The effect of oxidation on shrinkage and water retention behavior of organic dredged sediments

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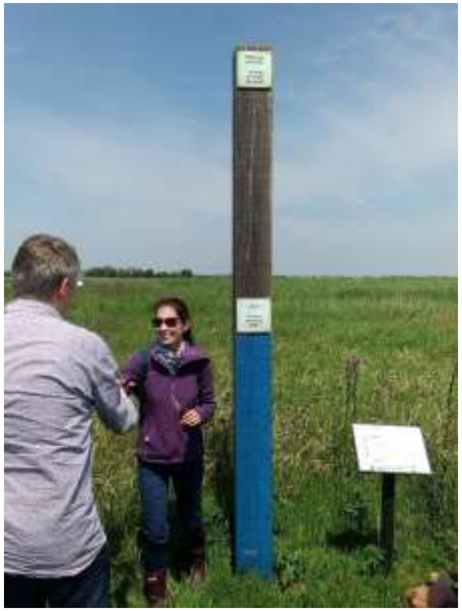
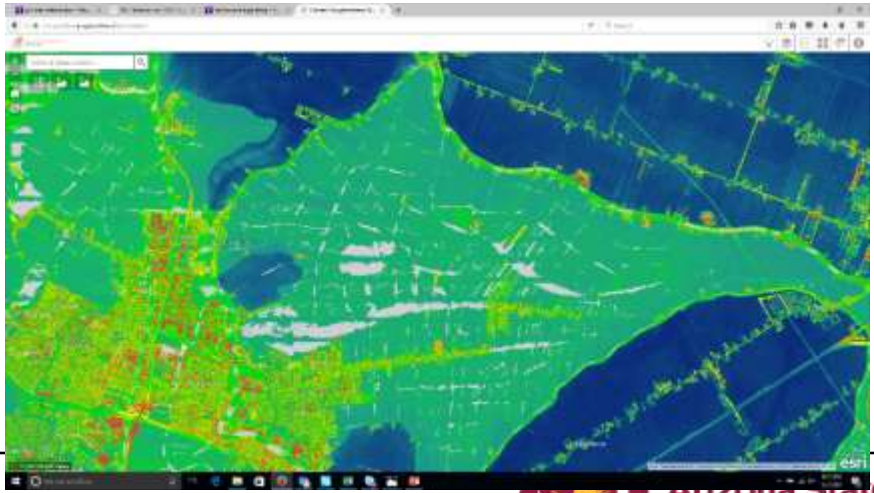
Location:
Wormer & Jisperveld, The Netherlands

Agriculture, recreation, natural habitat

Ongoing Subsidence and oxidation

- 1000 BC:
  - thickness of peat: 6 m;
  - surface level at + 2 m AMS
- 1900 AD:
  - Peat thickness: 3 m
  - Surface level at -0.5 m AMS
- 2013 AD:
  - Peat thickness 2.5 m
  - Surface level at -1.2 m AMS





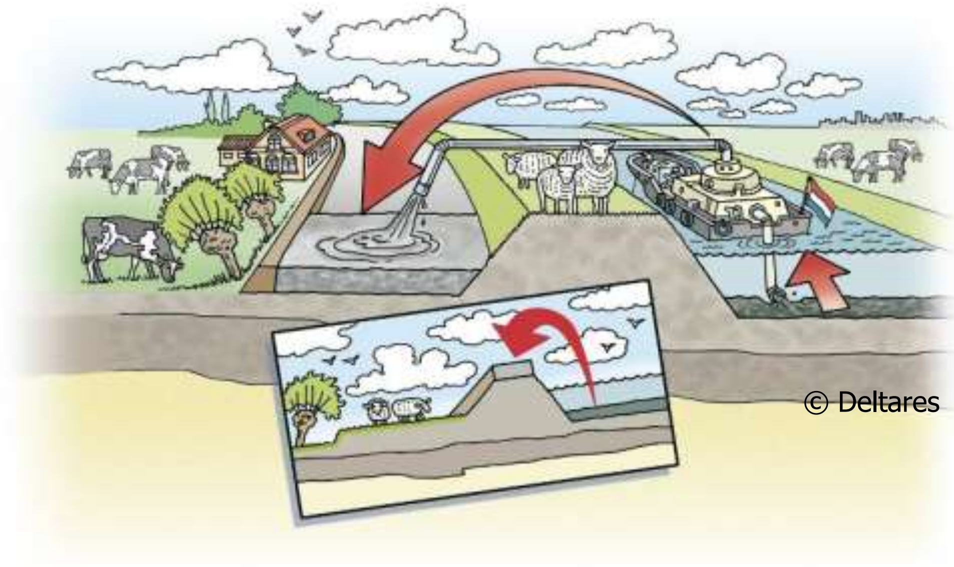
Dredged sediments

- From 2009 – 2014: 2.3 million m^3 dredged sediments from ditches and lakes
- Maintaining water ways for navigation
- Improve Water quality
  - Remove nutrients
  - Remove suspended sediments

November 2013: constructed pond for sediment storage

Solution- Lift up lowlands

Using dredged sediments to mitigate subsidence in low lying peatlands



Research questions

- What is the best strategy to deal with dredged sediments?
- How does the volume and surface elevation change in time?
- How does oxidation of organic material affect the volume change and surface settlement?
- What is the best strategy for longterm peatland conservation?

