Effect of the shape of diatomaceous species on the macroscopic behaviour of soils, GRENOBLE 21/11/2019

EFFECT OF THE SHAPE OF DIATOMACEOUS SPECIES ON THE MACROSCOPIC BEHAVIOUR OF SOILS

LABORATOIRE 3SR

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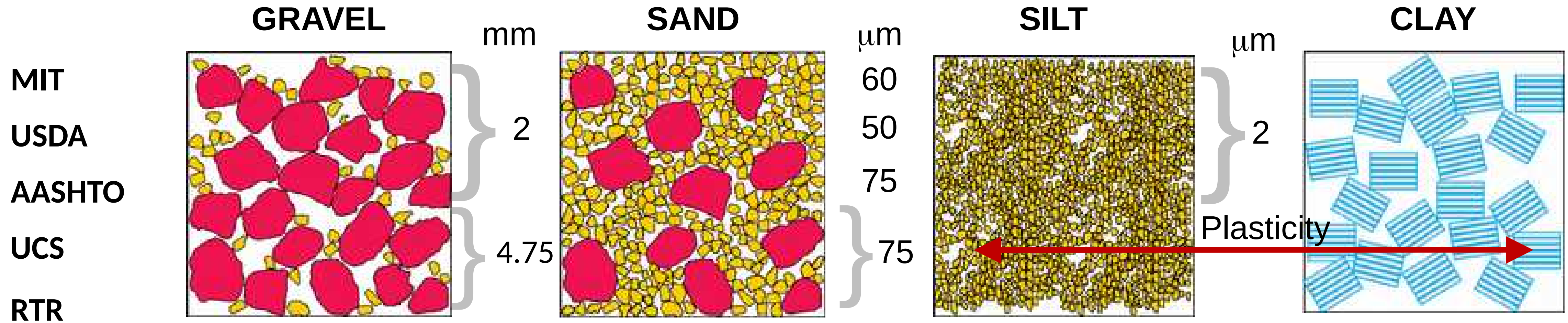
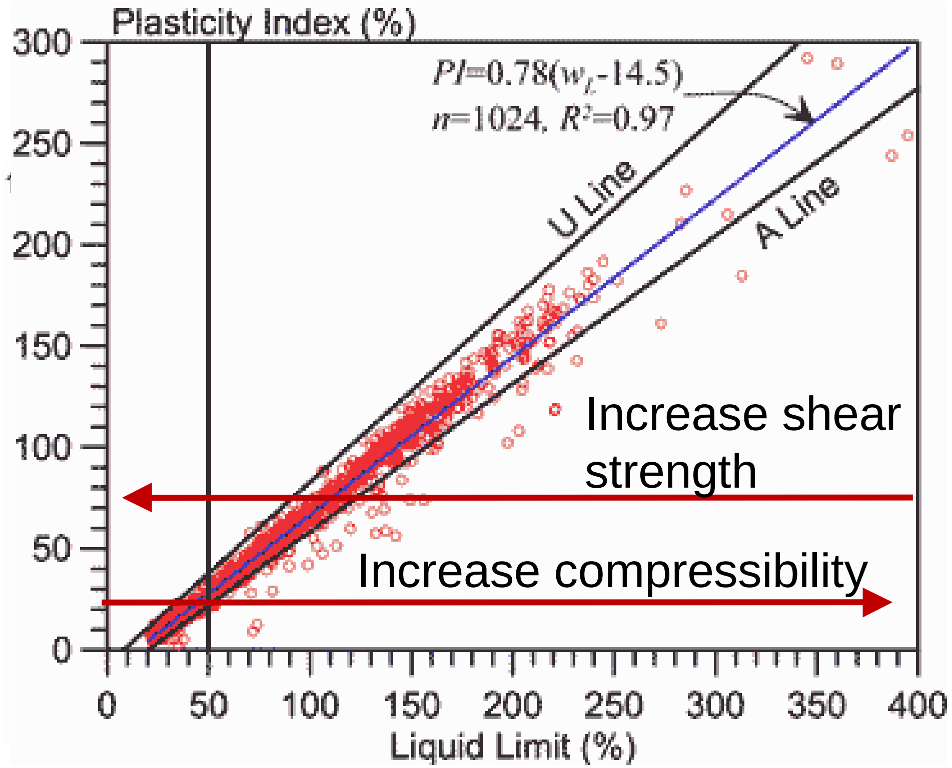
WATH WE LEARN IN TEXT BOOKS





- **MIT :** Massachusetts Institute of Technology (MIT)
- **USDA :** US Department of agriculture (USDA)
- **AASHTO :** American Association of State Highway and Transportation Officials (AASHTO)
- **UCS :** Unified Classification System (U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, America Society for testing materials ASTM
- **RTR :** French Classification for Road's Works RTR

MEXICO CITY

1911

2000

BOGOTÁ CITY

Bogotá City
regional subsidence
2 to 7 cm/year

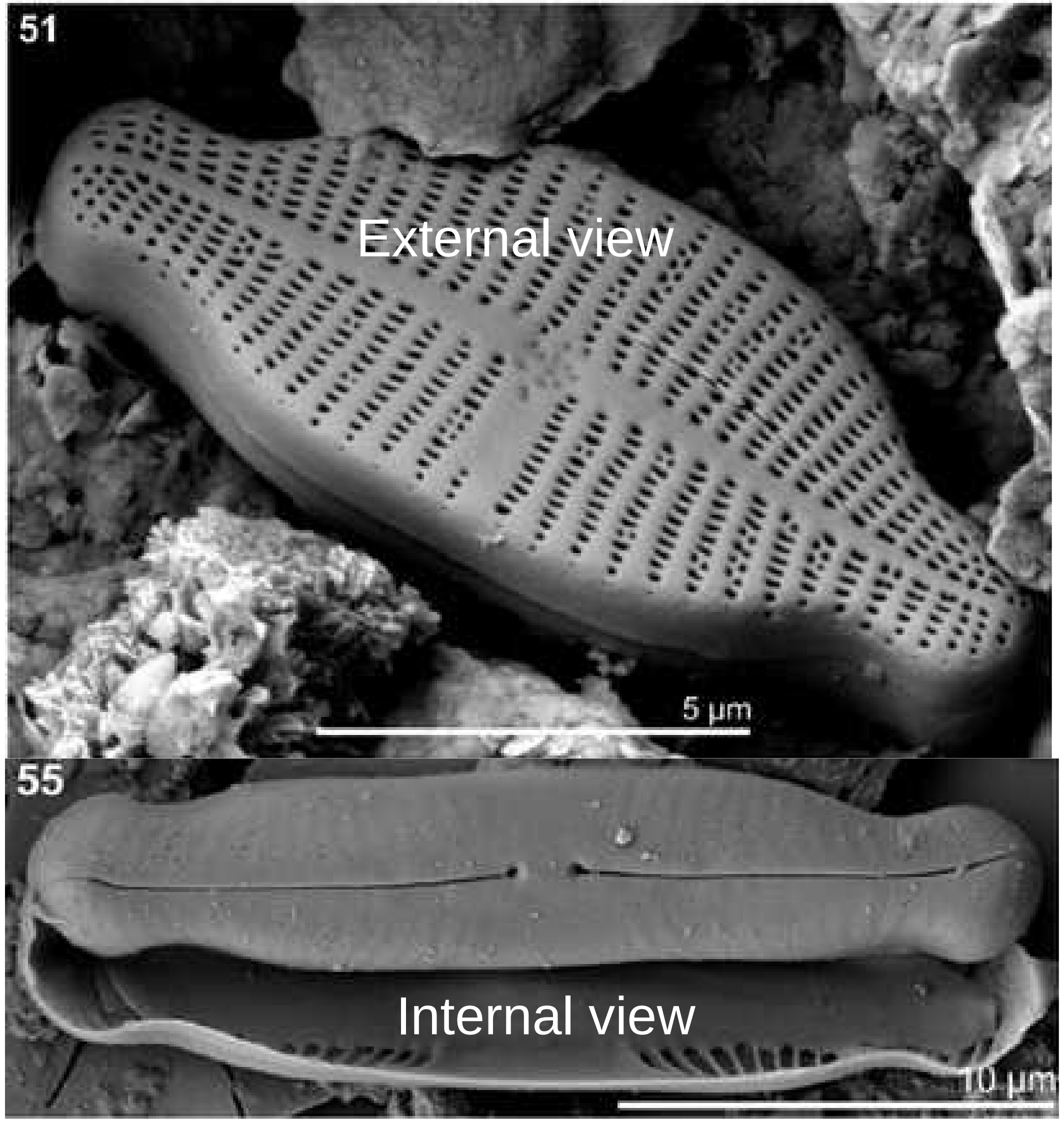
Tomado de:
http://portfolios.uniandes.edu.co/gallery/53479301/CC UA-Teoria_Arquitectura-Critica-Arq-Bogotana_201620

The origin of the soil's deposits of most of these cities is lacustrine or marine

From: https://www.jdsupra.com/post/contentViewerEmbed.aspx?fid=9396b19e-928a-489f-85d1-87ba5e68c5fc

DIATOMS

- Diatoms are single-celled algae with cell walls composed of transparent, opaline silica.
- Diatom cell walls have intricate patterns of silica.
- Nearly all diatoms are microscopic - cells range in size from 2 µm to 500 µm.
- Diatoms are the most diverse protists on earth. Estimates of the number of diatom species range from 20,000 - 2 million. Scientists are discovering new species every year.
- Diatoms are so successful because silica walls are more energetically efficient than carbonate biominerals.
- Are not sensitive to pH.
- Traces of diatoms was detected in deposits of 185 millions of years and diatoms have been unstoppable since them.



