Lime Treatment of Soils
Hydraulic Earthworks Application

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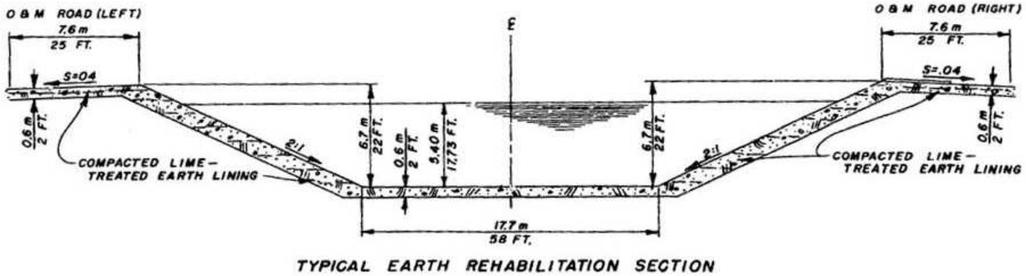
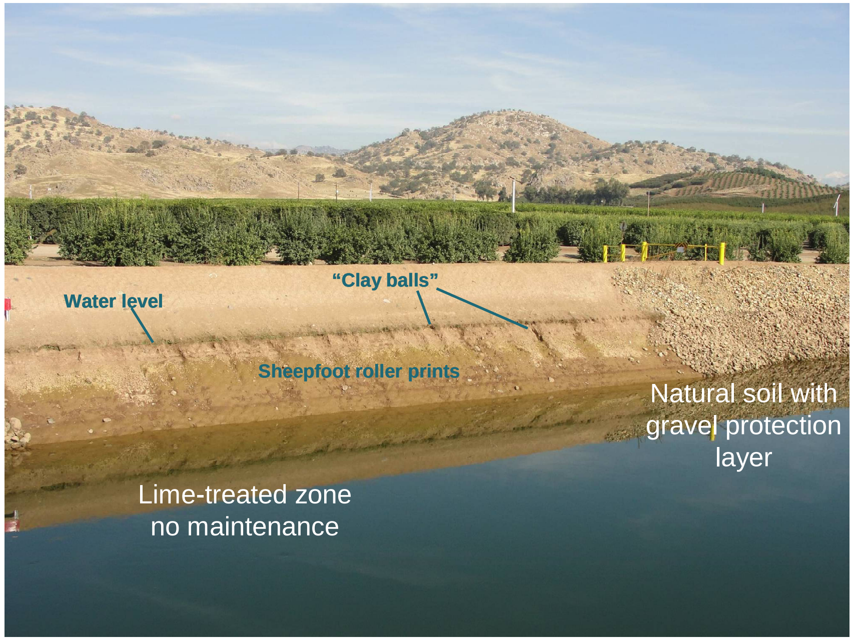
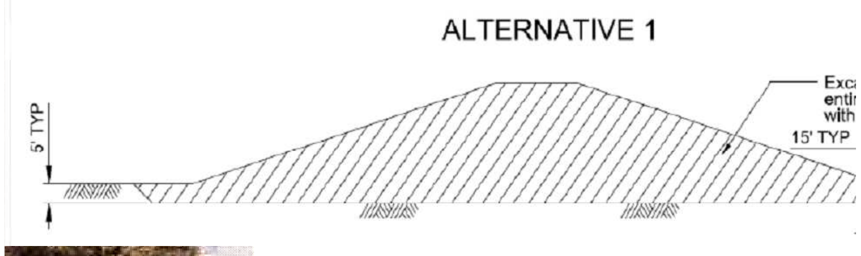
Examples

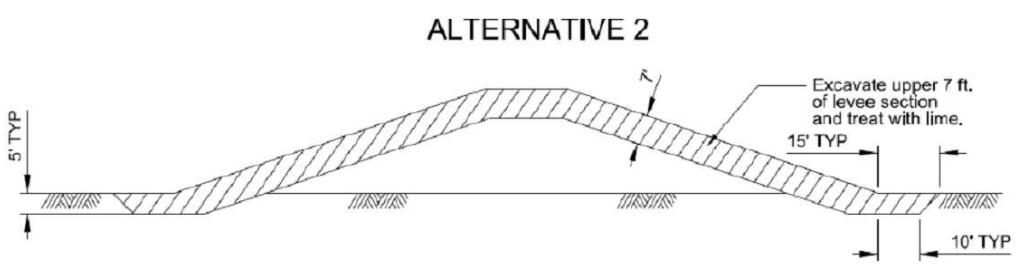
- ♦ **Friant-Kern Irrigation canal**
  - **Built in 1946, 240 km long**
  - **Canal discharge rate : 100 m³/s**
  - **Speed of 1,3 m/s**
  - **6,4 km of blankets treated with 4% lime between 1972 and 77**
  - **Highly plastic clays : PI ~ 40**