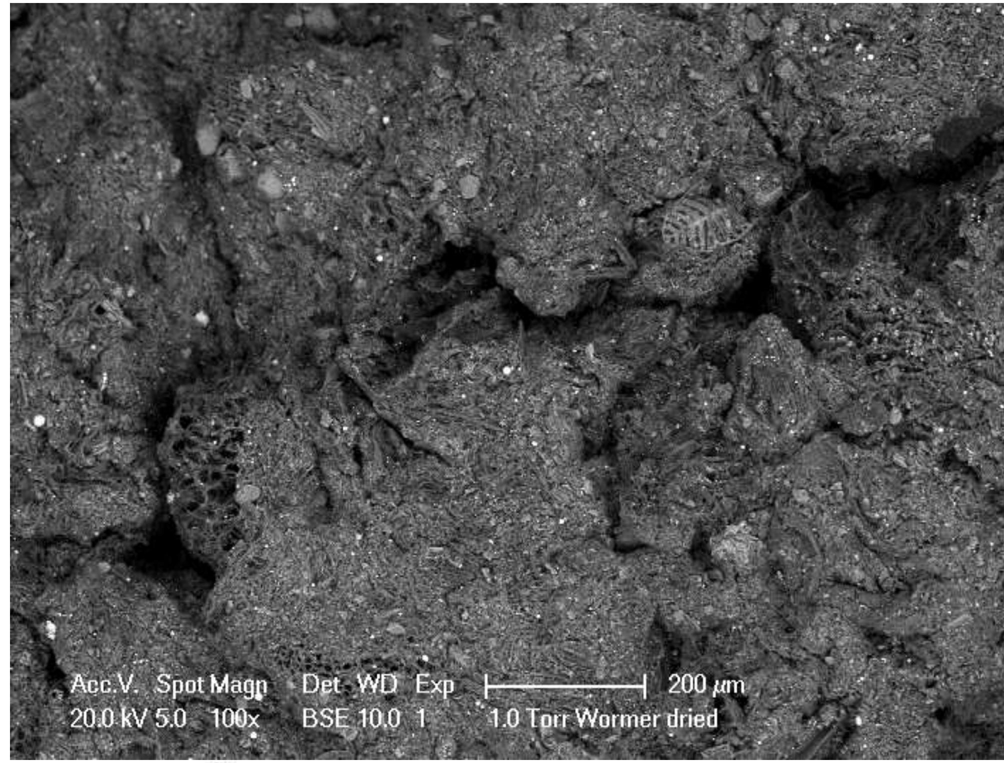
Material characterization

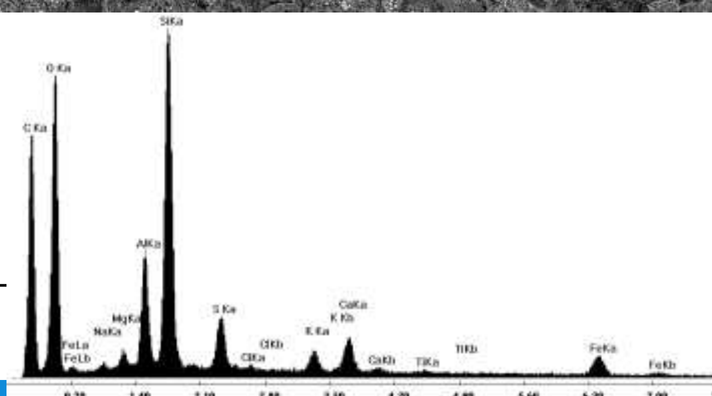
	Peat	Dredged sediments
• Organic content:	70- 98%	50%
• Fibre content:	50-60%	2%
• Moisture content:	1000-1500%	1000-1500%
• Specific gravity:	0.88	1.8
• Composition:	Reed, Sphagnum	

ESEM and EDAX analysis

Bulk composition

Elem	Wt%	At%
C	**46.38**	**58.84**
O	**32.32**	**30.78**
Si	9.4	5.1
Al	3.3	1.87
Fe	2.77	0.75
S	1.85	0.88
Ca	1.68	0.64
K	0.91	0.35
Mg	0.65	0.41
Na	0.34	0.22
Ti	0.21	0.07
Cl	0.2	0.09