Guiseppina et al. (2019)

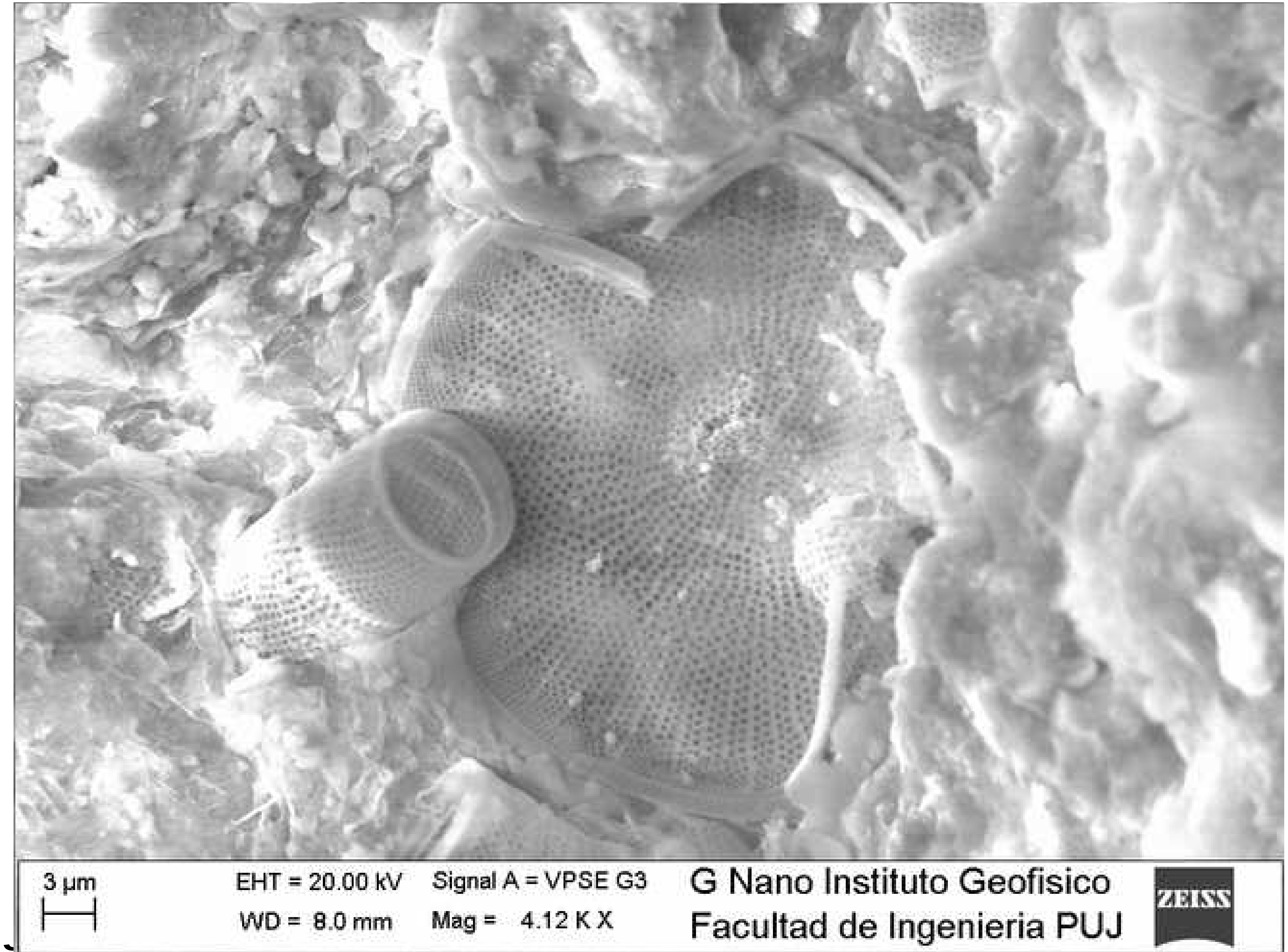
DIATOMS

- Diatoms feed the oceans, lakes and rivers.
- The silica cell walls of diatoms are inorganic, so they do not decompose.
- When diatoms die, they sink to the bottom of the wetland or lake or ocean.
- The glass cell walls can be preserved over long periods of time, up to tens of millions of years.
- Diatoms are not true fossils, because the cell walls are not *fossilized*, or replaced by another mineral.
- The silica cell walls accumulate in the bottom of lakes and oceans.

DIATOMS COMMERCIAL USES

- Diatomaceous earth, or diatomite, is composed by the silica cell walls of diatoms.
- Diatomites are commercially mined for many uses:
- Diatomite is a crucial component of dynamite: Alfred Nobel, discovered that nitroglycerin was more stable if it was mixed in diatomite.
- Diatomite is used in filtration for
  - swimming pools
  - fish tanks
  - and for beer and wine.
- Diatomite is a non-toxic powder used as an insecticide: the diatom silica absorbs oils from the waxy outer exoskelton of pests, causing pests to become dehydrated and die.