- ♦ **Mississipi dikes : « Alton to Gale » (350 km)**





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Lhoist

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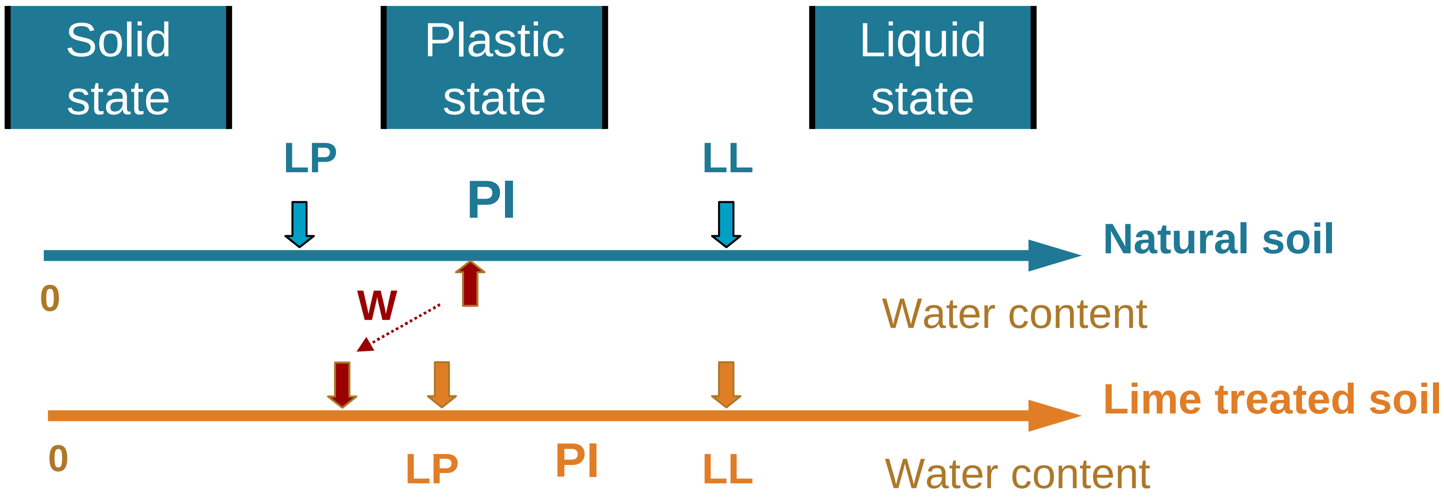
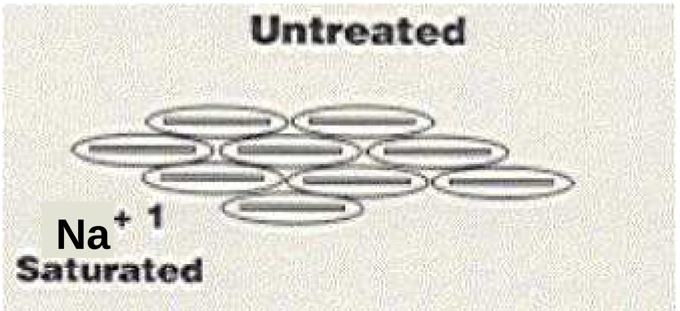
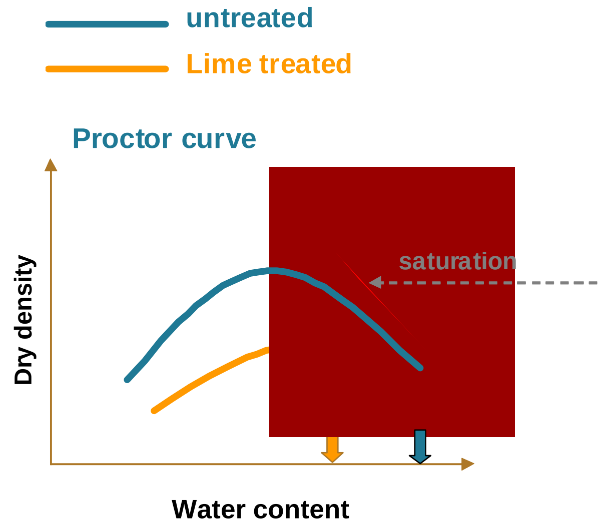
Action of lime : soil improvement by clay flocculation

