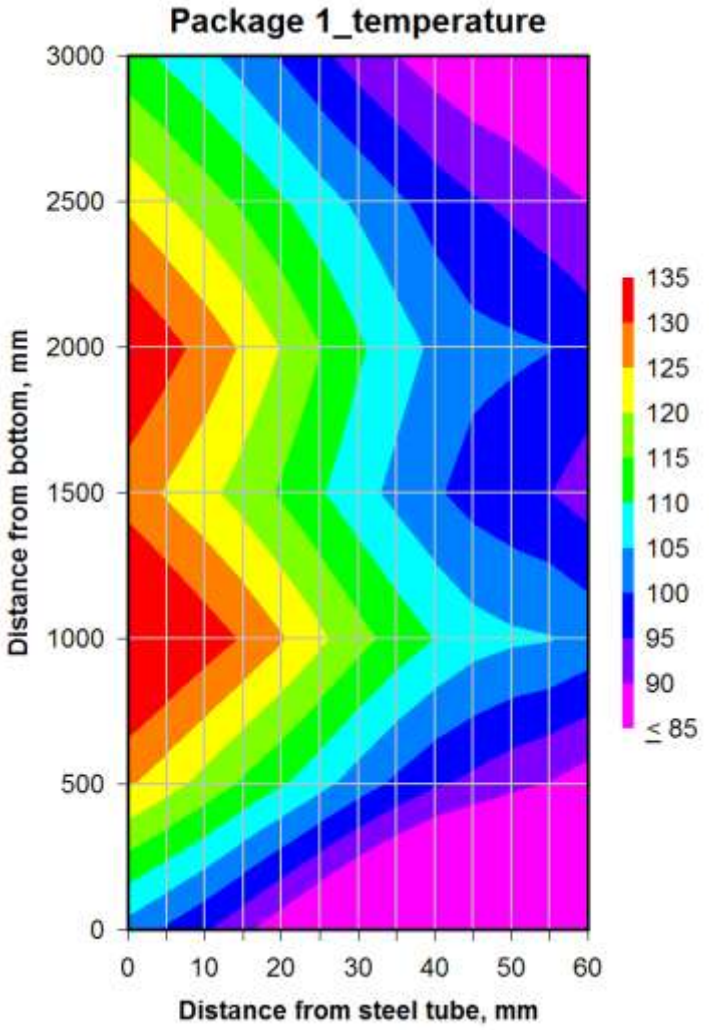

Kunigel
Asha 505
IbecoSeal
Ikosorb
Febex
Dep CAN
MX-80
Rokle
Friedland
Calcigel
Callovo-Oxfordian

Standard investigation of reference materials

Material	Water content	Free swelling	Liquid limit	Grain density
	%	ml	%	kg/m^3
MX-80	12.9	17.0	545	2735
Calcigel	8.2	4.0	119	2695
Ikosorb	15.6	6.2	326	2740
Rokle	11.5	3.0	116	2940
Kunigel	7.8	9.7	462	2681
Febex	14.7	2.4	109	2735
Callovo Oxfordian	2.4	1.6	-	2682
Asha 505	12.7	8.8	337	2869
Friedland	5.2	3.9	68	2828
Ibeco Seal	14.0	11.2	522	2753
Deponit CAN	16.8	6.2	160	2678

Package 1 Temperature distribution





Termination of test package 1

- Seam drilling
- 2 x core drilled holes (d=300 mm)