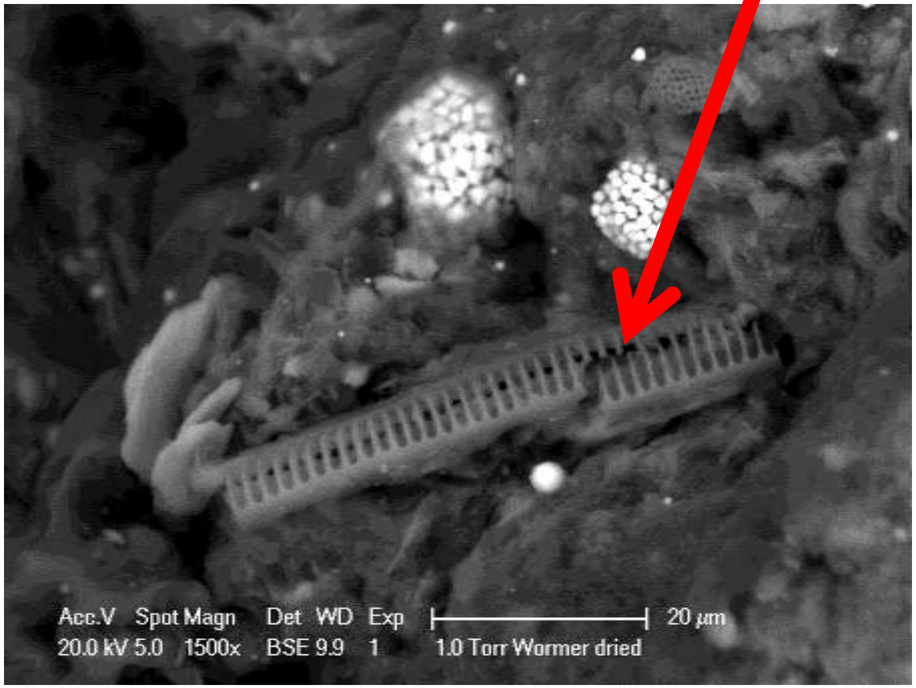




ESEM and EDAX analysis

Siliceous Diatoms

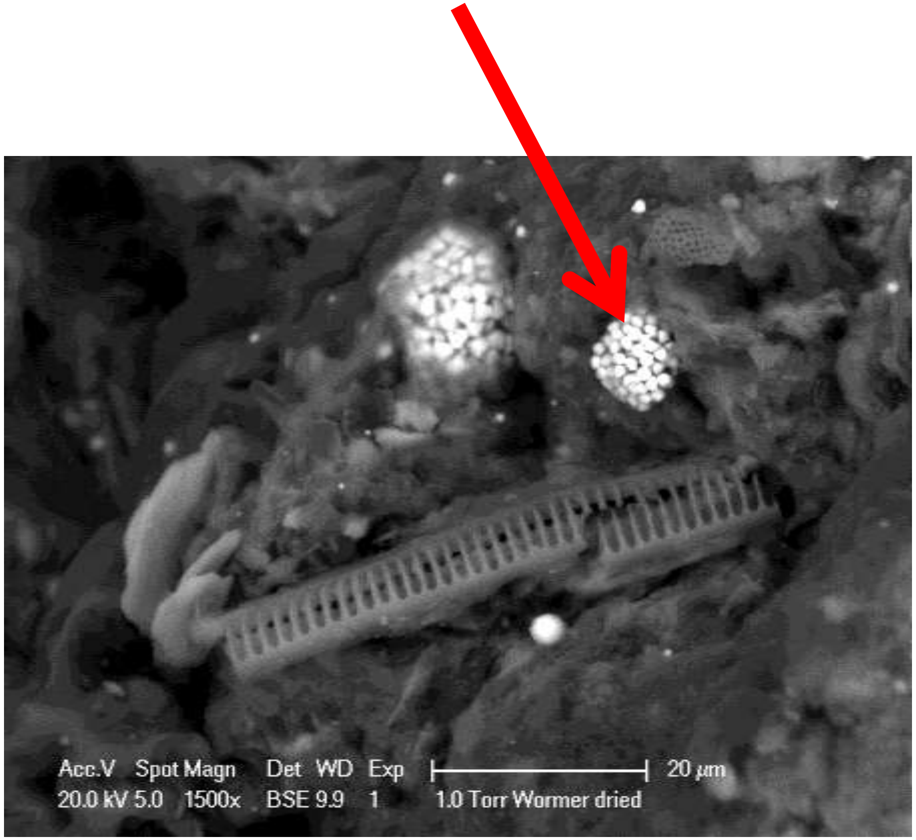
Elem	Wt%	At%
C	45.08	55.94
O	38.23	35.61
Si	**11.96**	**6.35**
Al	1.4	0.77
S	0.92	0.43
Ca	0.88	0.33
Fe	0.85	0.23
Mg	0.36	0.22
K	0.3	0.12



ESEM and EDAX analysis

Pyrite framboids

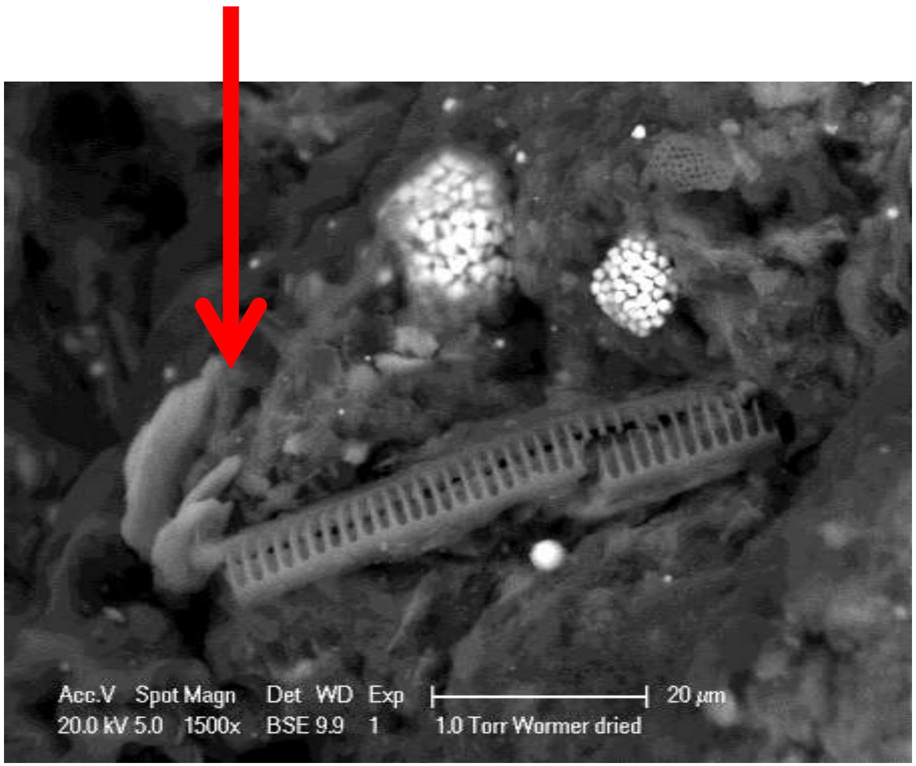
Elem	Wt%	At%
Fe	**28.89**	**11.44**
S	**28.53**	**19.68**
C	27.83	51.26
O	10.36	14.32
Si	2.54	2
Al	1.03	0.84
Ca	0.58	0.32
K	0.24	0.14



ESEM and EDAX analysis

Clay minerals

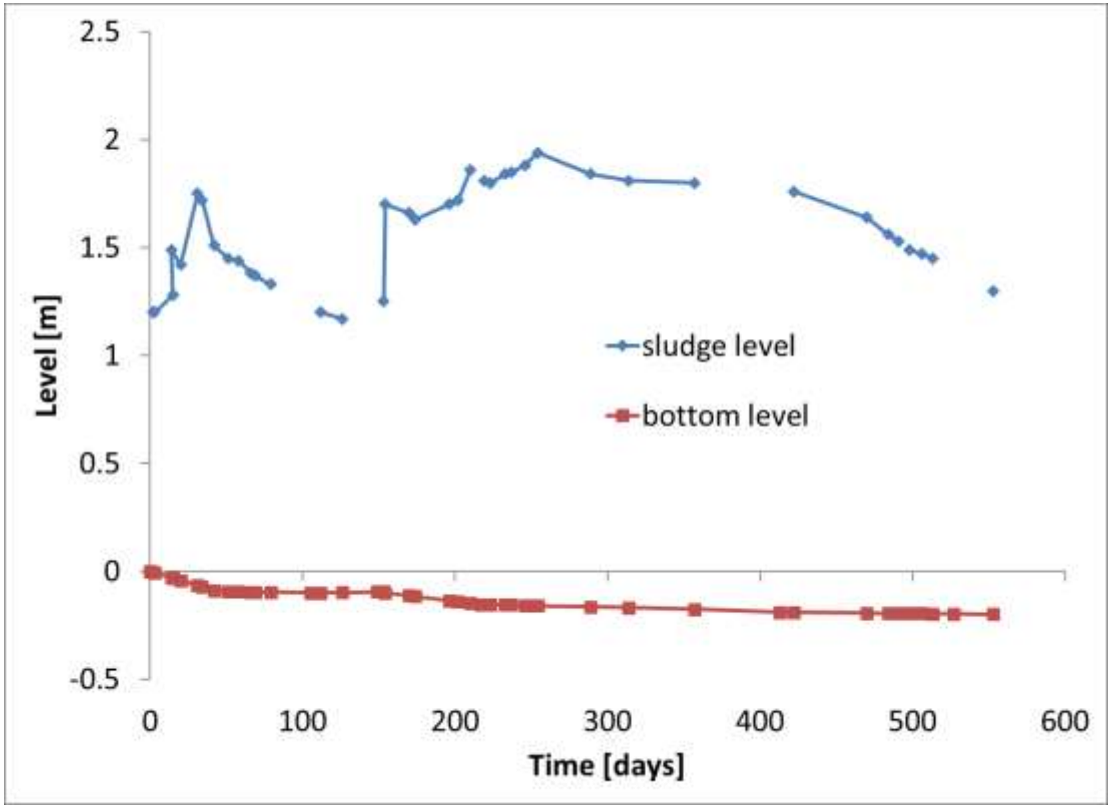
Elem	Wt%	At%
C	30.16	44.03
O	29.99	32.87
Si	**15.81**	**9.87**
Al	**11.21**	**7.28**
K	**5.83**	**2.62**
Fe	2.39	0.75
Ca	1.13	0.49