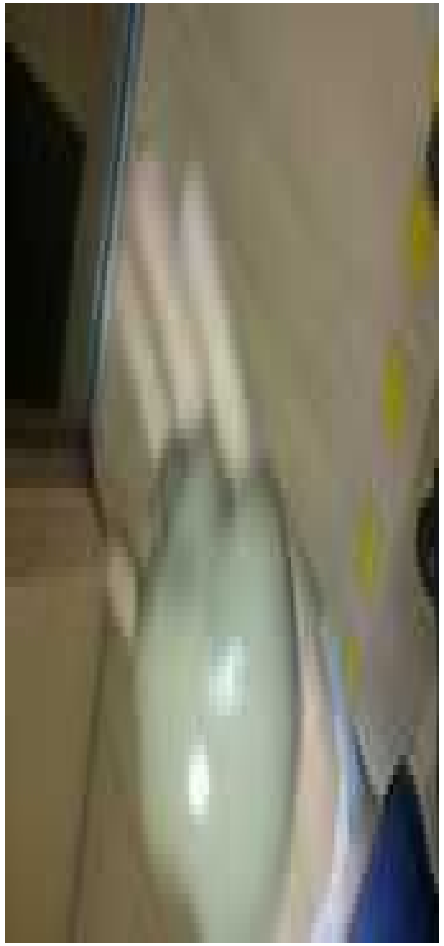
DIATOMS IN SOILS

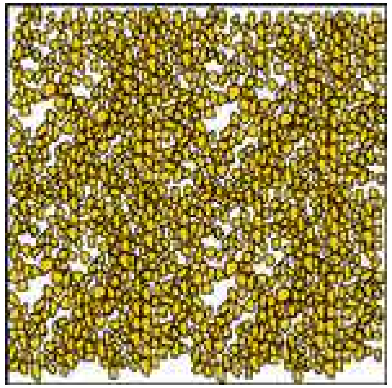


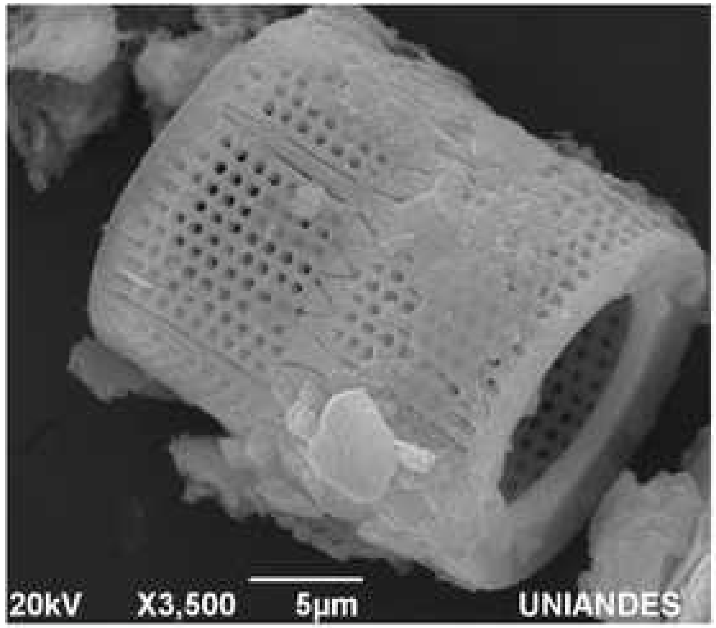
DIATOMS WITH WATER

Size > 2 μm

SILT



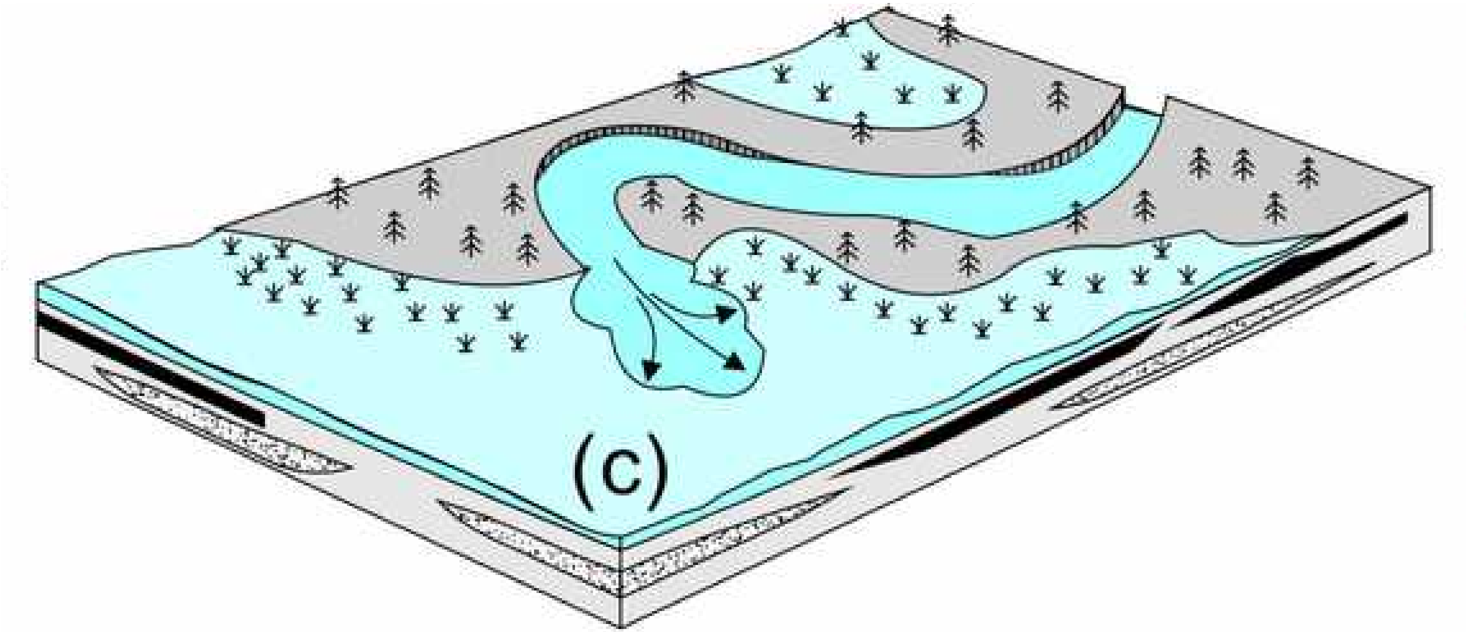




Aulacoseira Granulata

DIATOMS
IN NATURAL SOILS
CASE STUDY OF BOGOTÁ

BOGOTÁ DEPOSIT



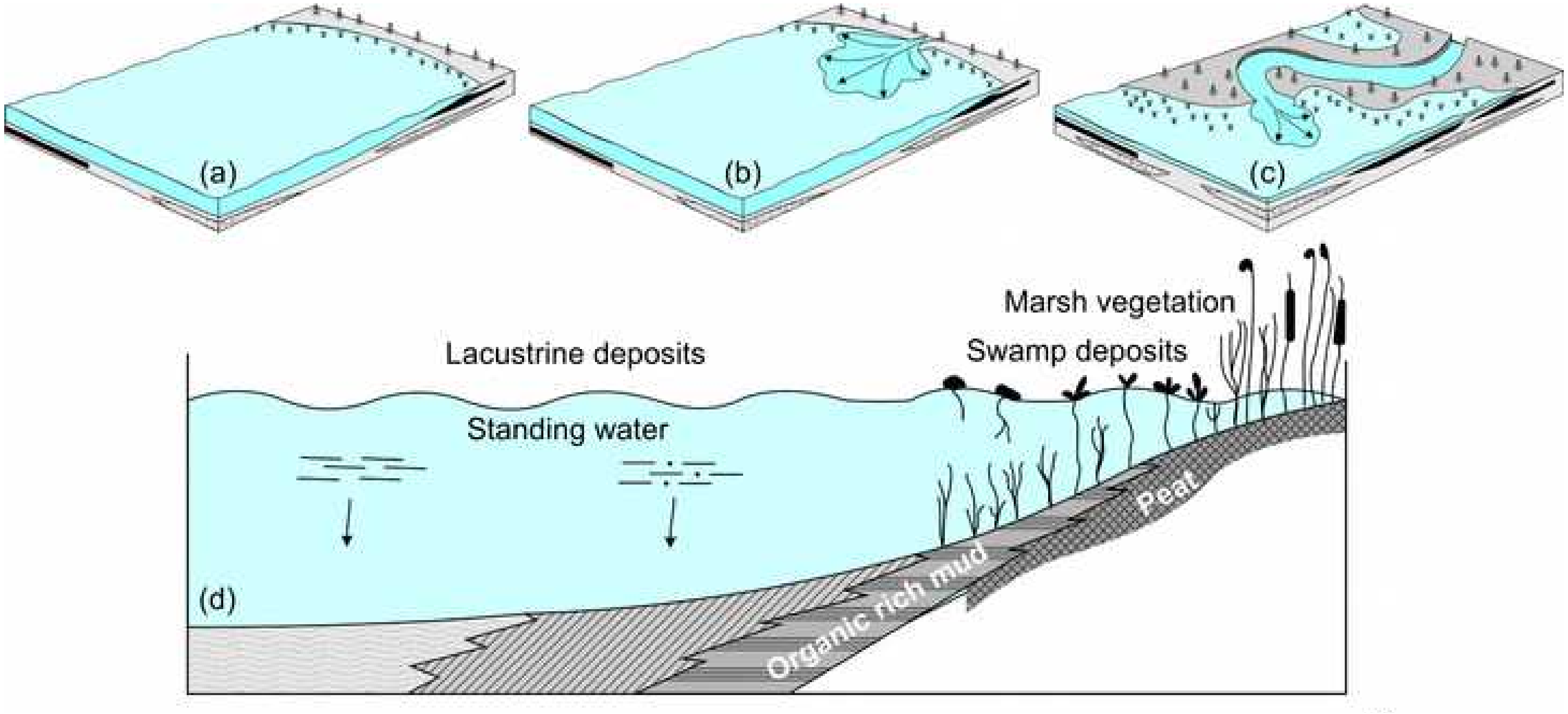
An environmental reconstruction of the sediment infill of the Bogotá basin (Colombia) during the last 3 million years from abiotic and biotic proxies

Vladimir Torres, Jef Vandenberghe, Henry Hooghiemstra

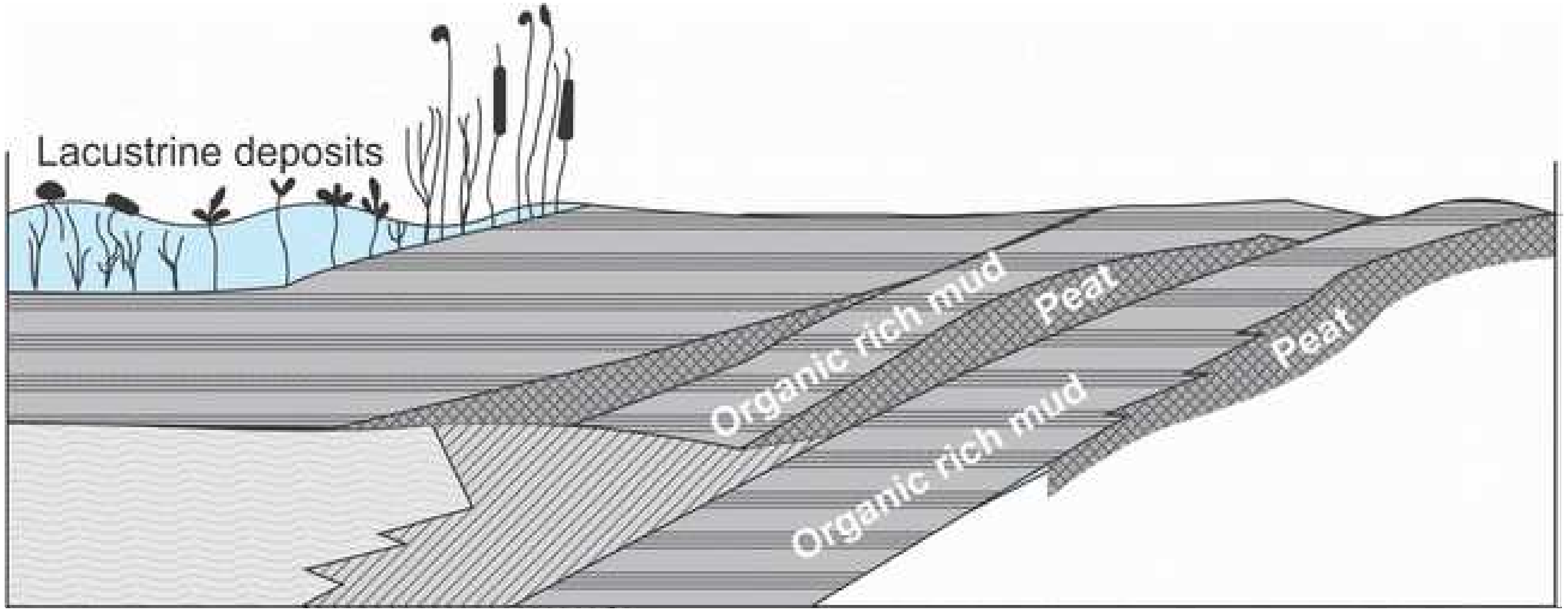
Palaeogeography, Palaeoclimatology, Palaeoecology