Immediate improvement of workability :
Wet silty or clayey soils can be treated and used in embankments





- **Well-known benefits of lime treatment**
  - Placement of materials : workability, bearing index
  - Increase of cohesion and mechanical properties
  - Reduction of swelling-shrinkage of clayey soils
  - Displacement of shrinkage limit above OMC



- **State of the art in 2005**
  - Is lime treatment of soils relevant for earthfill hydraulic structures ?
  - **Negative approach : "Density will decrease, therefore porosity and permeability will rise up ??"**
  - Only a few data published
  - Lhoist have launched a research program on treated soils permeability

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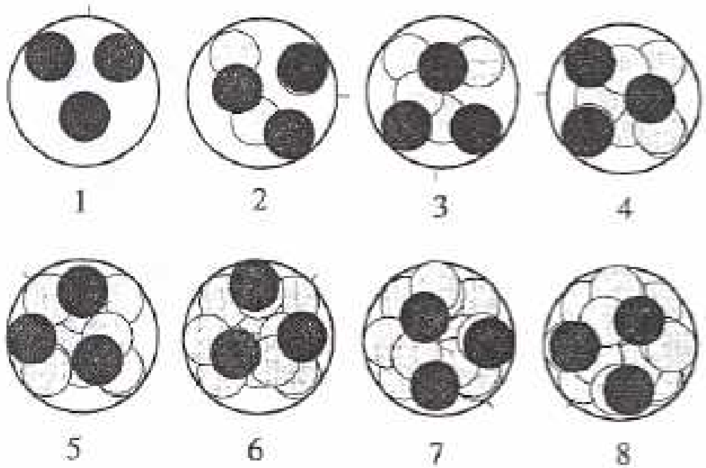
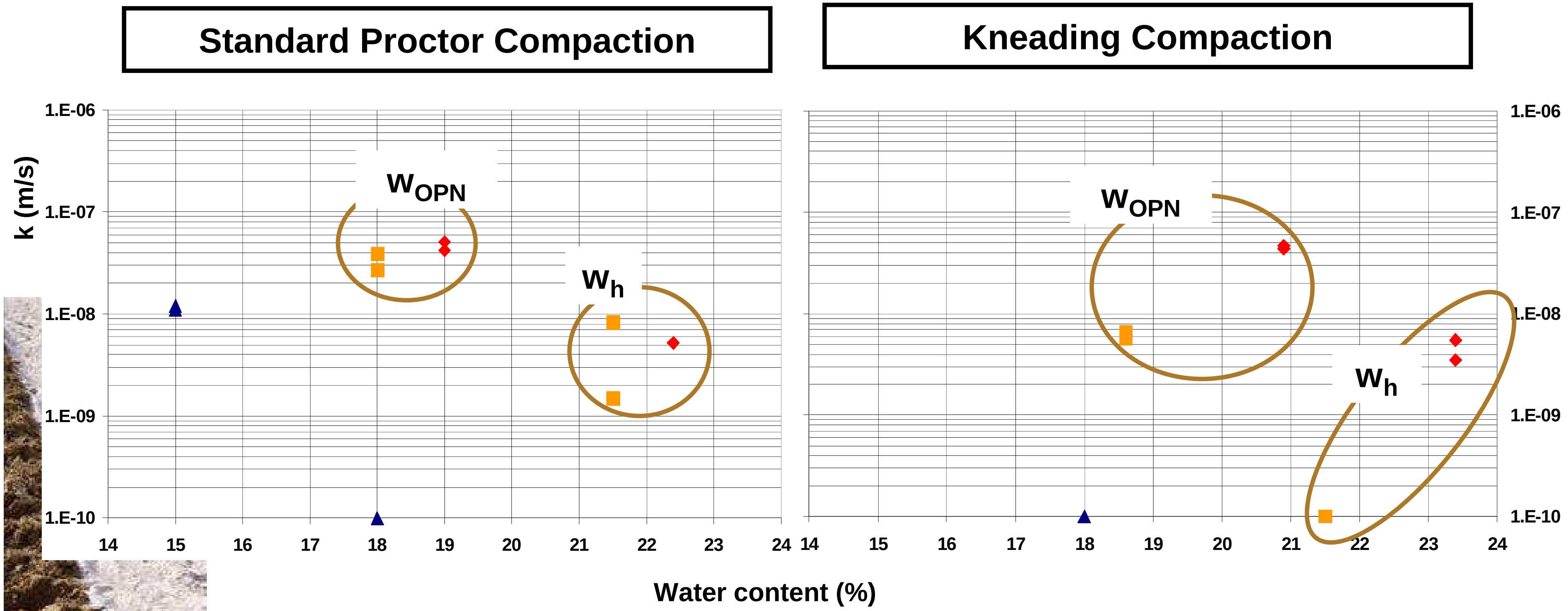
Kneading Compaction Procedure