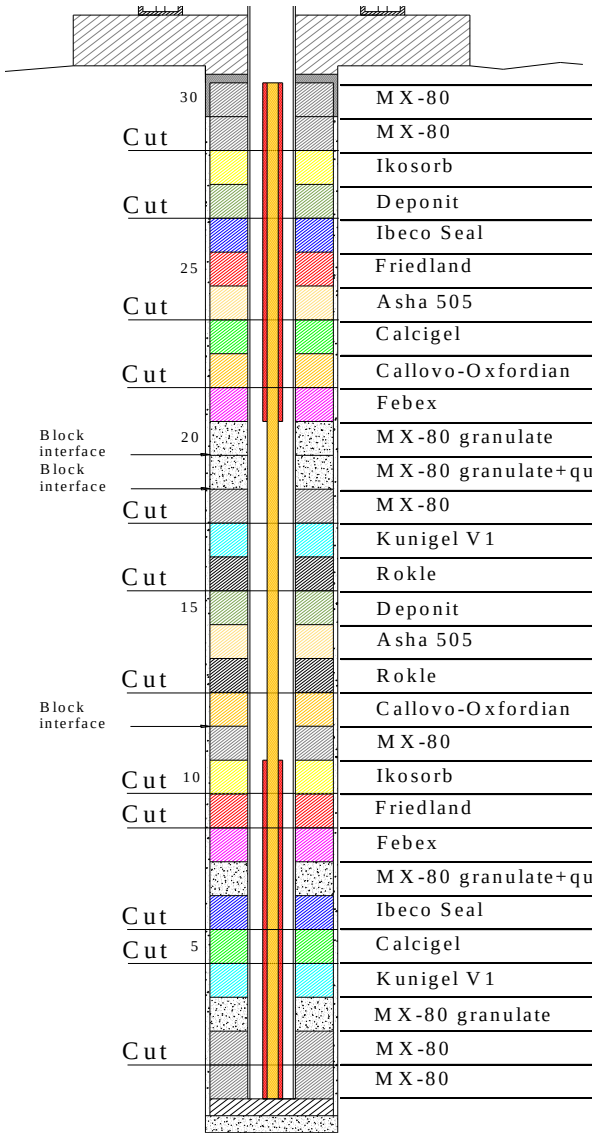
Termination of test package 1

Termination of test package 1

Termination of test package 1

Block division in laboratory

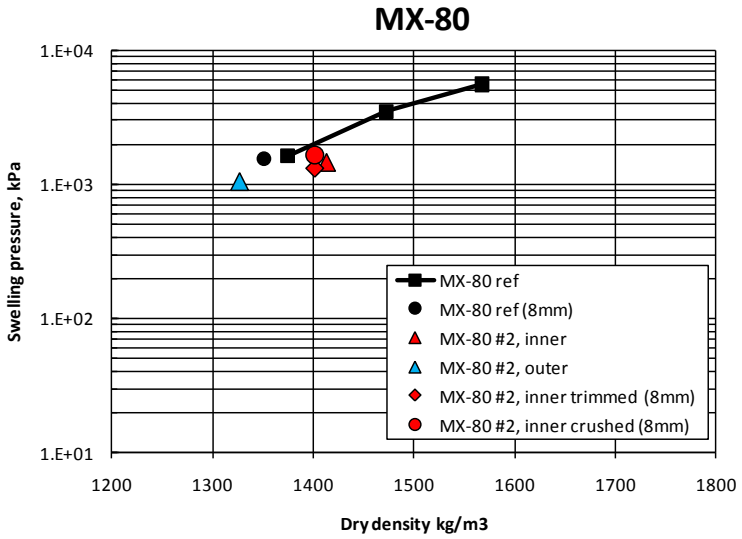
Density distribution

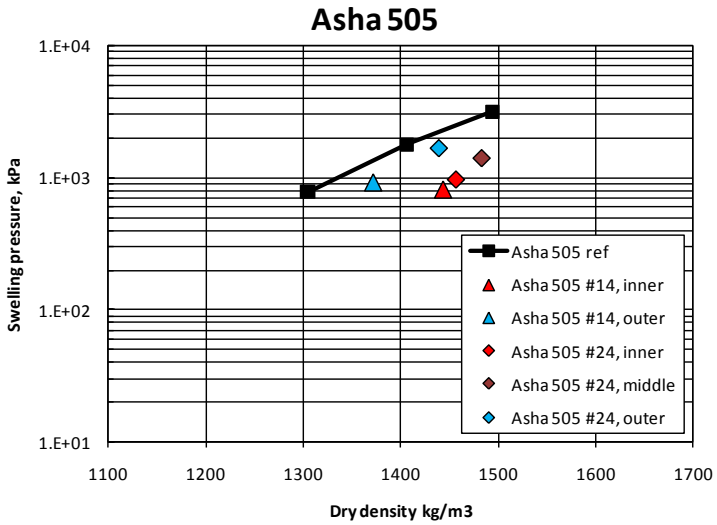


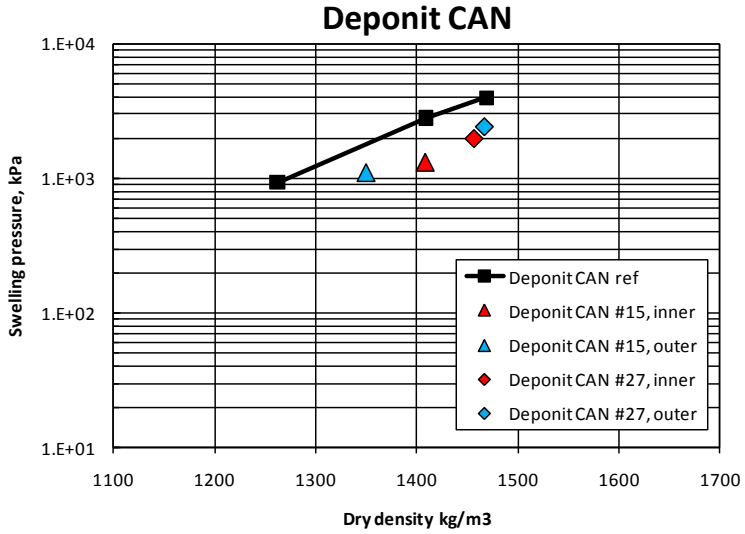
	1	2	3	4	5
MX-80	1545	1513	1485	1464	1444
MX-80	1578	1591	1560	1546	1520
Ikosorb	1627	1604	1598	1585	1568
Deponit	1547	1543	1529	1509	1528
Ibeco Seal	1534	1528	1516	1494	1546
Friedland	1974	1955	1940	1917	1930
Asha 505	1534	1528	1527	1508	1519
Calcigel	1534	1525	1519	1497	1513
Callovo-Oxfordian	2025	2031	2026	2010	1976
Febex	1457	1455	1446	1426	1464
MX-80 granulate	1308	1294	1279	1263	1240	1222
MX-80 granulate+quarz	1532	1510	1495	1479	1453	1455
MX-80	1458	1443	1443	1432	1399
Kunigel V1	1729	1698	1692	1680	1656
Rokle	1492	1492	1483	1458	1393
Deponit	1480	1476	1477	1449	1433
Asha 505	1512	1486	1491	1492	1422
Rokle	1953	1947	1938	1881	1894
Callovo-Oxfordian	2016	1999	1995	1979	1921
MX-80	1455	1441	1437	1417	1364
Ikosorb	1921	1940	1932	1929	1883
Friedland	1858	1839	1834	1810	1742
Febex	1448	1513	1438	1426	1433
MX-80 granulate+quarz	1513	1493	1484	1478	1443	1419
Ibeco Seal	1439	1441	1431	1419	1409
Calcigel	1463	1426	1424	1419	1405
Kunigel V1	1688	1662	1657	1641	1656
MX-80 granulate	1445	1399	1390	1381	1370	1350
MX-80	1481	1478	1468	1462	1457
MX-80	1500	1470	1456	1434	1457

Swelling pressure and hydraulic conductivity

Swelling pressure







- There is a tendency that the swelling pressure of the test material is lower than the reference material
- The amount of tests is limited