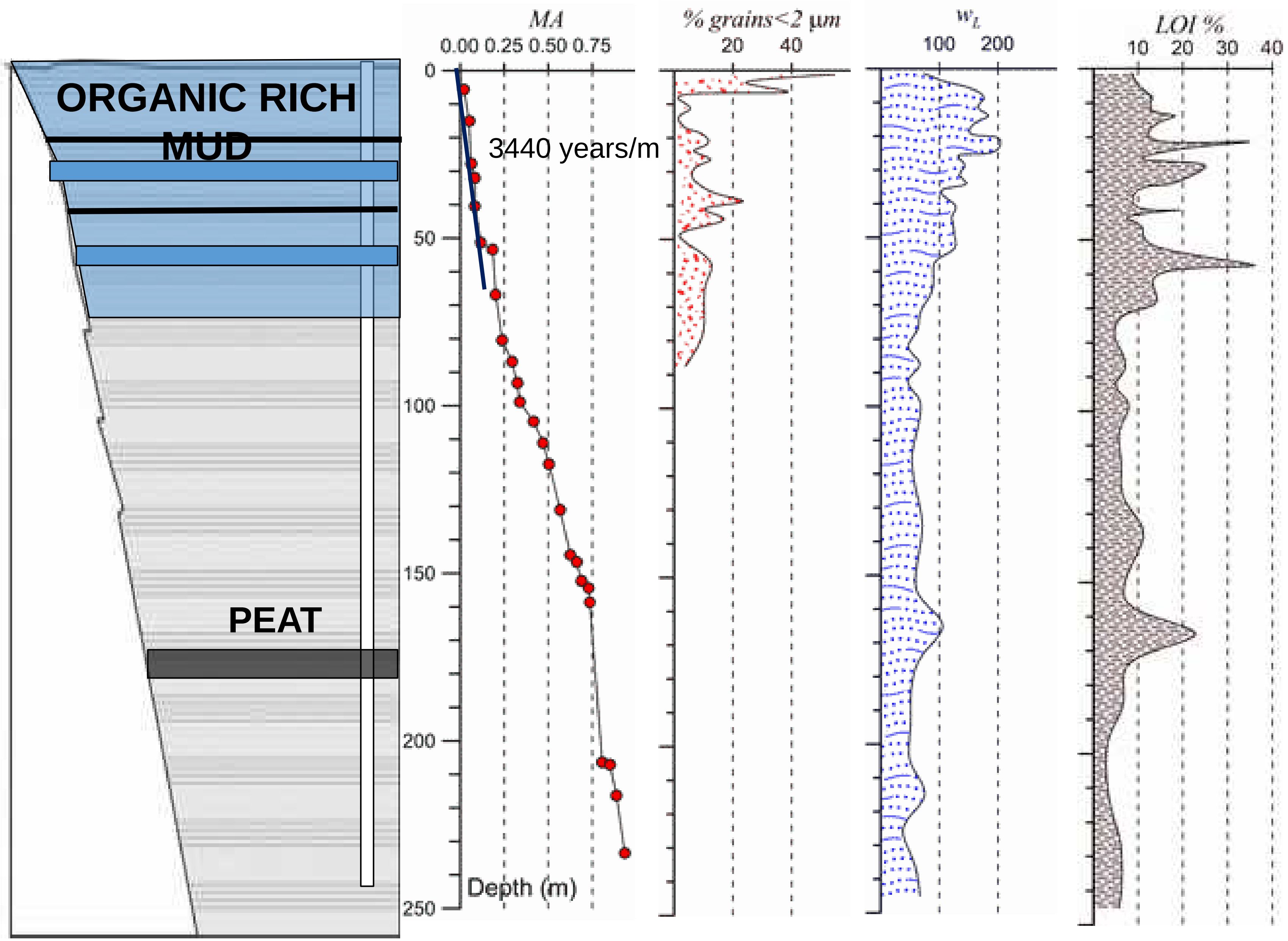
Volume 226, Issues 1–2, 3 October 2005, Pages 127-148