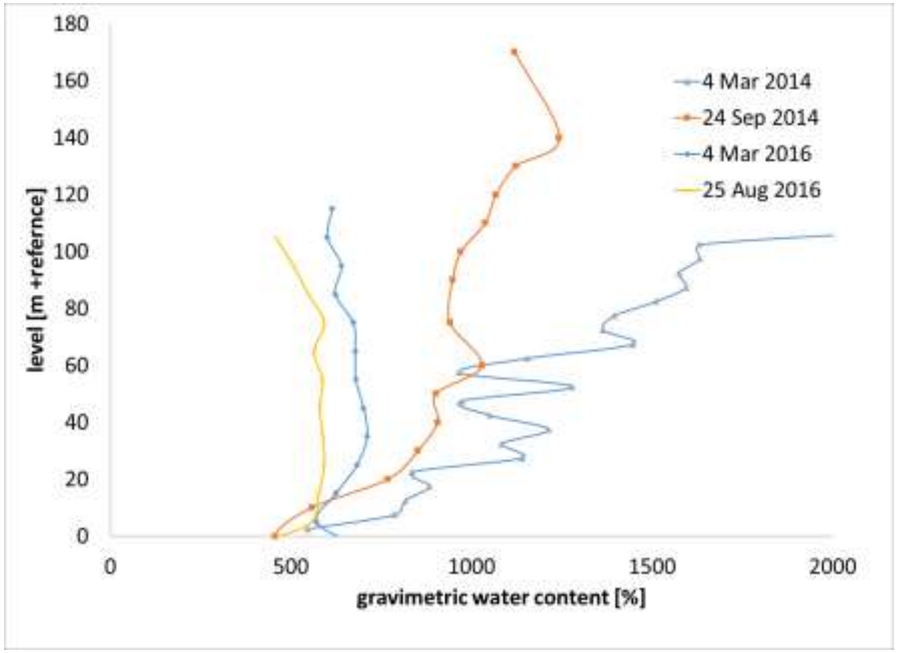
June 2014: first filling stage

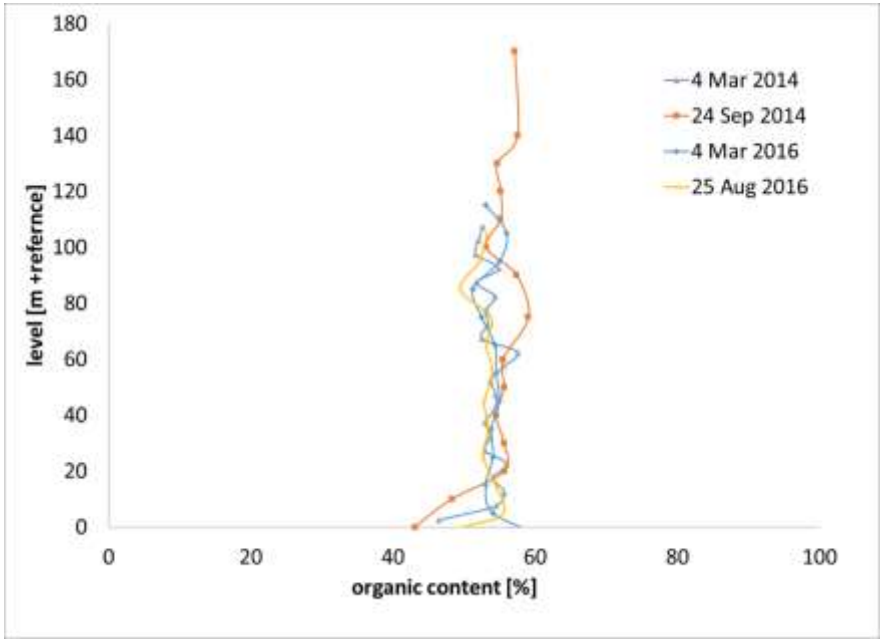
September 2015, Reed growth needs recultivation

Volume change and subsidence



Change in water and organic content





Laboatory concolidation experiments

- 1-Dimensional Consolidation Test

- Loading = 2, 5, 10, 20, 40, 80, 160 kPa
- Unloading = 40, 10, 2 kPa

- Test scenarios

1. No oxidation
2. In-situ chemical oxidation at 5 kPa ->10% Hydrogen Peroxide
3. Ex-situ oxidation prior to loading (fully oxidised)