Sample set

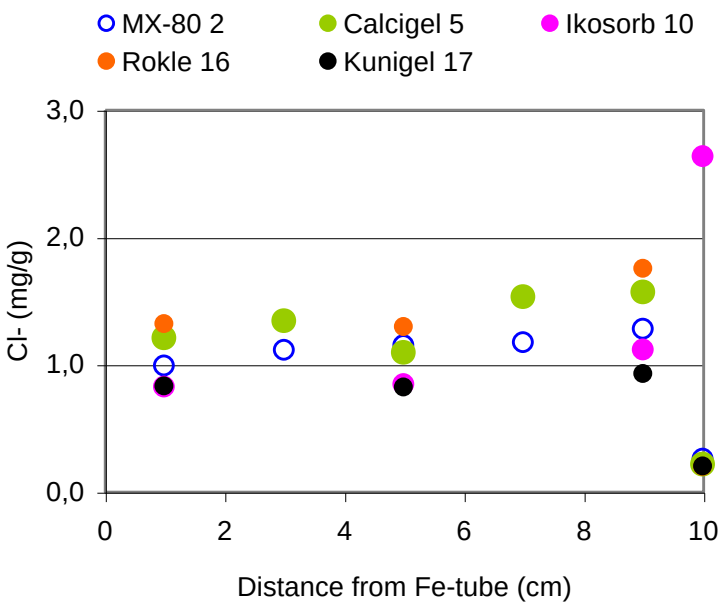
	JNB ABM 'Kunigel V1' Bentonite	CAN ABM 'Deponit Ca N' Bentonite	ROK ABM "RAWRA" = ROK???? Bentonite	CAL ABM 'Calcigel' Bentonite	IBE ABM 'IBECO Seal' Bentonite
Block	*#17*	*#15*	*#13*	*#23*	*#6*
	"metallic" crust, hard, a little rusty but thin	*blue until 1 cm depths, direct contact bluegreen*	*thin black crust at contact, pristine clay underneath*	*a thick (1mm) black layer*	*black layer at contact with white spots, smells rotten*
					
1 mm	JNB 0	CAN 0	ROK 0	CAL 0	IBE 0
1 cm	JNB 1	CAN 1	ROK 1	CAL 1	IBE 1
3 cm	JNB 2	CAN 2	ROK 2	CAL 2	IBE 2
5 cm	JNB 3	CAN 3	ROK 3	CAL 3	IBE 3
7 cm	JNB 4	CAN 4	ROK 4	CAL 4	IBE 4
					IBE 0-1 white (1mg)

	LOT ABM 'MX 80' Bentonite	ASH ABM 'Asha 505' Bentonite	FRI ABM 'Friedland' Clay	FEB ABM 'Febex' Bentonite	IKO ABM 'Ikosorb' Bentonite
Block	*#11*	*#14*	*#9*	*#8*	*#10*
	total sample dark, contact is brittle	*no colour change at contact, smells as a desinfactant*	*pieces fell apart, contact very hard*	*blue seems, contact brittle, thick, black*	*very hard dark corrosion products at contact*
					
1 mm	LOT 0	ASH 0	FRI 0	FEB 0	IKO 0
1 cm	LOT 1	ASH 1	FRI 1	FEB 1	IKO 1
3 cm	LOT 2	ASH 2	FRI 2	FEB 2	IKO 2
5 cm	LOT 3	ASH 3	FRI 3	FEB 3	IKO 3
7 cm	LOT 4	ASH 4	FRI 4	FEB 4	IKO 4

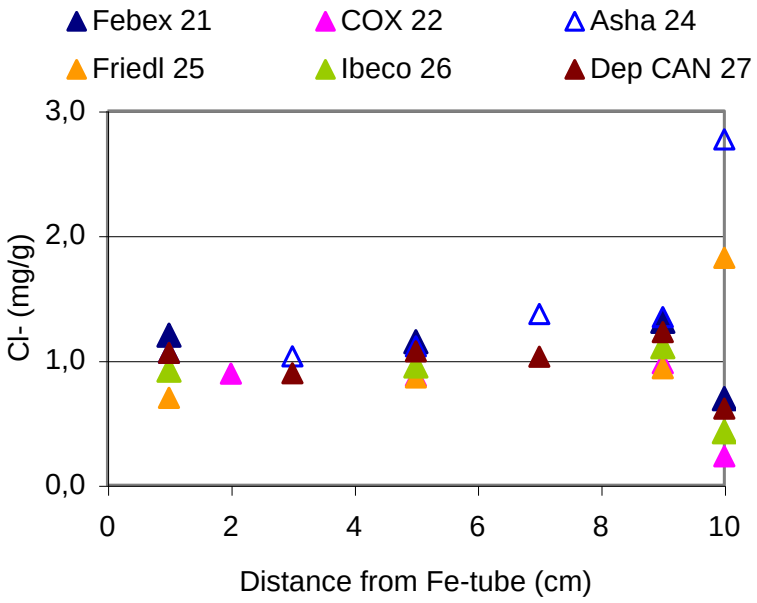
Figure 2: Fotographs of the blocks before sampling and sample list.

Water-soluble chloride (dispersion in water)