BOGOTÁ DEPOSIT



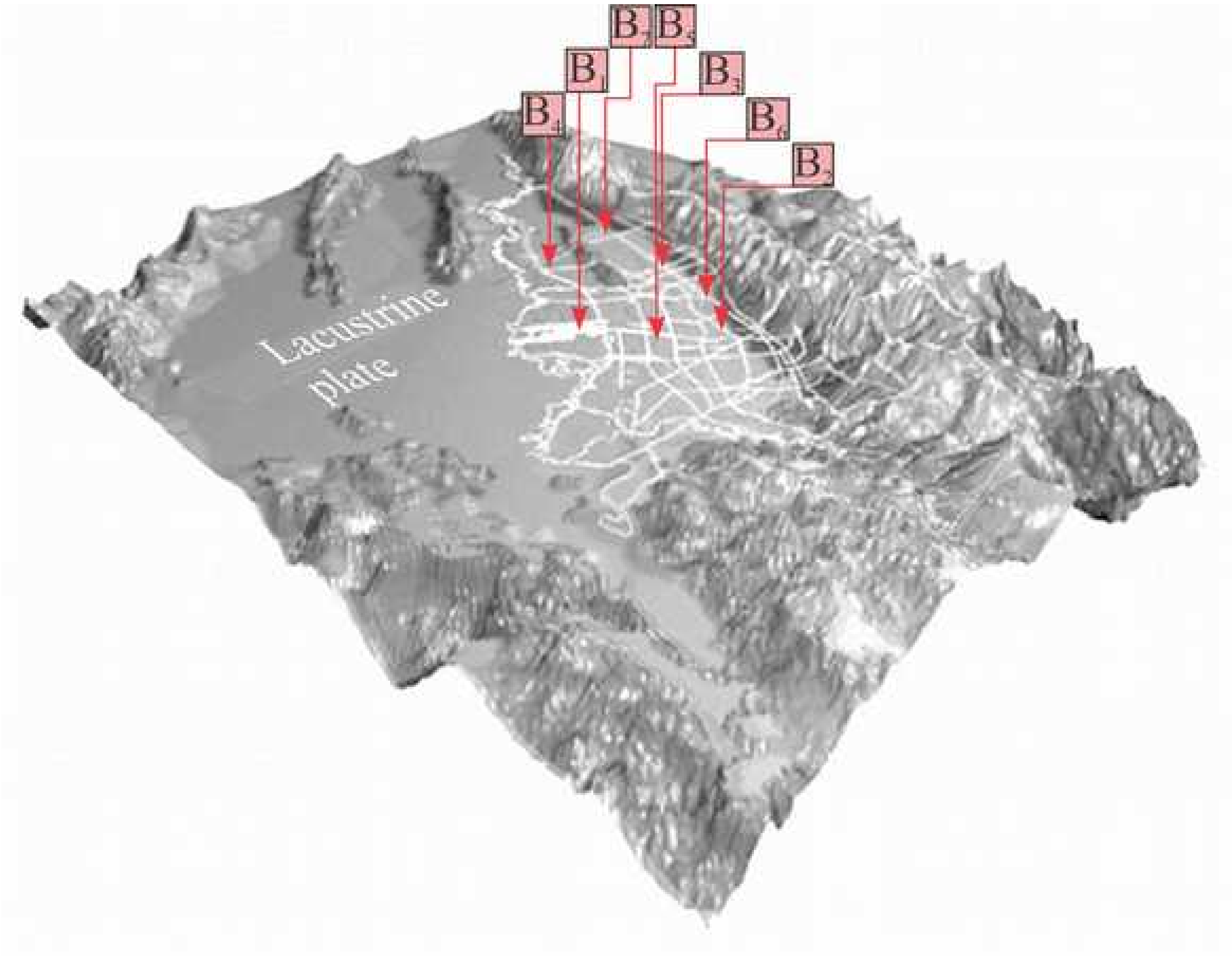
BOGOTÁ DEPOSIT

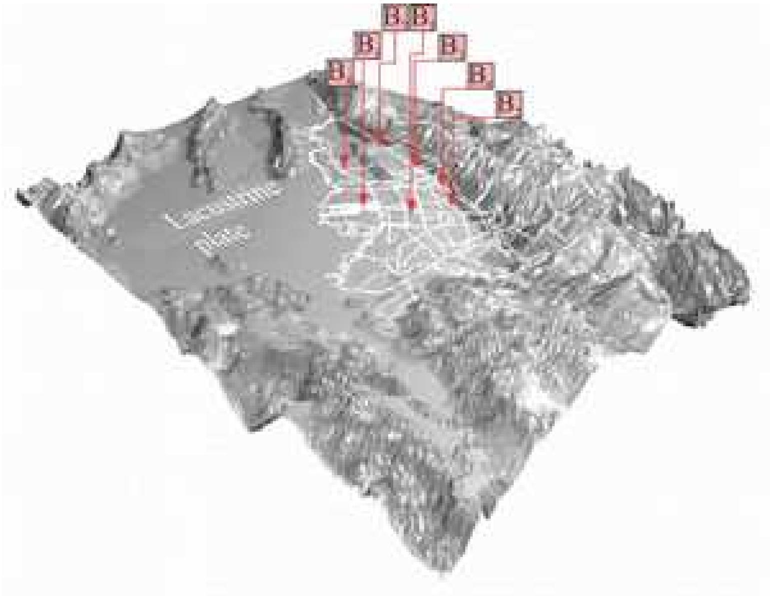




ORGANIC RICH MUD
PEAT
MA
0.00 0.25 0.50 0.75
3440 years/m
Depth (m)
0
50
100
150
200
250
% grains<2 µm
20
40
w_L
100
200
LOI %
10
20
30
40

	Localización	Prof.(m)
B1	Aeropuerto Eldorado	250
B2	Servicio Geológico	180
B3	Cll 126 - Cra 29	190
B4	Av. Cund. - Cll 139	246
B5	Terminal Transportes	100
B6	Los Héroes	100
B7	Univ. Agraria Cll 170	130