- Results

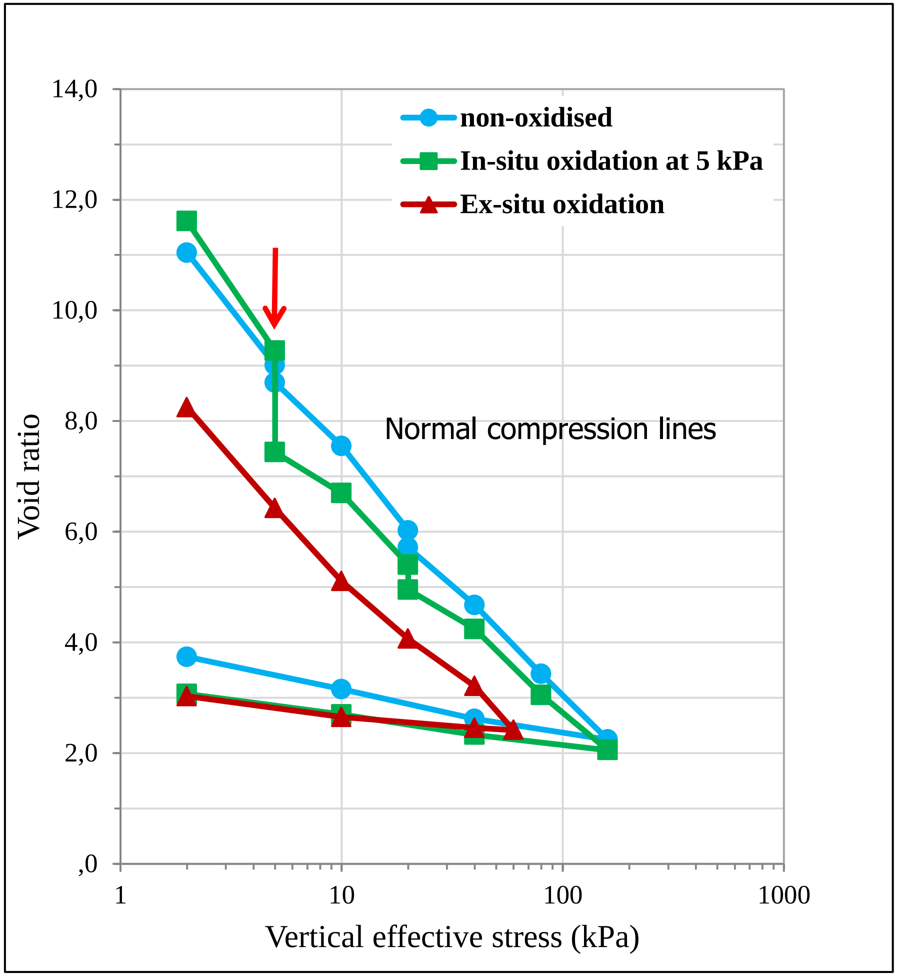
- Volumetric strain with time >> Final height for each pressure

Laboratory consolidation experiments

- During oxidation void ratio decreases but **does not reach** the normal compression line (NCL) of ex-situ oxidised sample

- Once oxidised, sample shows a relatively **stiff** response upon further loading, approaching the NCL of the non-oxidised sample.

- Upon unloading, the oxidised samples show much **lower swelling capacity**

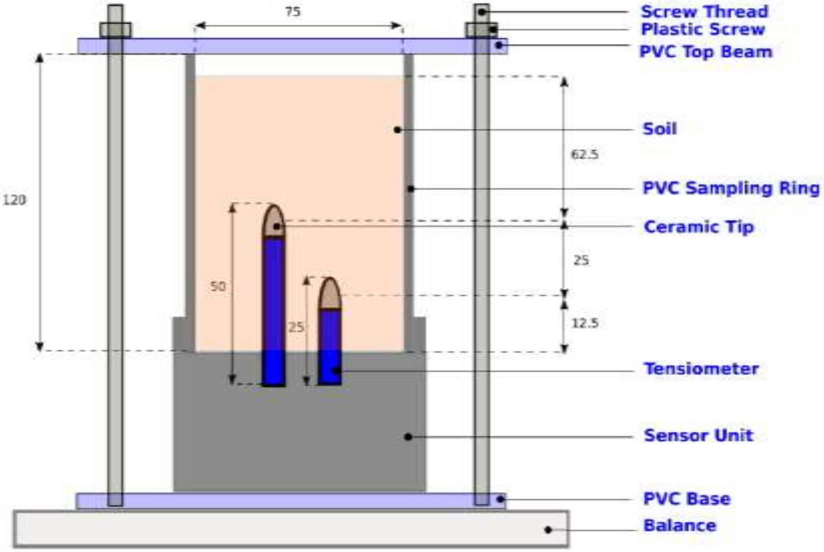


Laboratory Shrinkage tests

Using modified HYPROP set-up and CT-scanning to measure:

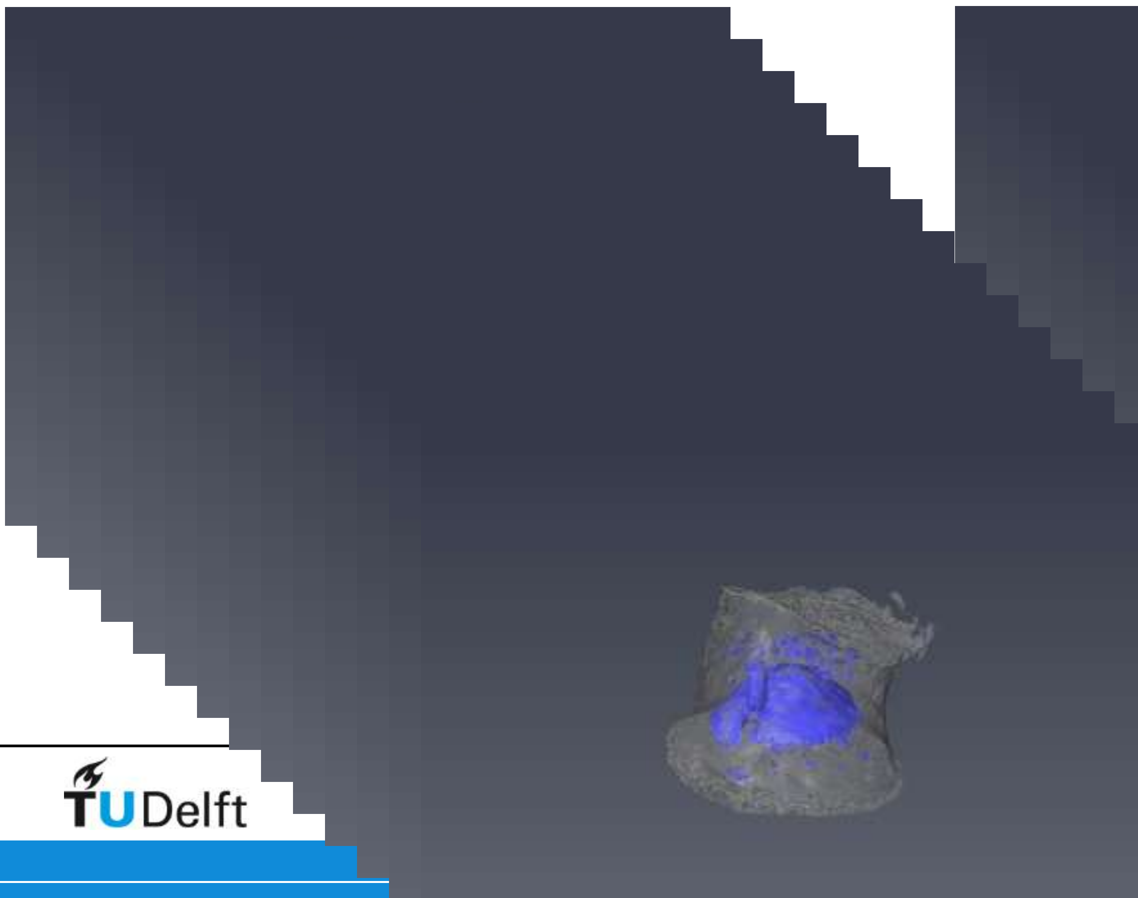
- Total volume
- Suction
- Water content
- Gas content