Figure 14. Outil de pétrissage à 3 pieds.



Measurements of permeability coefficients (k)

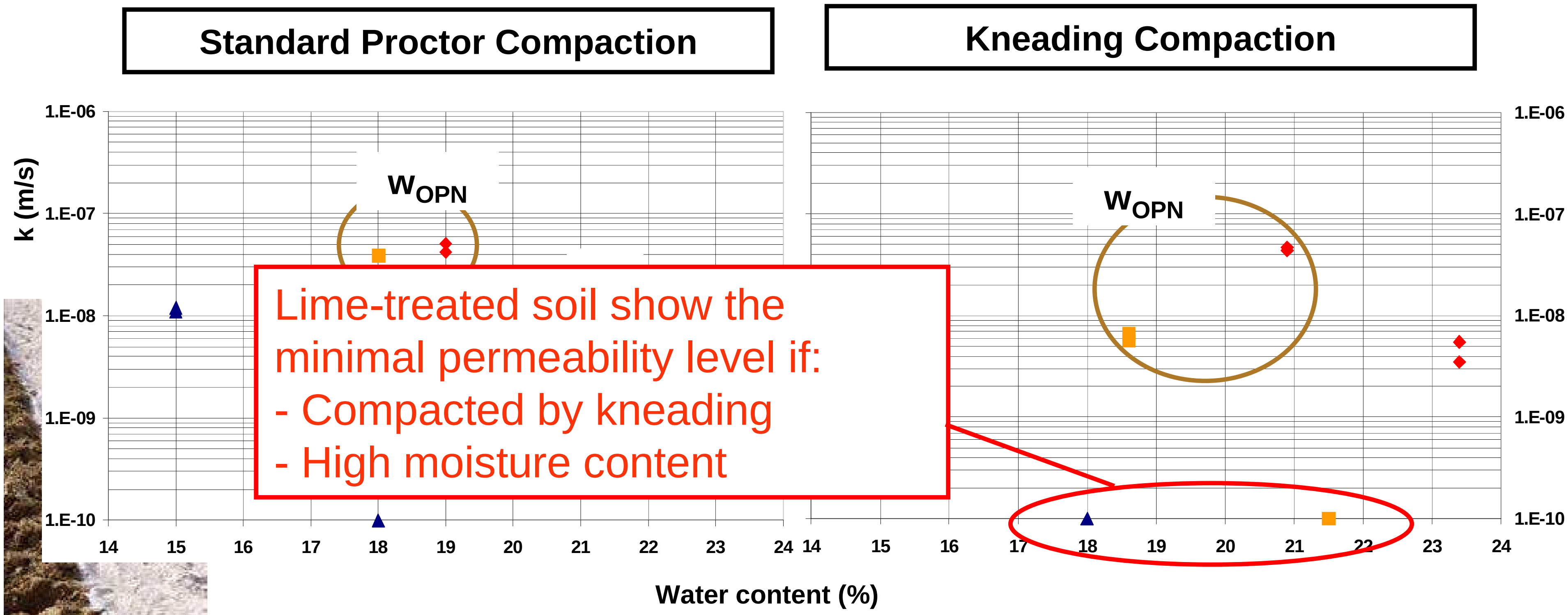


▲ Untreated – no lime

■ 2 % quicklime

◆ 3% quiklime

Measurements of permeability coefficients (k)



Permeability

Why density and permeability are not correlated ?