B1: Aeropuerto Eldorado

B2: Av. 30 Servicio Geológico

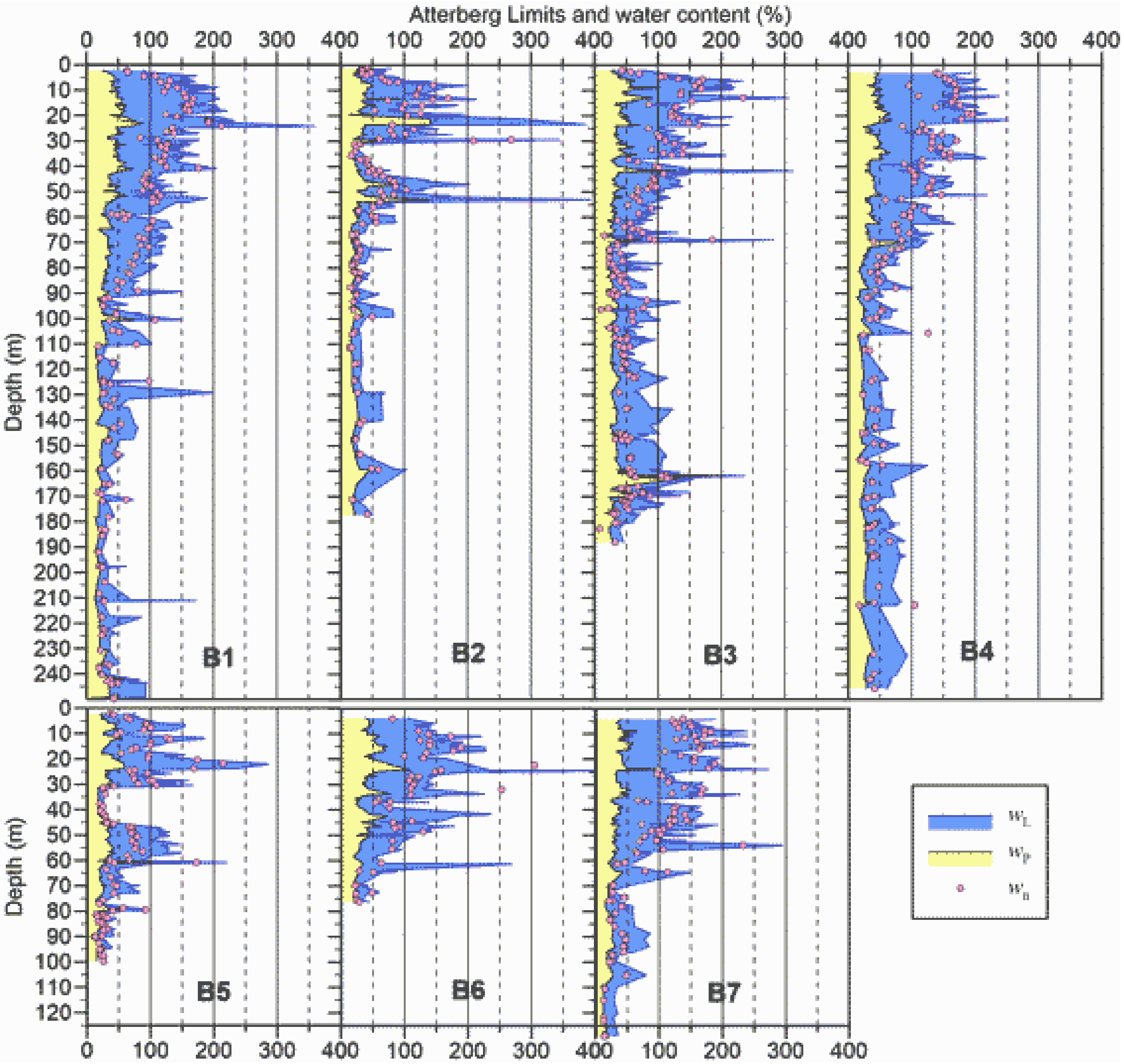
B3: Cll 126 - Cra 29

B4: Av. Cundinamarca - Cll 139

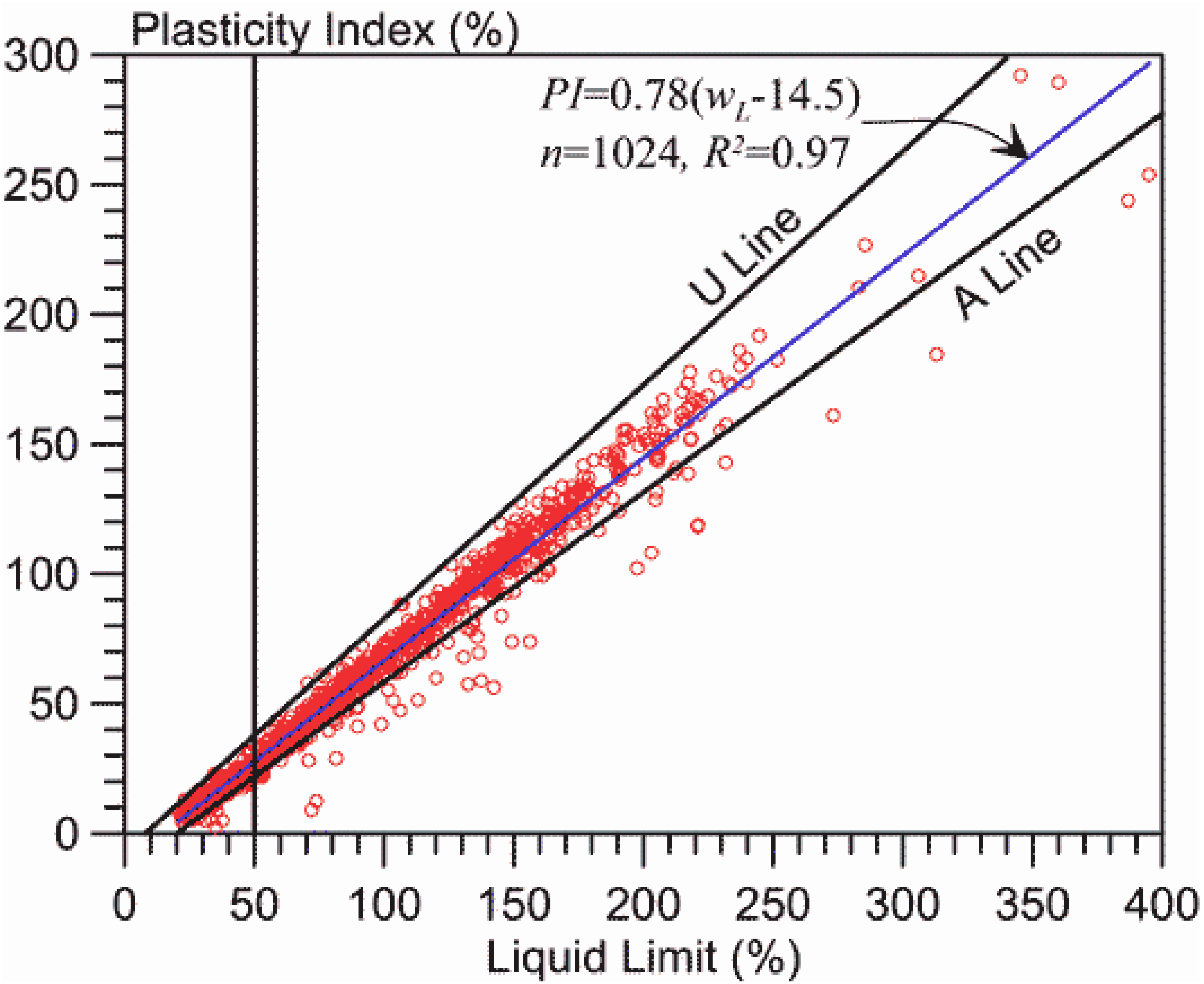
B5: Terminal Transportes

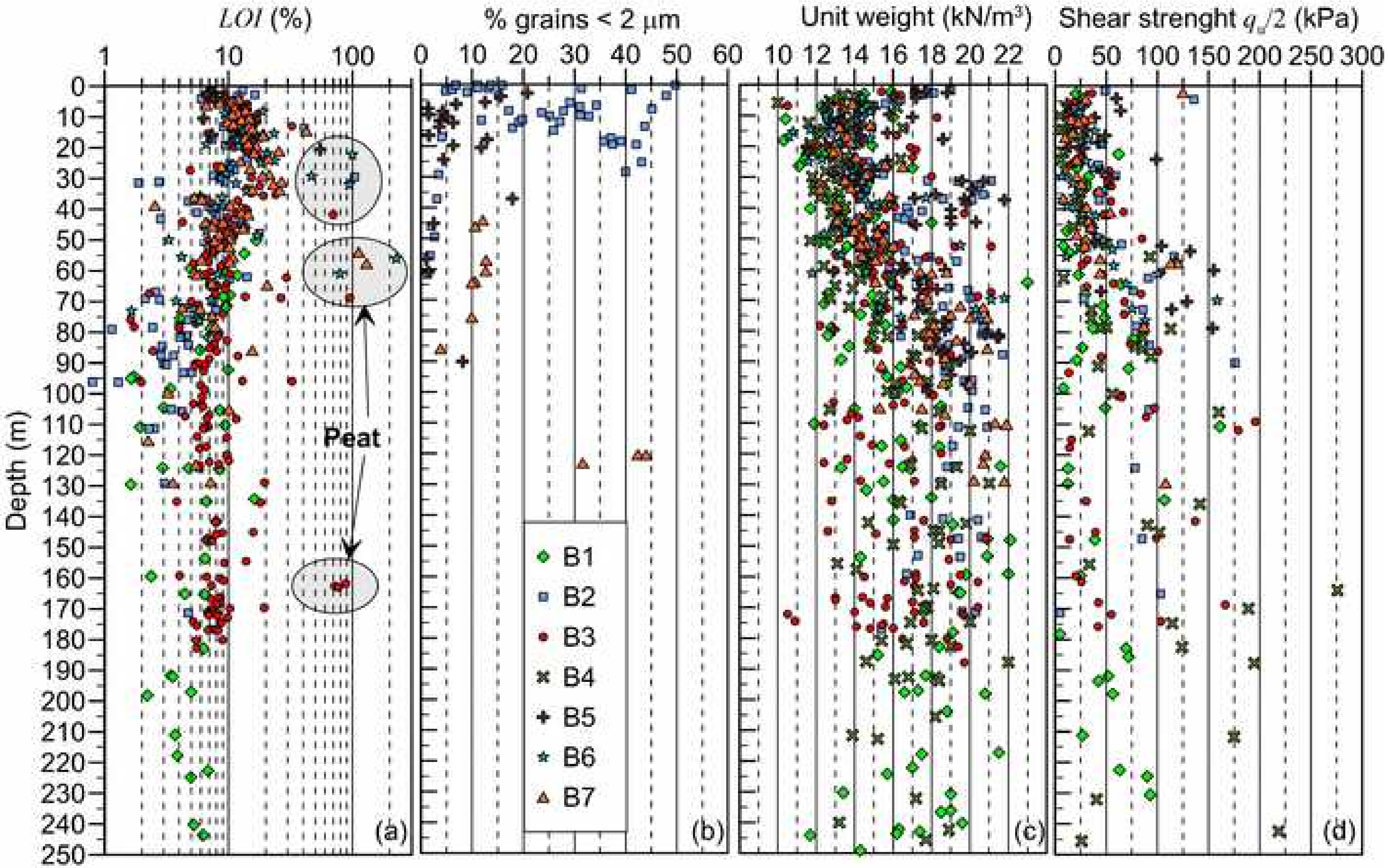
B6: Monumento los Héroes

B7: Univ. Agraria Cll 170



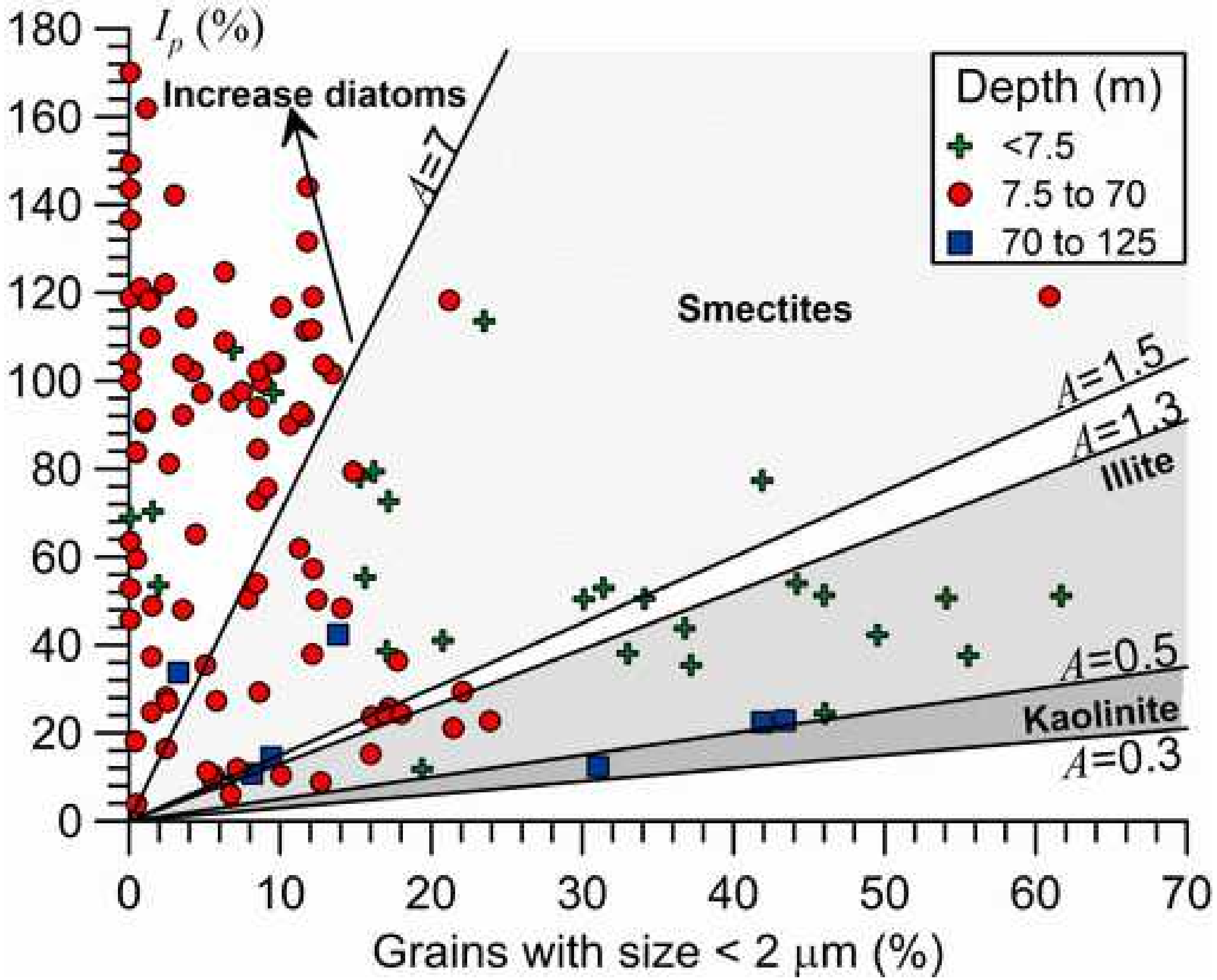