- Non-oxidized
- Oxidised (with H_2O_2)

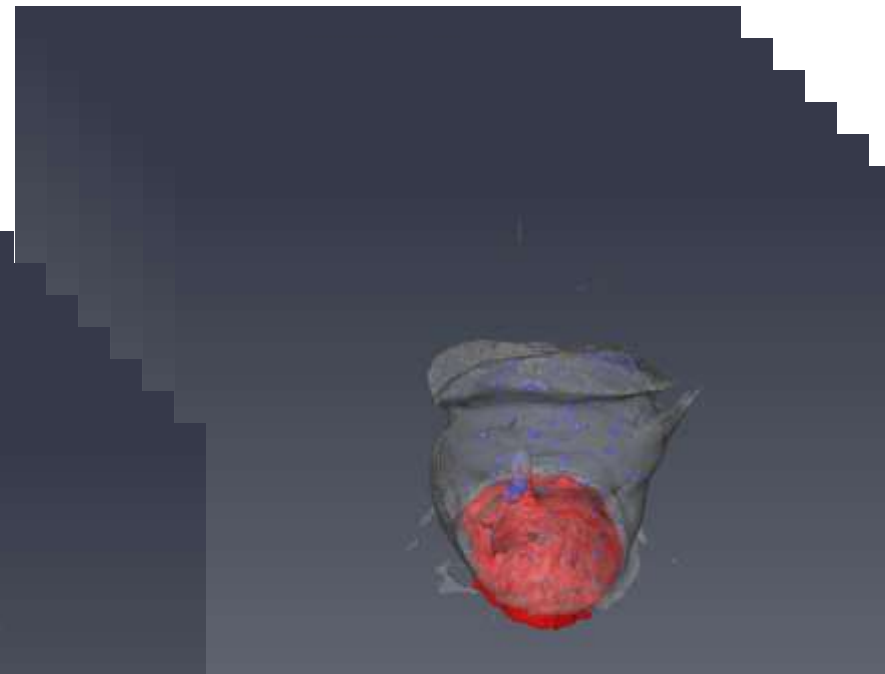


Laboratory Shrinkage tests

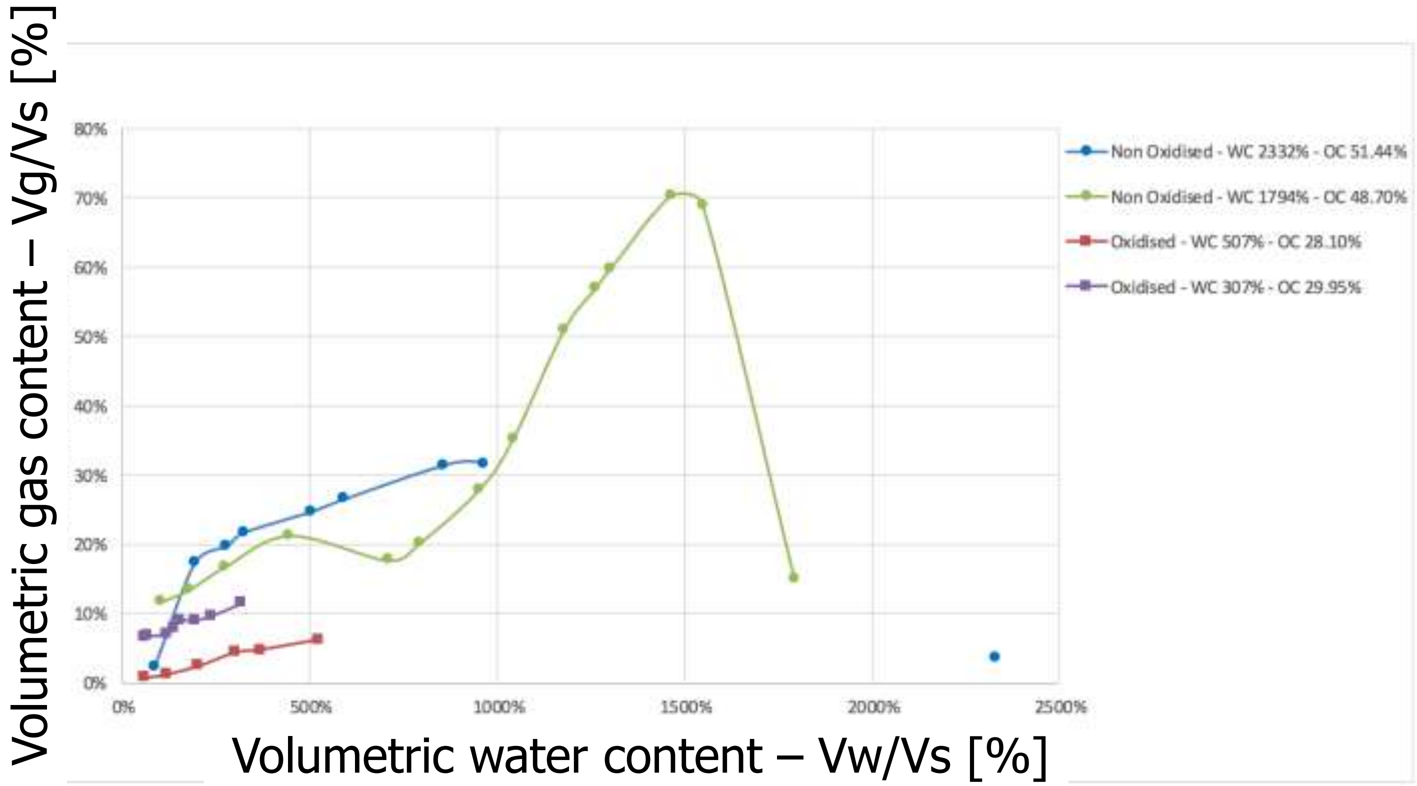
Non-oxidised t = 49; WC = 58%



Oxidised t = 19; WC = 31%