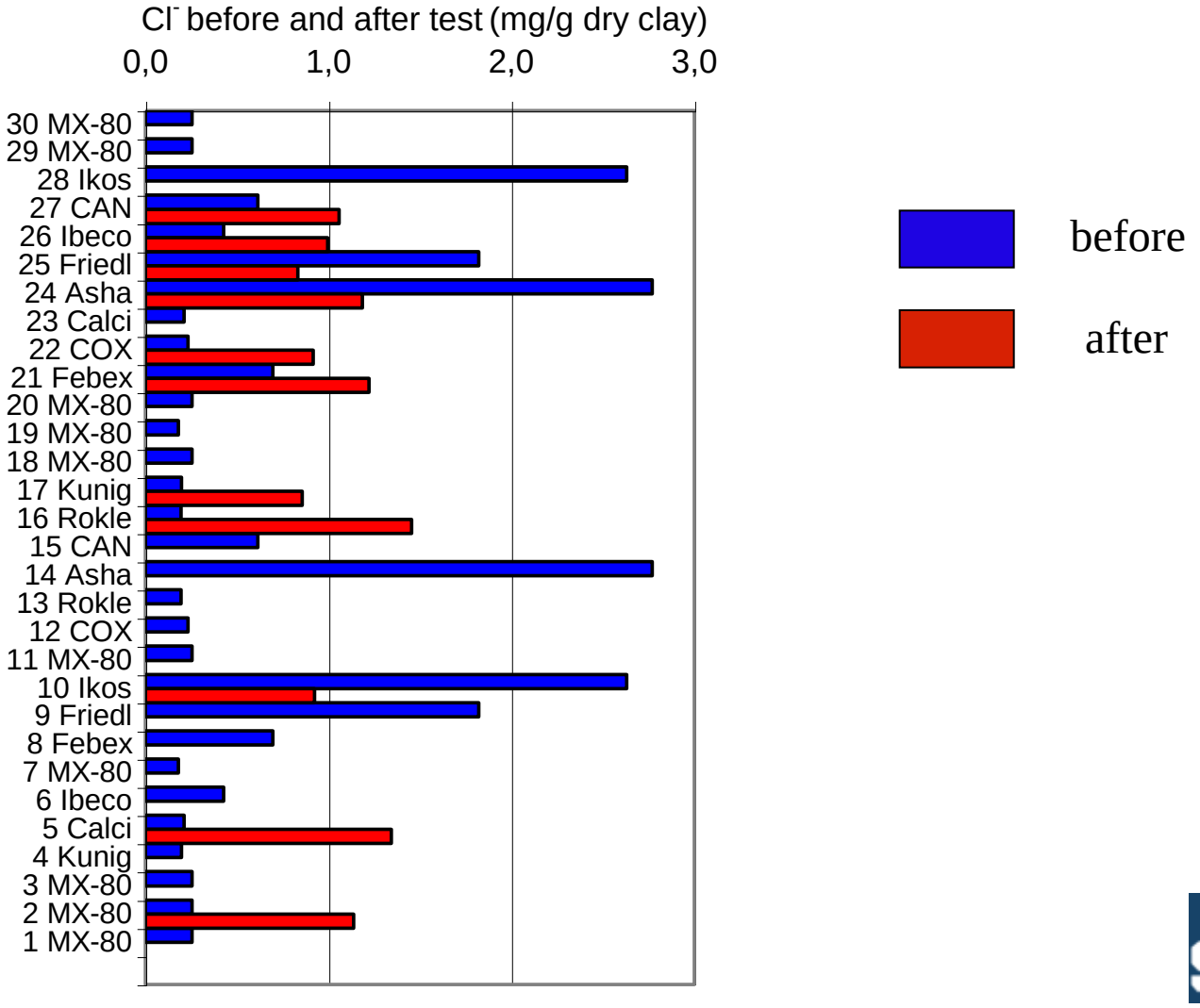
Lower part



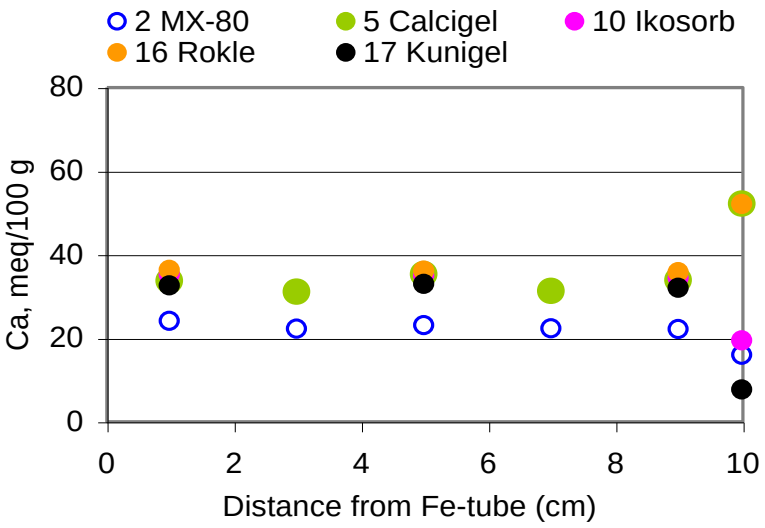
Upper part

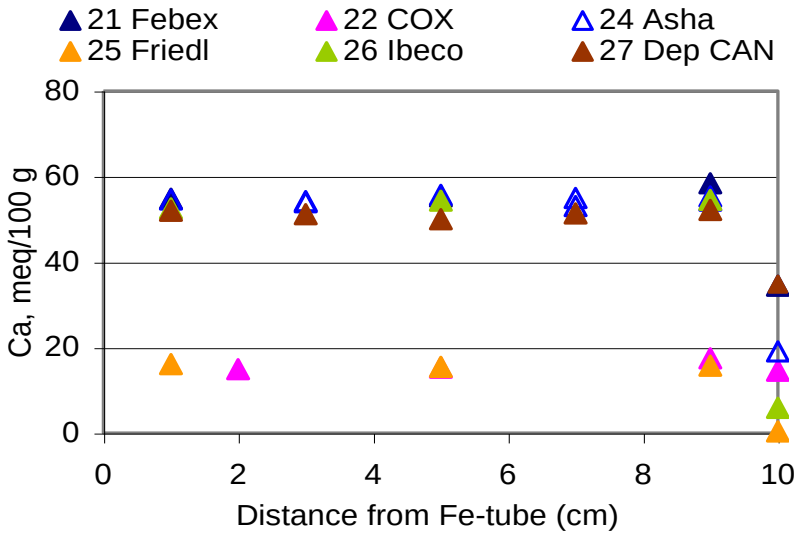


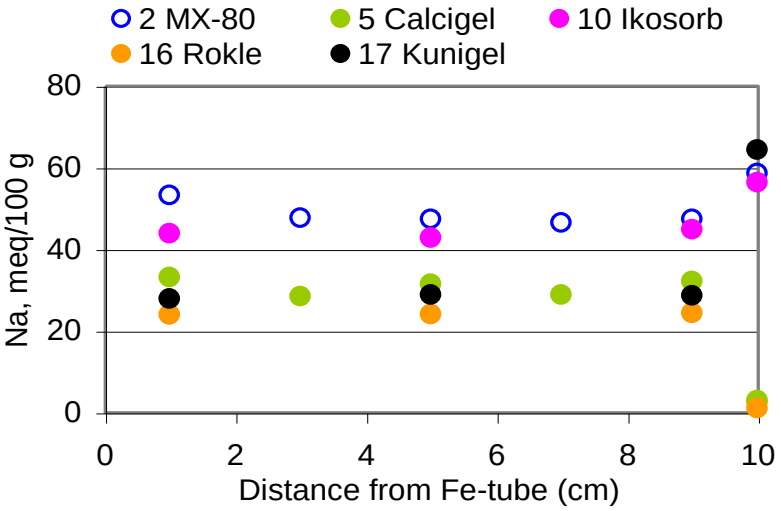