CASAGRANDE PLASTICITY CHART





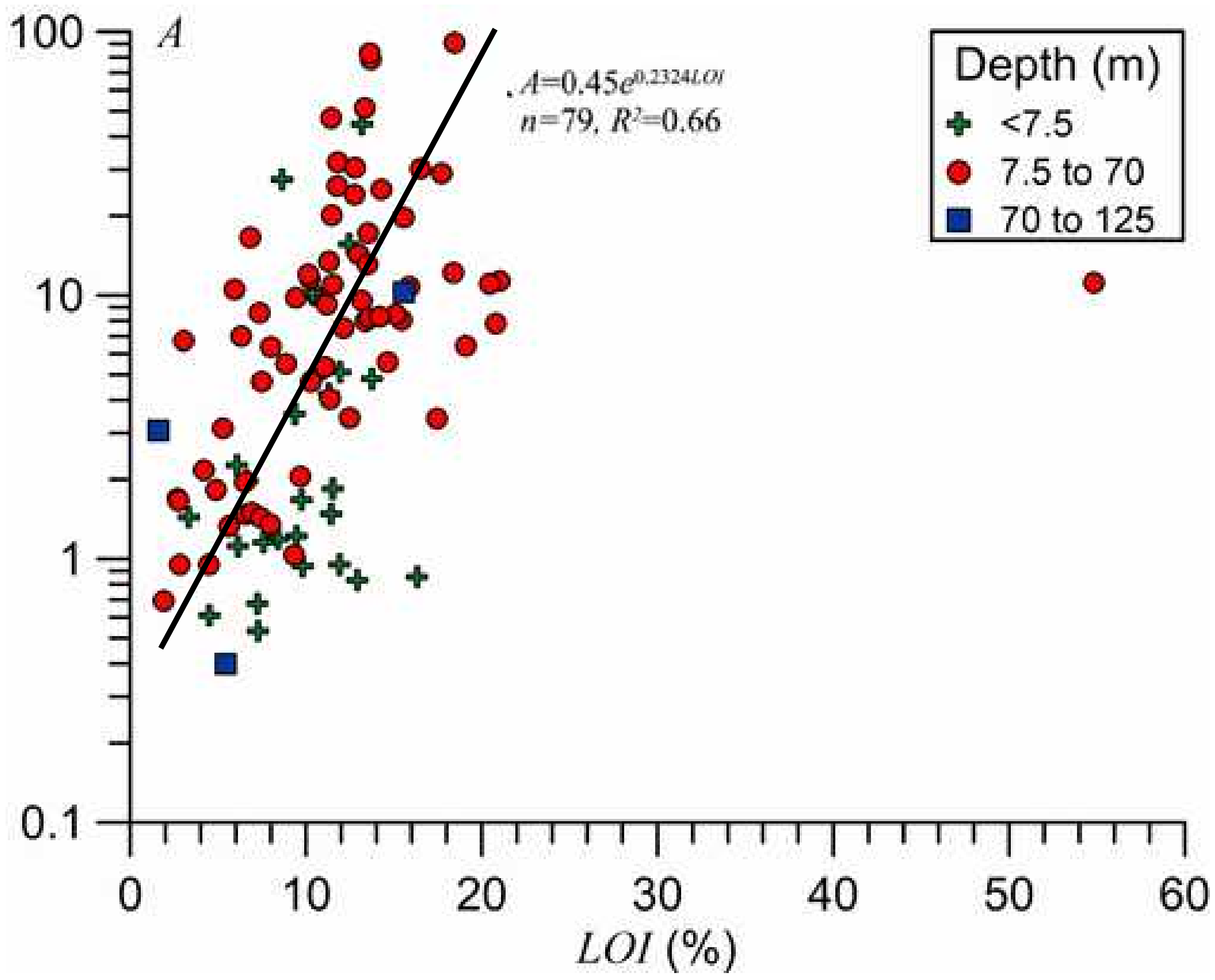
LOI (%)
% grains < 2 μm
Unit weight (kN/m³)
Shear strenght $q_u/2$ (kPa)
Depth (m)
Peat
B1
B2
B3
B4
B5
B6
B7
(a)
(b)
(c)
(d)

ACTIVITY

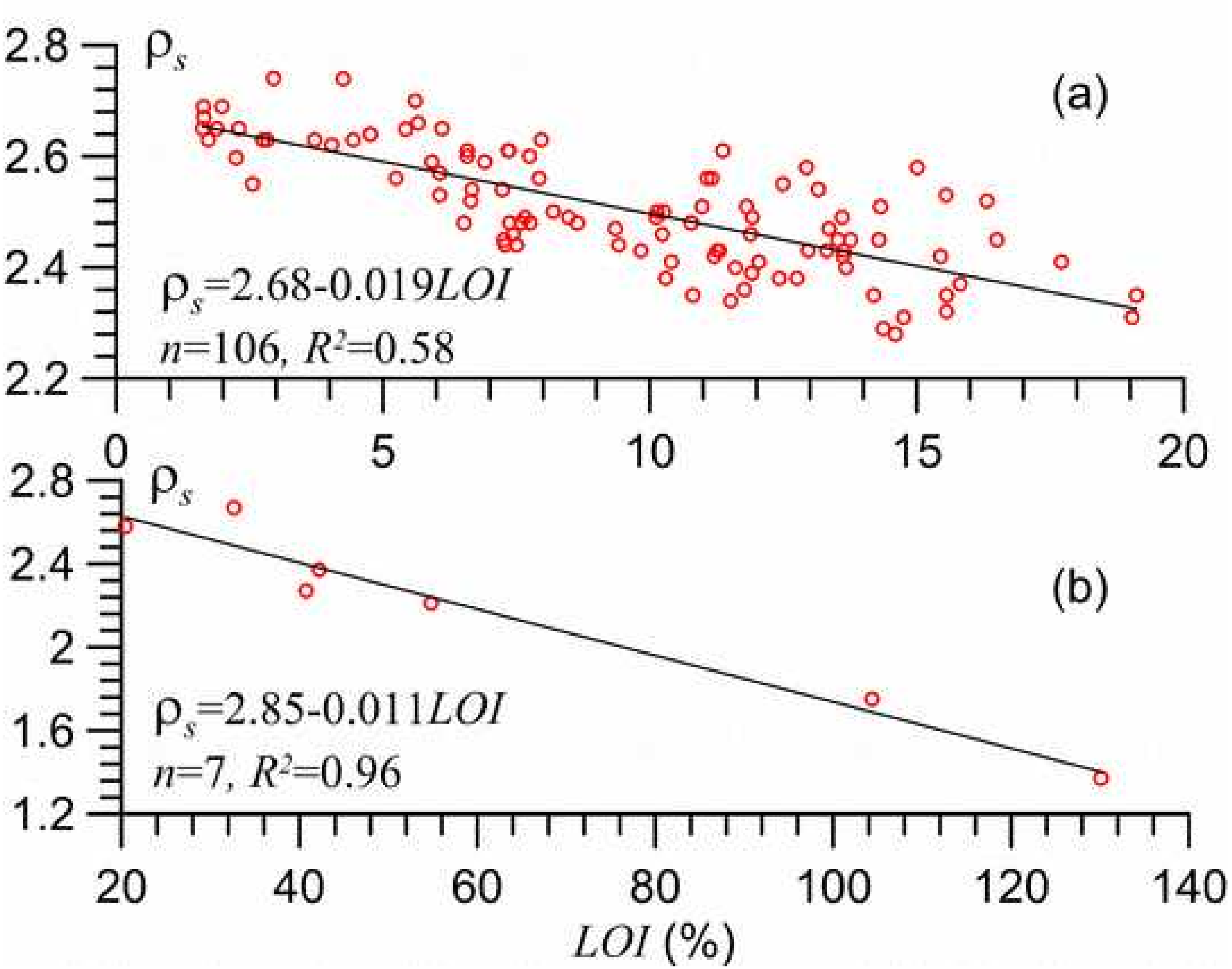


$$A = \frac{PI}{\%\ particles\ <2mm}$$

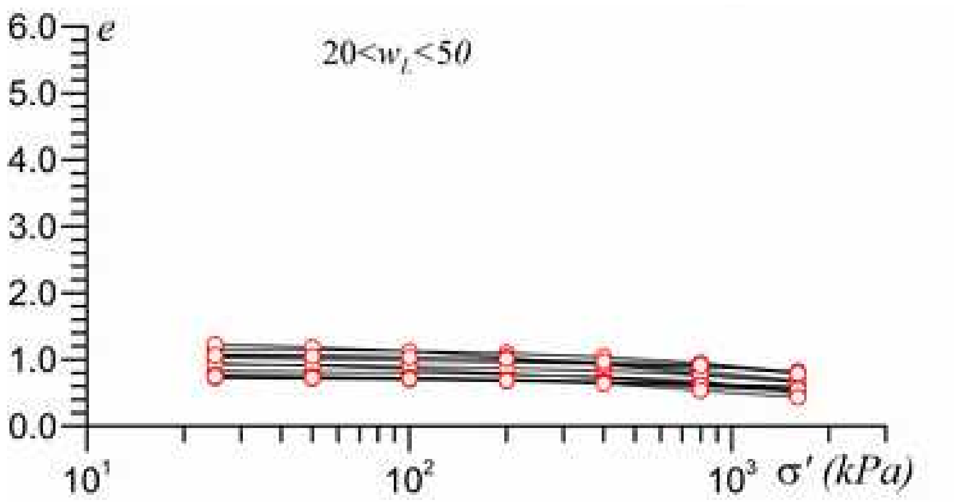
RELATIONSHIP BETWEEN ACTIVITY AND ORGANIC MATTER