- ♦ **Voids size distribution in the soils**
  - Mercury Porosimetry at Laboratoire Central des Ponts et Chaussées (Nantes, France) (now IFSTTAR)

Untreated soil

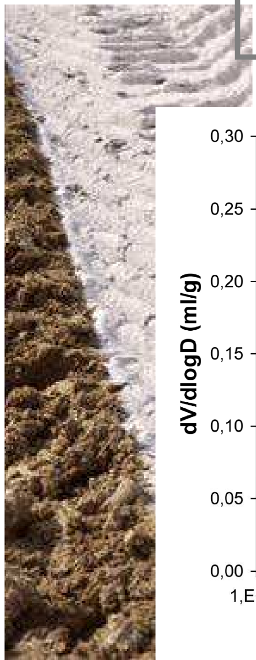
•pores ~1µm and ~10µm (Proctor + OMC)

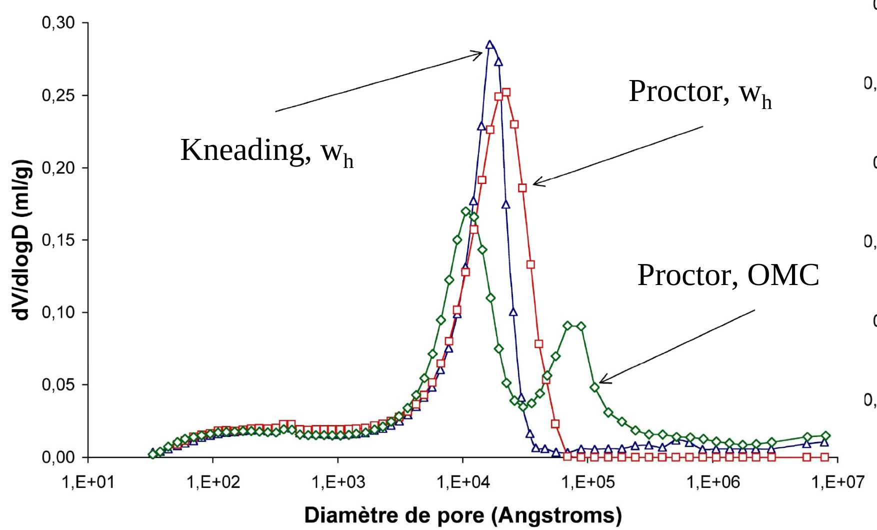
•pores ~1µm (Proctor+ Humid or kneading + Humid)

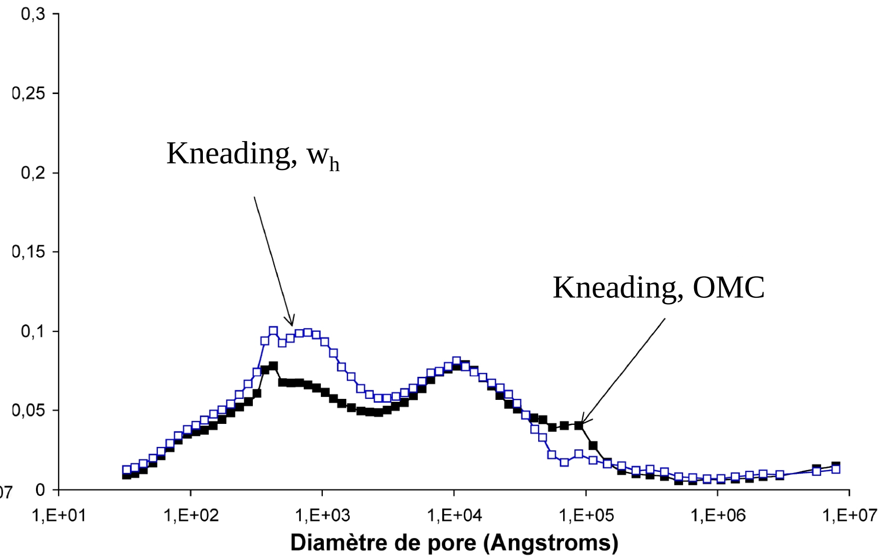
With lime

•pores ~0.1µm / ~1µm / ~10µm (Kneading+OMC)

•pores ~0.1µm / ~1µm (Kneading + Humid)