Chloride before and after the test

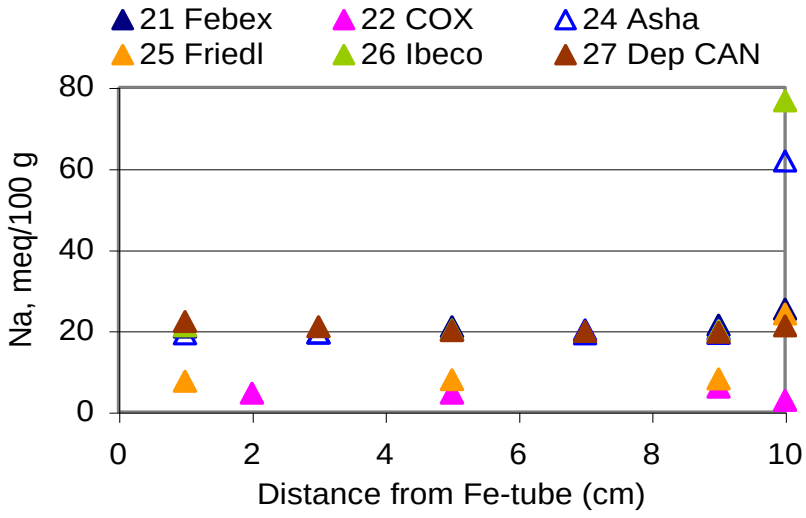


Exchangeable Ca and Na

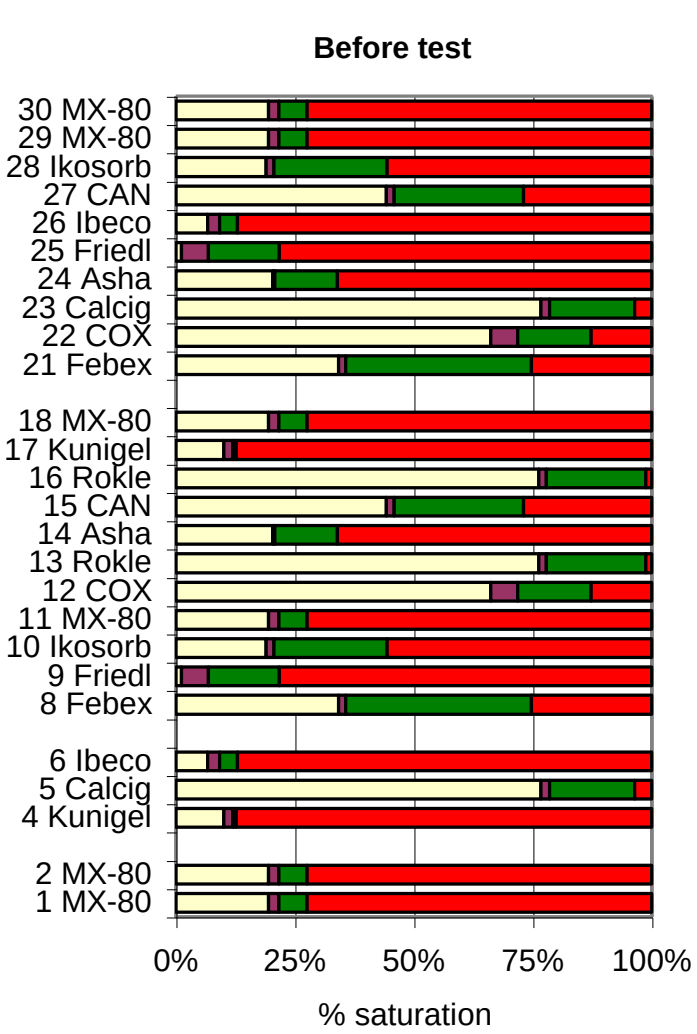