Laboratory Shrinkage tests



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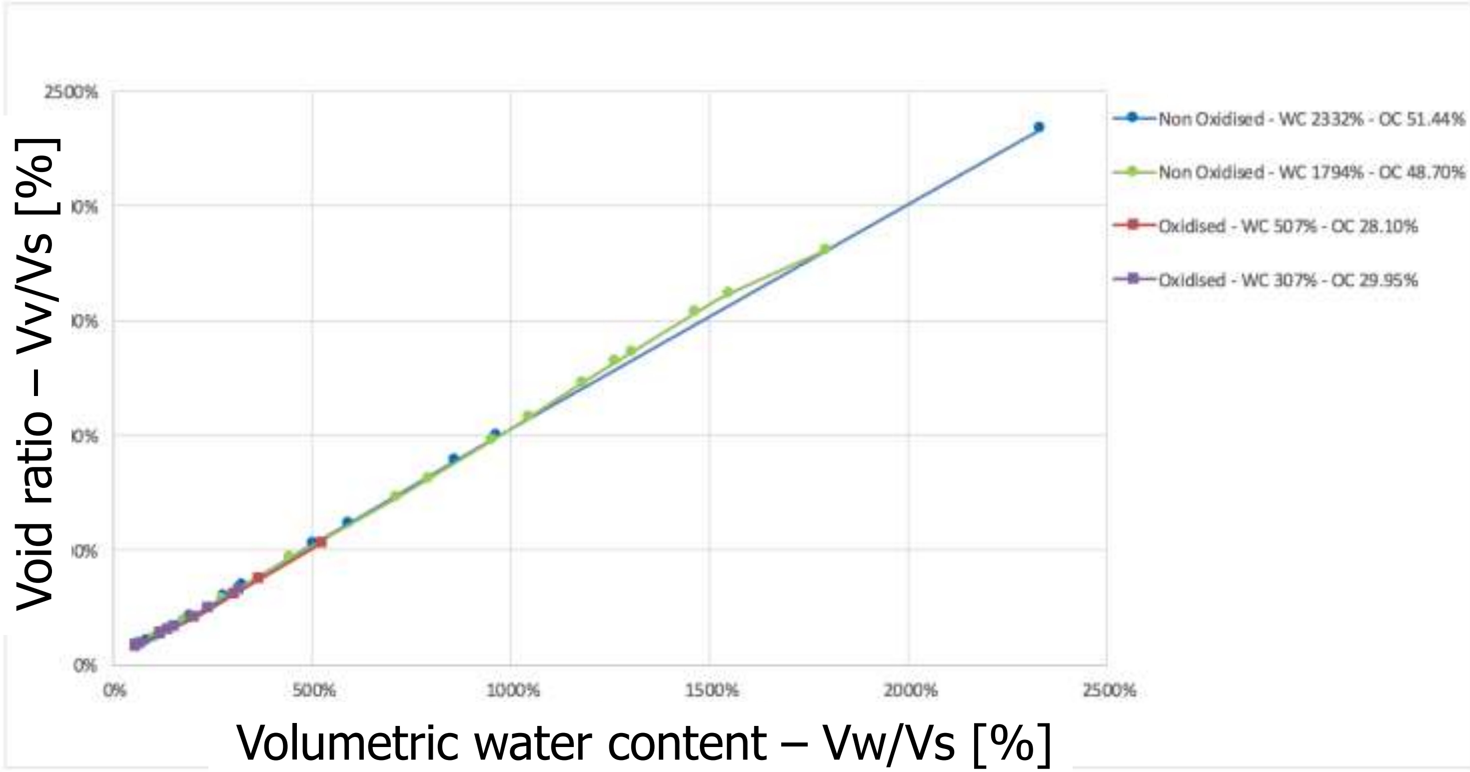

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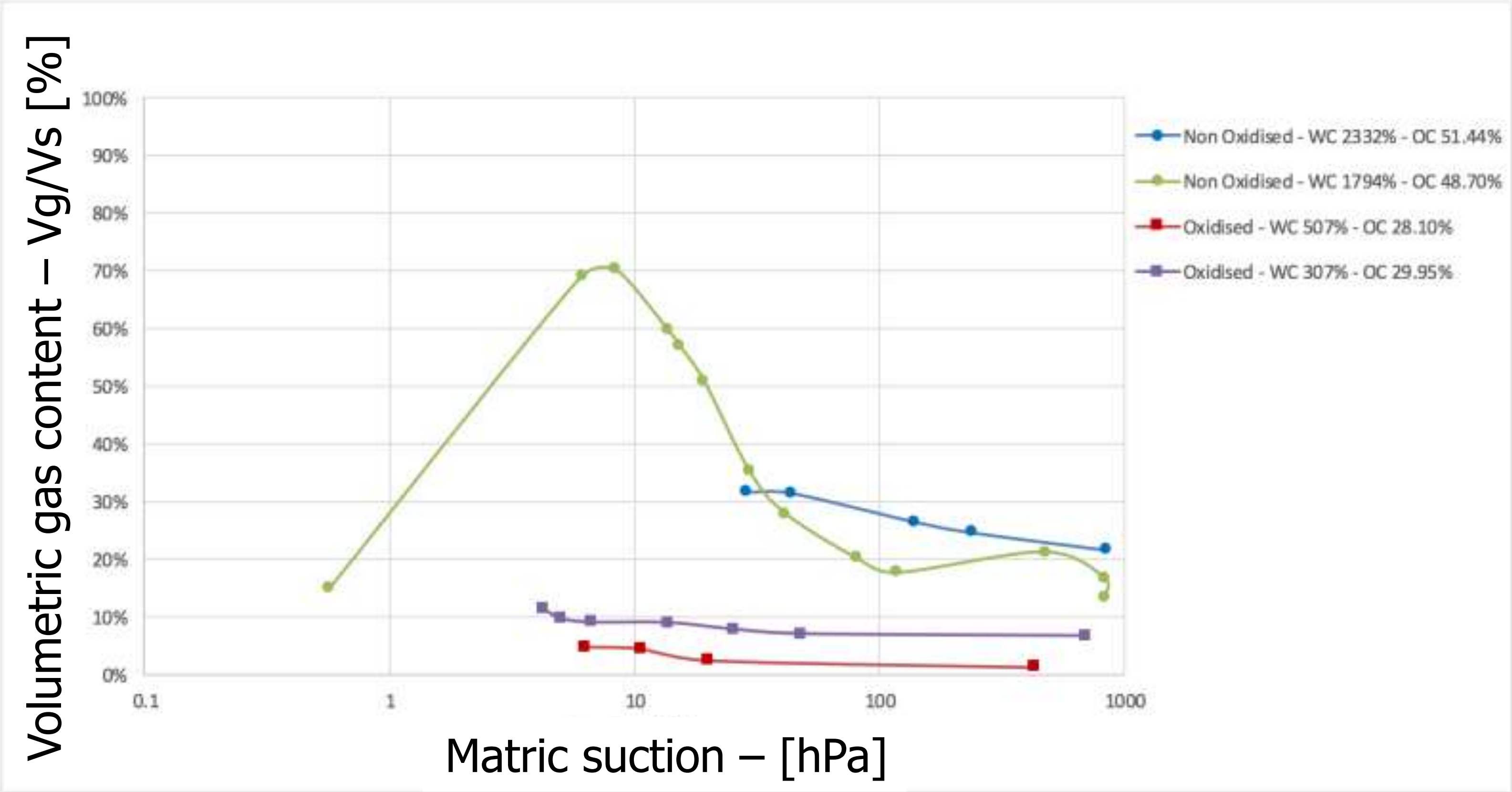