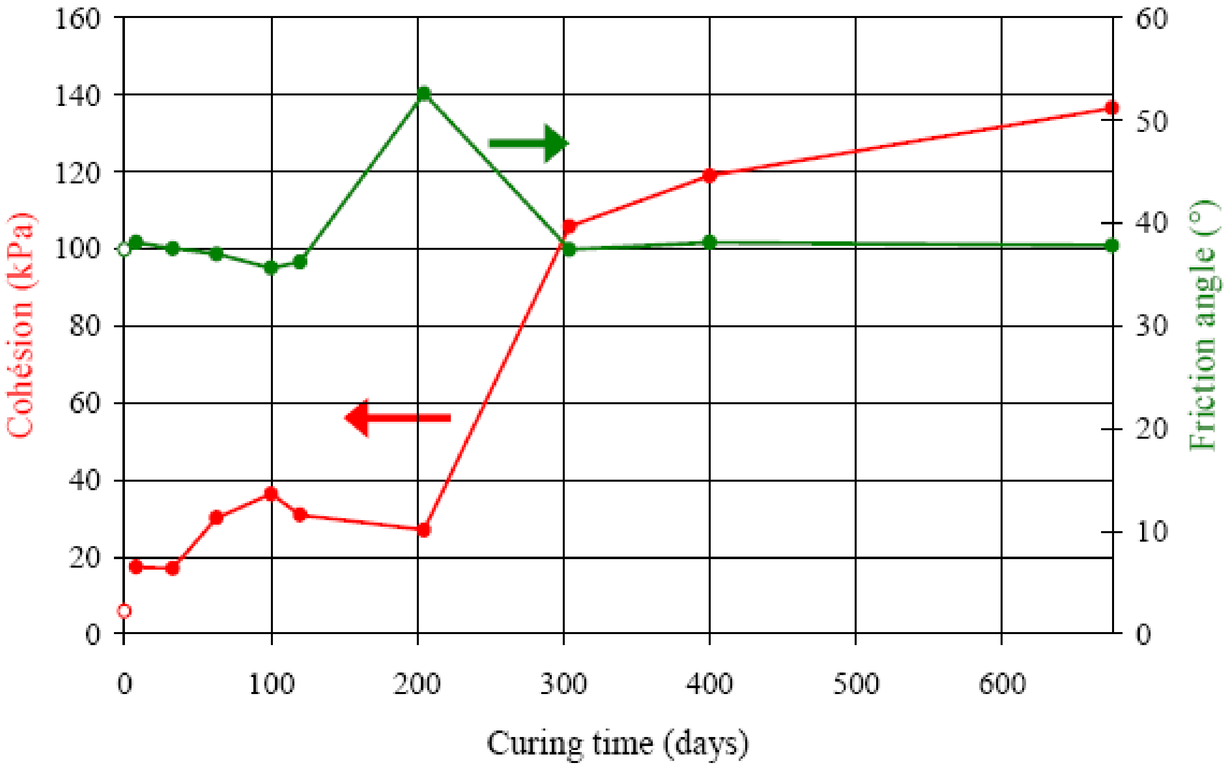






Additional Results : mechanical Stability

- **Triaxial tests on silts (IP = 11)**
  - Results from Univ. Libre Bruxelles / Cogestac project
  - Friction angle unchanged
  - Cohesion highly improved



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Erosion resistance

- **Trials at IRSTEA (ex-Cemagref) and IFSTTAR**

$$\dot{\varepsilon} = \kappa_d .(\tau - \tau_c)$$

Amount of eroded soil = erosion rate x (water pressure – critical stress)