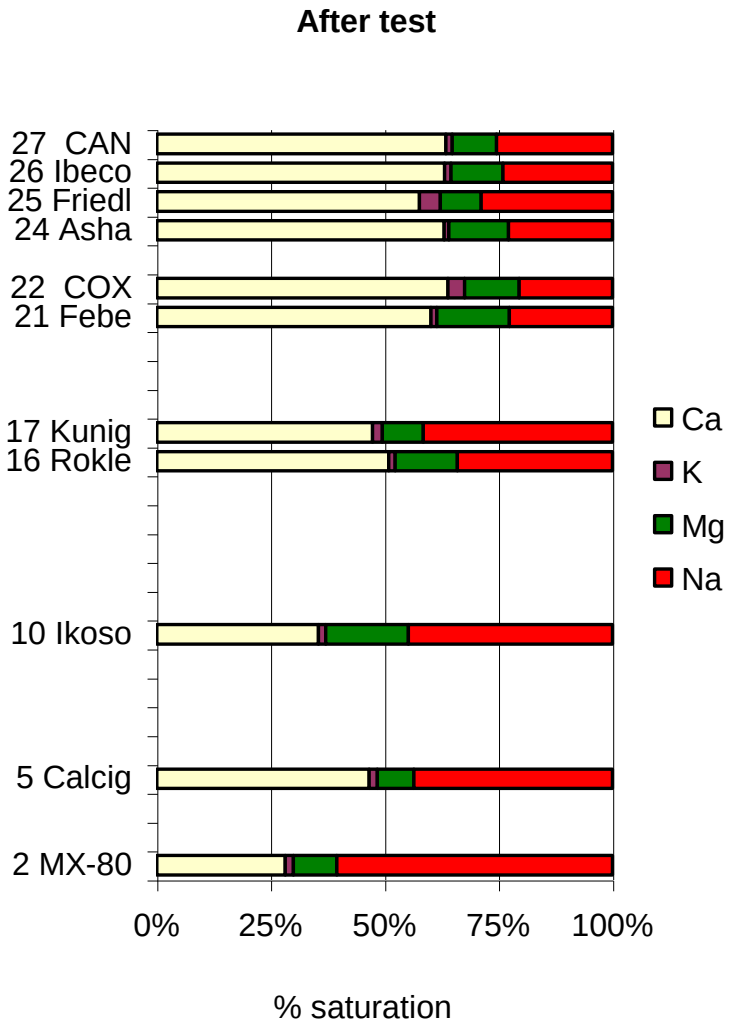




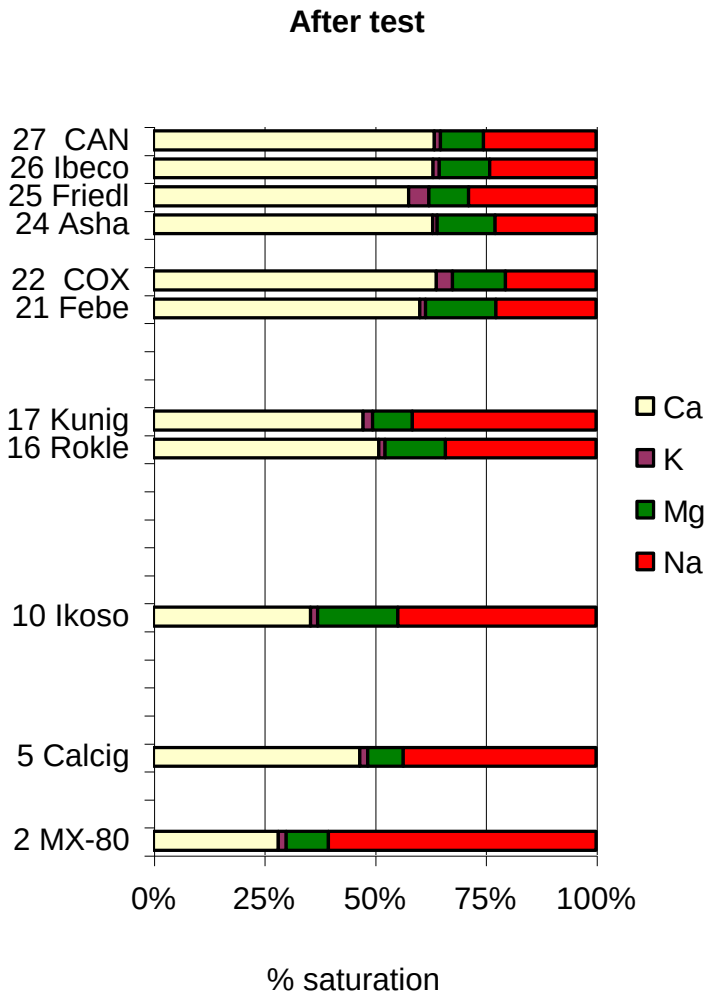


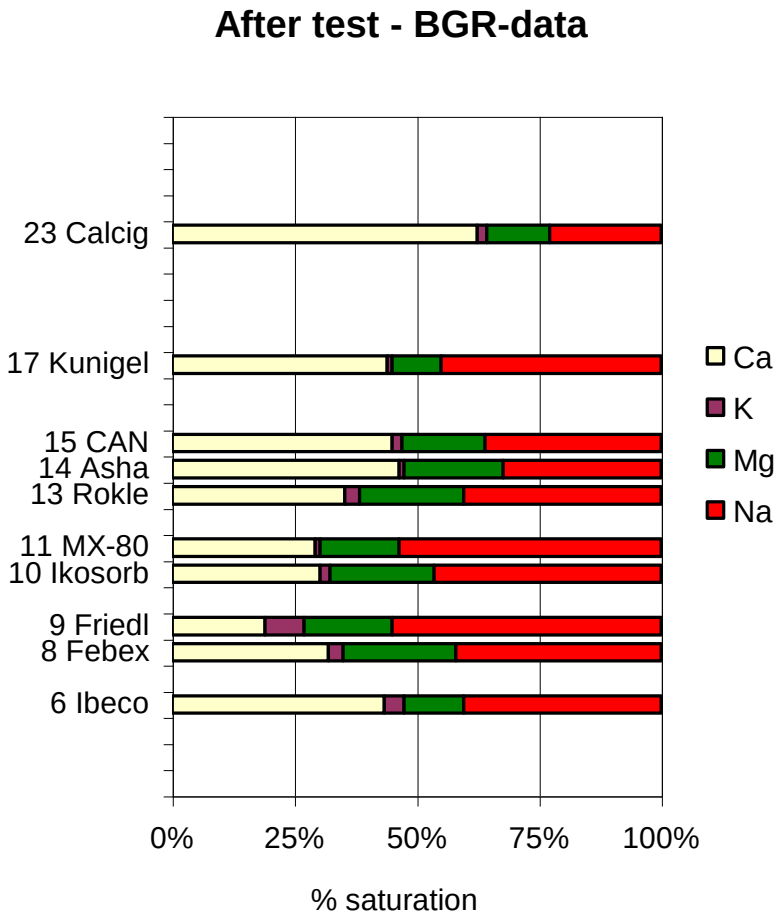
Relative cation distribution before and after the test