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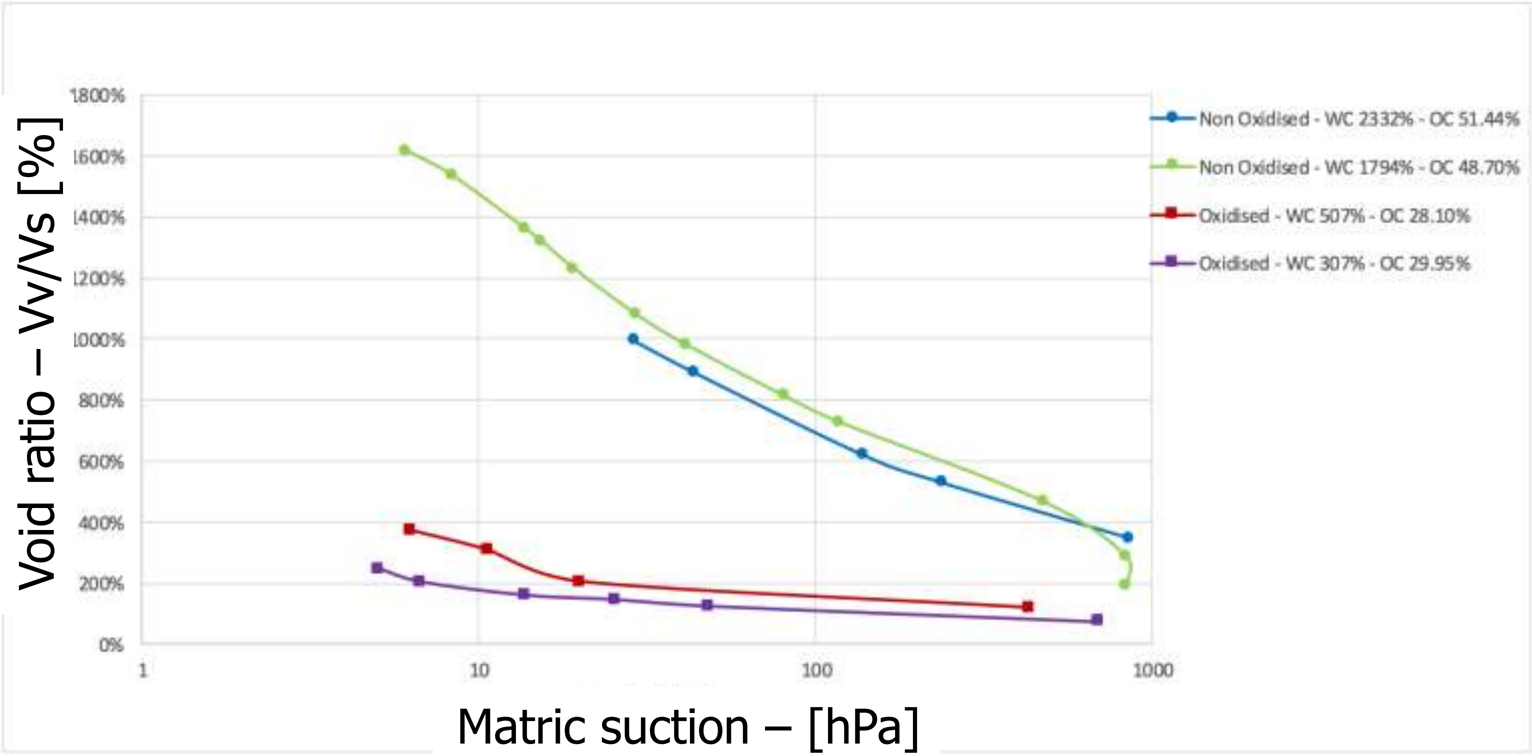


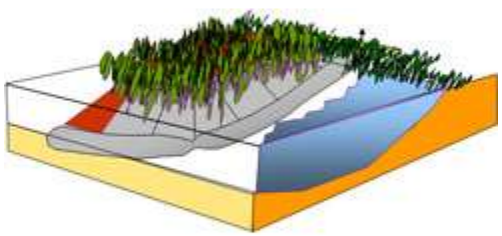
Conclusions

- Subsidence is mainly due to:
  - Shrinkage by downward drainage and evaporation
  - Oxidation in dredged sediments is negligible
- Subsidence is not directly correlated to oxidation of organic matter, but mostly a result of dewatering
- On land storage leads to compaction of underlying strata
- Oxidation weakens soil structure, reduces water retention capacity and swelling capacity

Alternative developments

- Underwater storage of dredged sediments using

sediment storer



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