Internal erosion

Hole Erosion Test

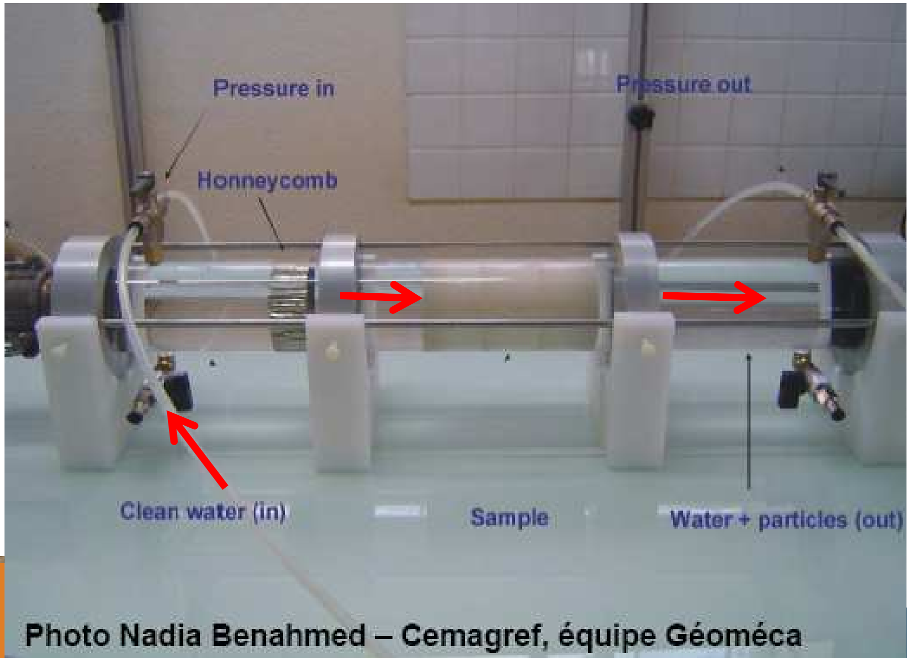


Photo Nadia Benahmed – Cemagref, équipe Géoméca

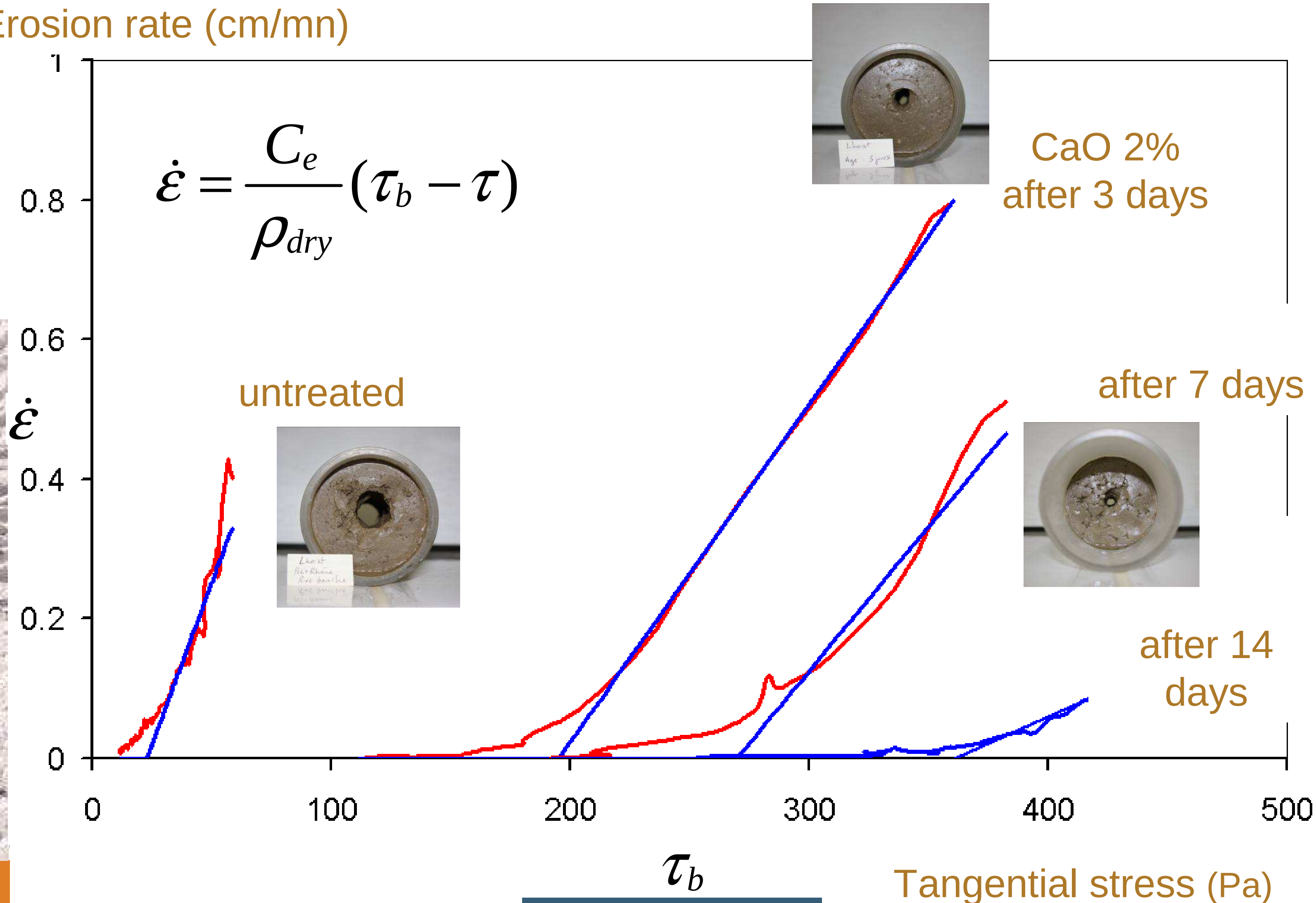
External erosion

Jet Test


Photo Géoconsult

Internal erosion : results

Tests from IRSTEA (2011) – Clayey silt from the Rhône River, IP = 11



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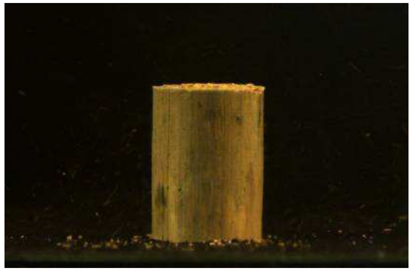
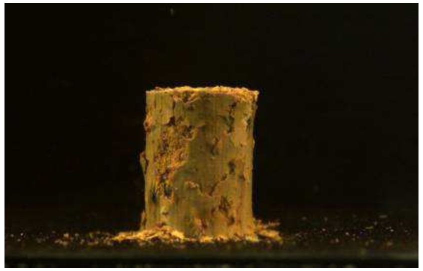
Enhanced Crumb-test trials from IFSTTAR (2011)

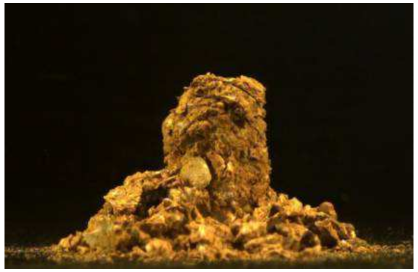
- silt PI= 11 untreated (90d)



Initial state



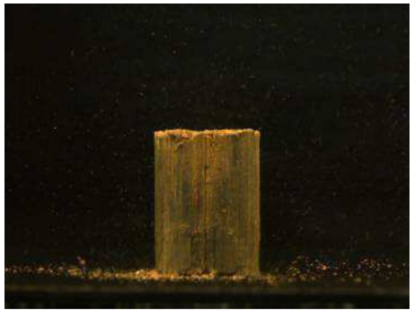
5 min



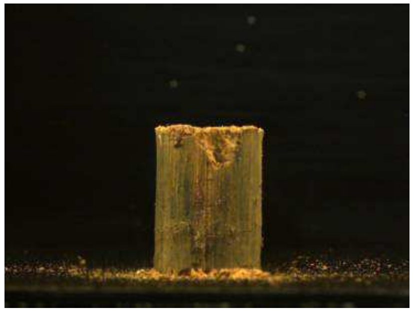
15 min

45 min

- silt treated with 2% lime (90d)

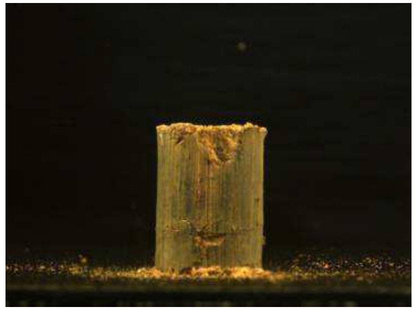


Initial state



5 **hours**

15 **hours**



45 **hours**

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- Soil treatment with lime, context of the research
- Properties for a use in hydraulic earthen structures
- Conclusions
- Companion presentations

Conclusions and Perspectives

- **Lime treatment of soils confers**
  - An enhanced workability (known from geotechnique)
  - A permeability level close to initial permeability
    - If kneading compaction (sheepfoot rollers) and humid state of materials applied
  - An improved mechanical stability
  - An improved resistance against internal and external erosion
  - A displacement of the shrinkage limit
  - A good chemical stability
  - A possible revegetalization

- **Jobs examples show the durability of this technique in hydraulic environment**
  - Friant-Kern Canal
  - Other works : examination in progress

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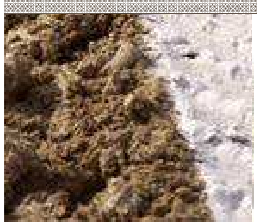
Fig. 8a Sheepsfoot imprints after 10 months

- **The 35-years old experience from Friant-Kern canal**
  - Gontran Herrier, Lhoist Group
  - Friday August 31, 14h10, room Esquillan

- **Experimental dike in lime-treated soil**
  - Isabelle Charles, CER / CETE Normandy
  - Friday August 31, 10h54, room C3

Lime Treatment :
A new solution with new perspectives for silty to plastic soils in hydraulic earthworks



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