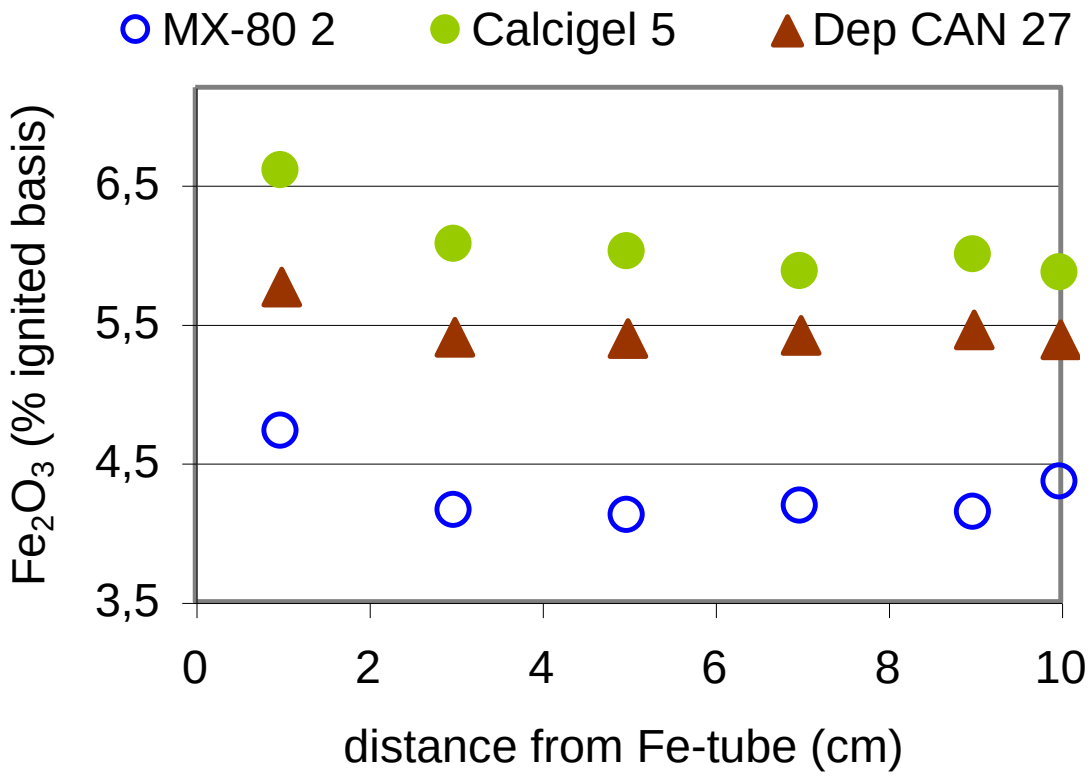


Comparison with BGR data

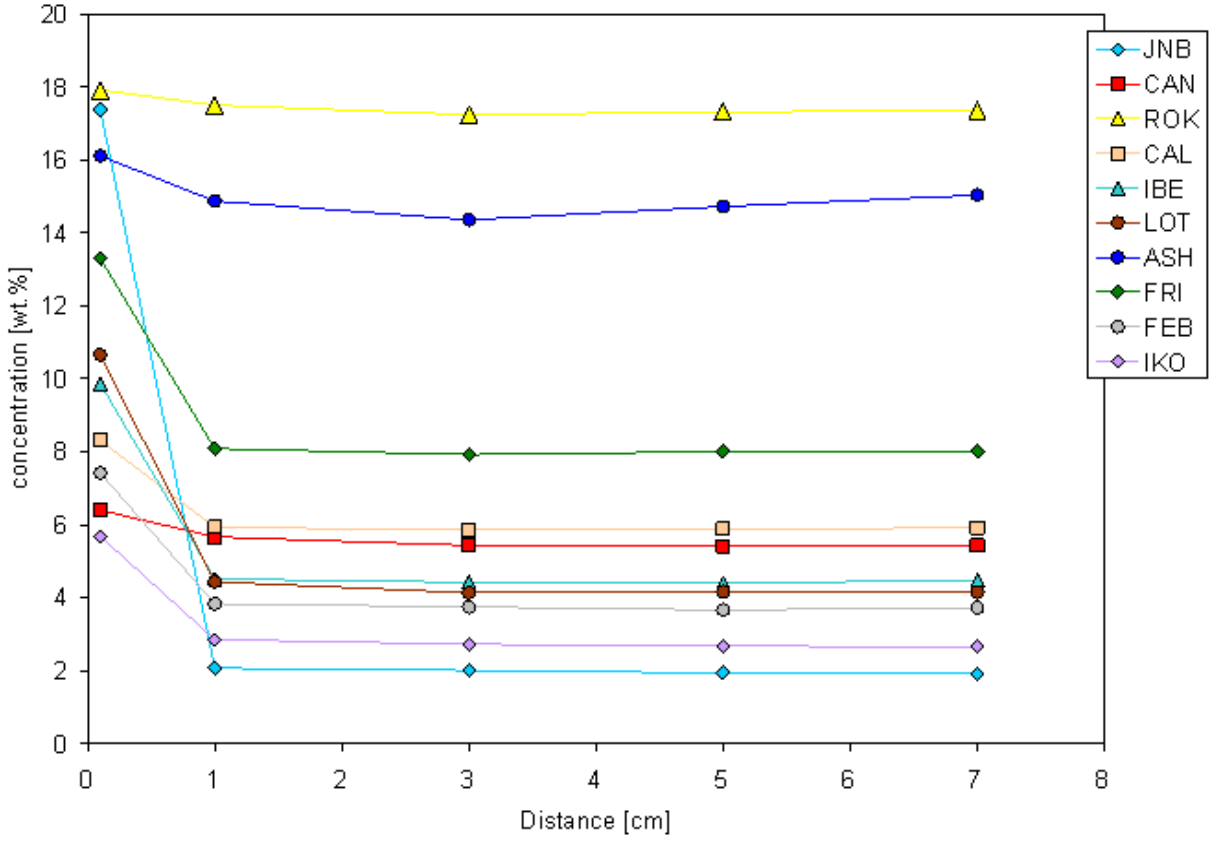




Iron distribution, bulk samples (Clay Technology)



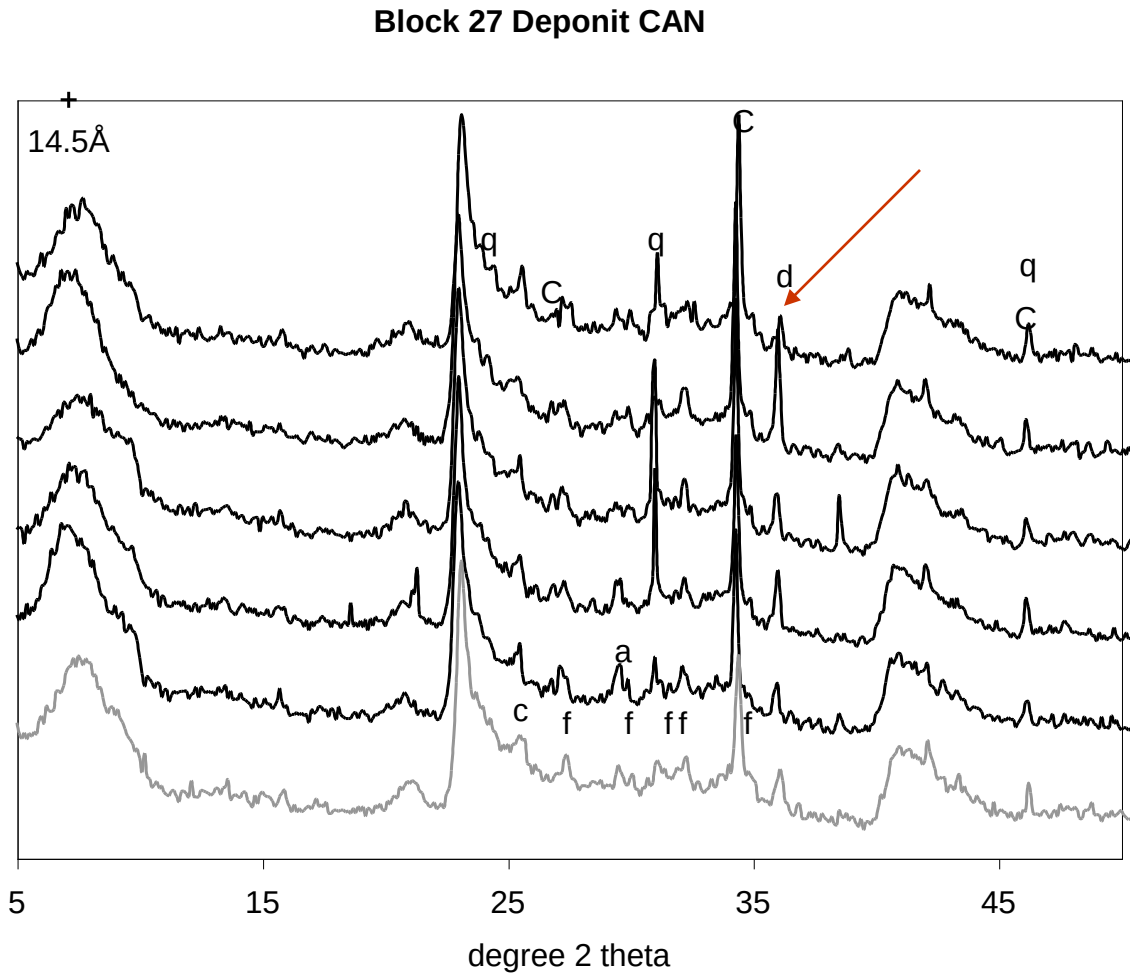
Iron distribution, bulk samples (BGR)



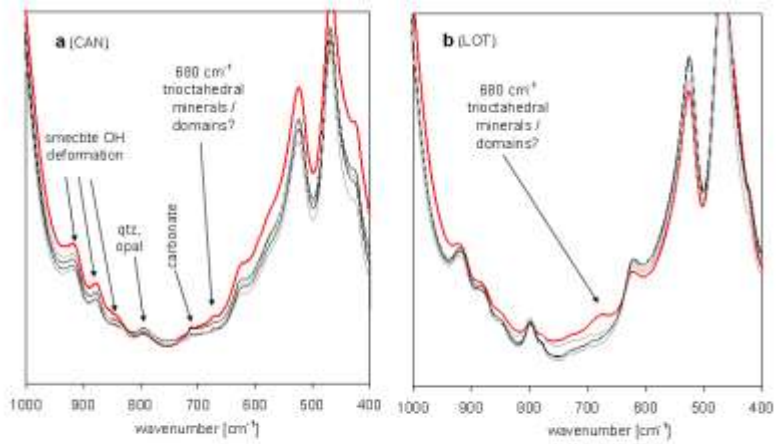
114

115 Figure 3: Content of Fe_2O_3 depending on the distance to the heater.

XRD-profiles of block 27, Deponit CAN-dolomite dissolution??



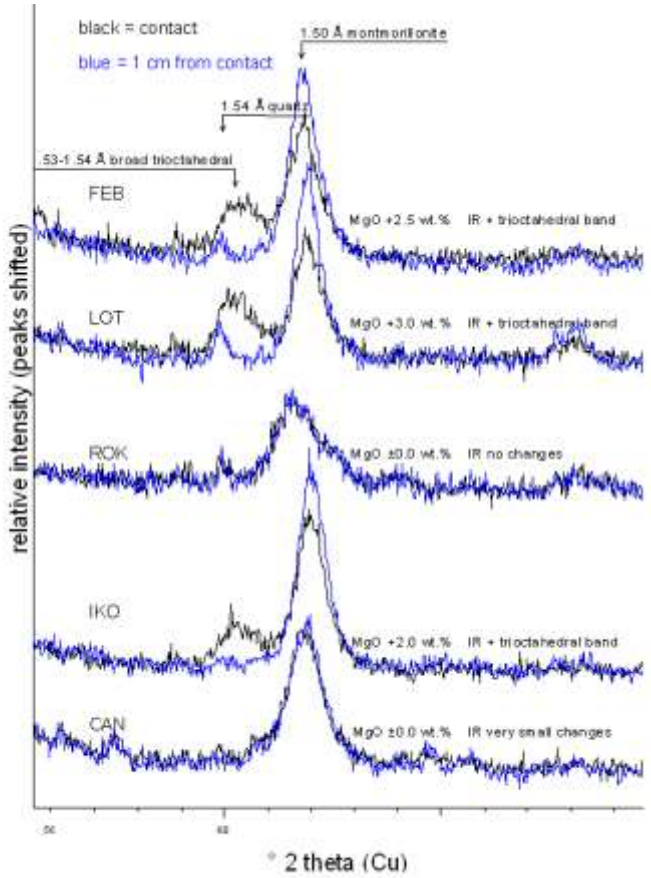
Trioctahedral minerals/domains



249

250 Abb 13: IR spectra of samples CAN and LOT showing increased 680 cm^{-1} intensity

251 which can not be attributed to precipitation of sulphates.



259

260 Figure 14: XRD 060 reflection of selected samples.

Main observations

- The saturation with groundwater resulted in more or less constant chloride concentration in all blocks
- differential equilibration of the exchangeable cation pool in the upper and lower part of the package
- Iron has been incorporated in the bentonite closest to the steel tube
- All blocks are depleted in magnesium and the loss is at a maximum in the outer parts
- Carbonate dissolution increases with temperature
- Nature of the trioctahedral mineral / domains?

Outlook

- New packages will be installed during 2012
  - Large interest in the project
  - Similar setup, but some materials will be replaced
  - Will generate data in the far future
- ABM 2 will be excavated in the beginning of 2013
- Parts of the “sister test” concrete & clay installed
  - More packages in the new tunnel