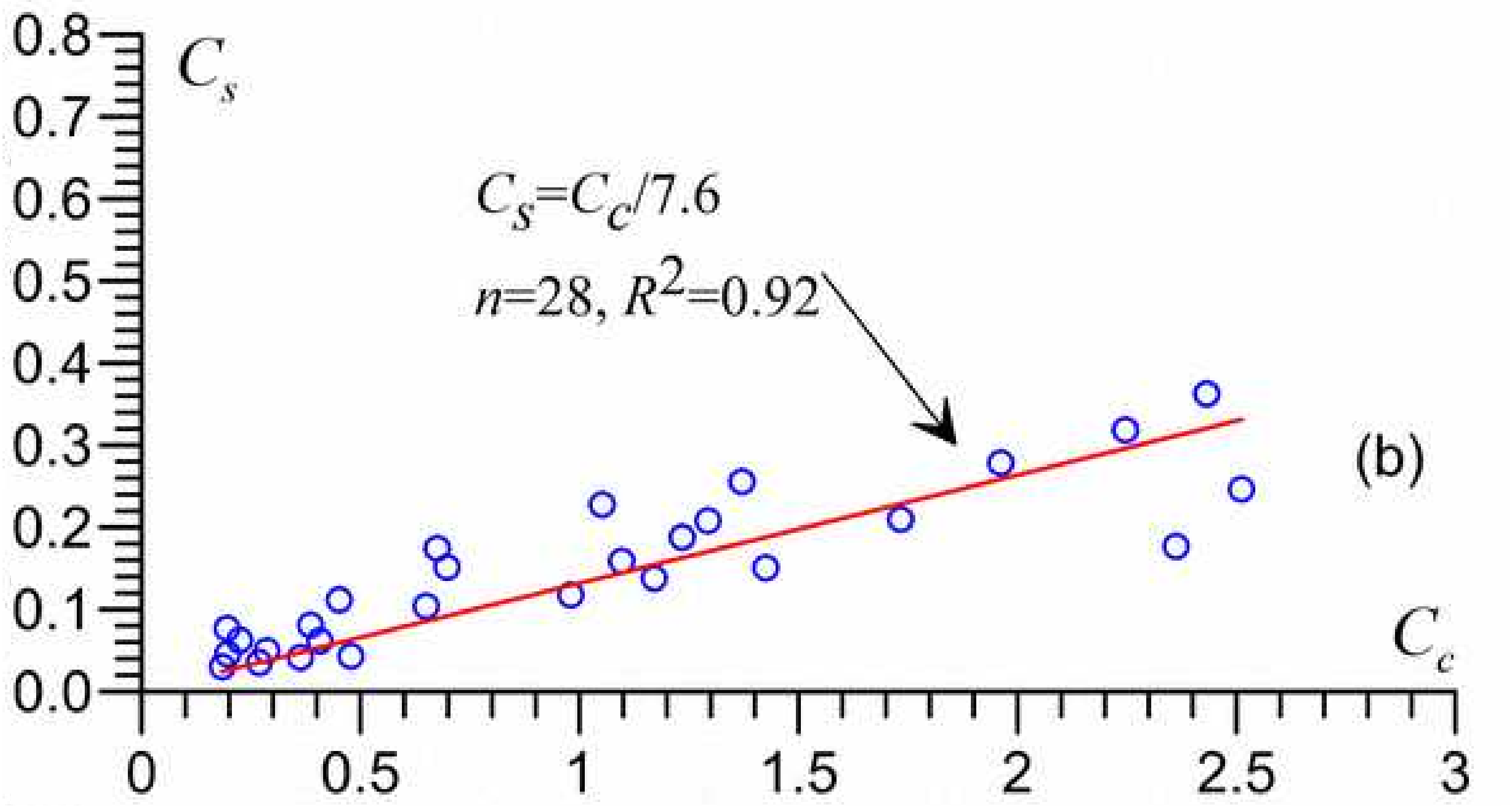
DENSITY OF GRAINS



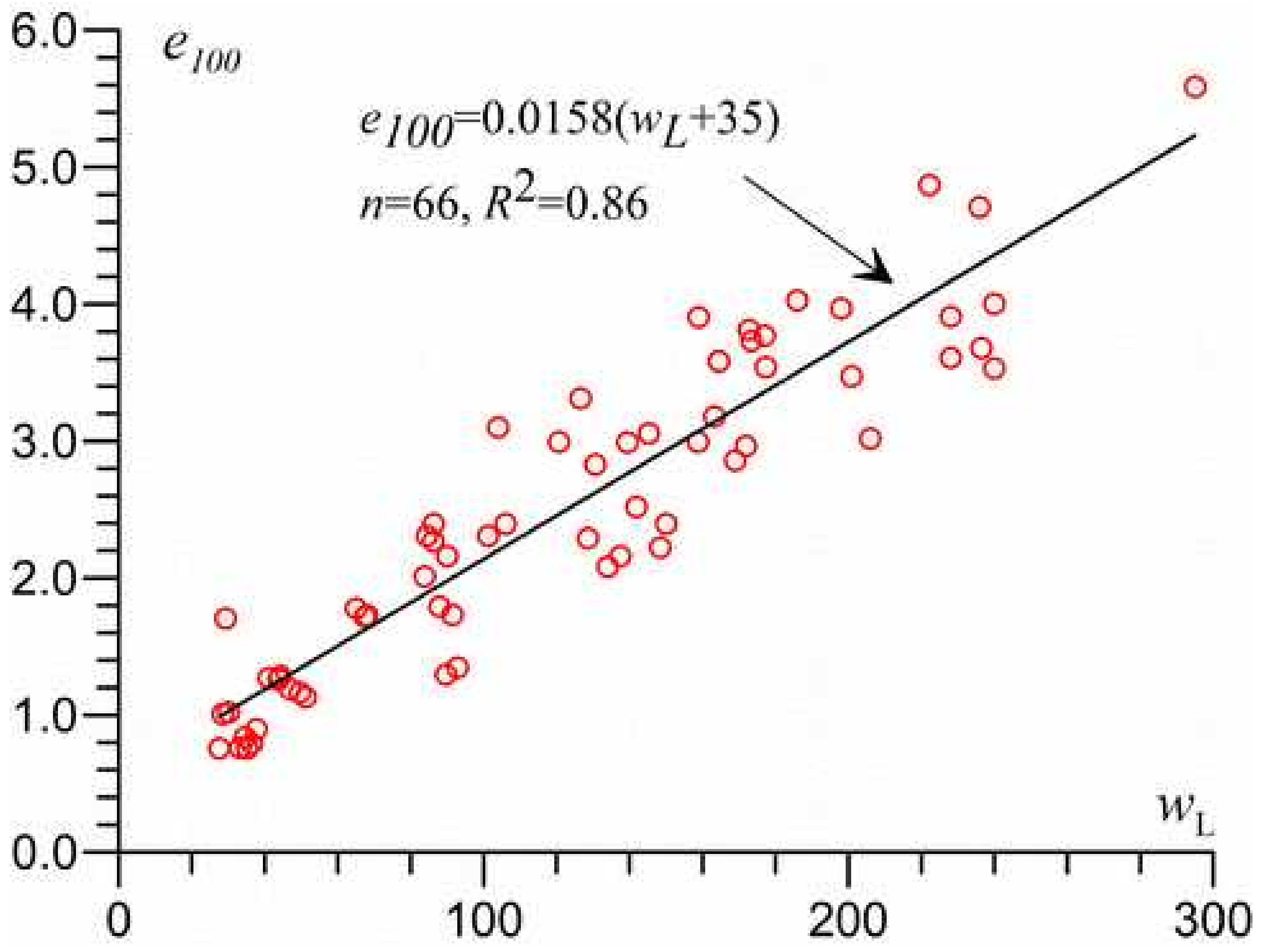
COMPRESSIBILITY



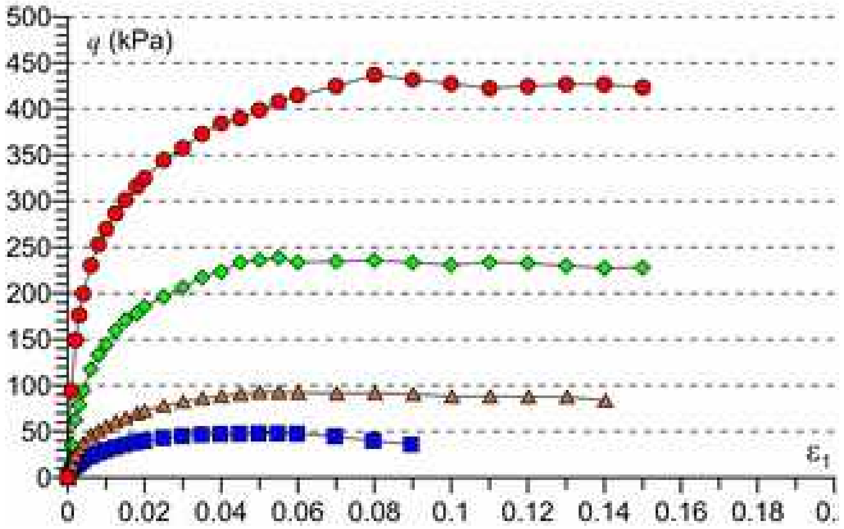
COEFFICIENTS OF COMPRESSIBILITY AND RE-COMPRESSION



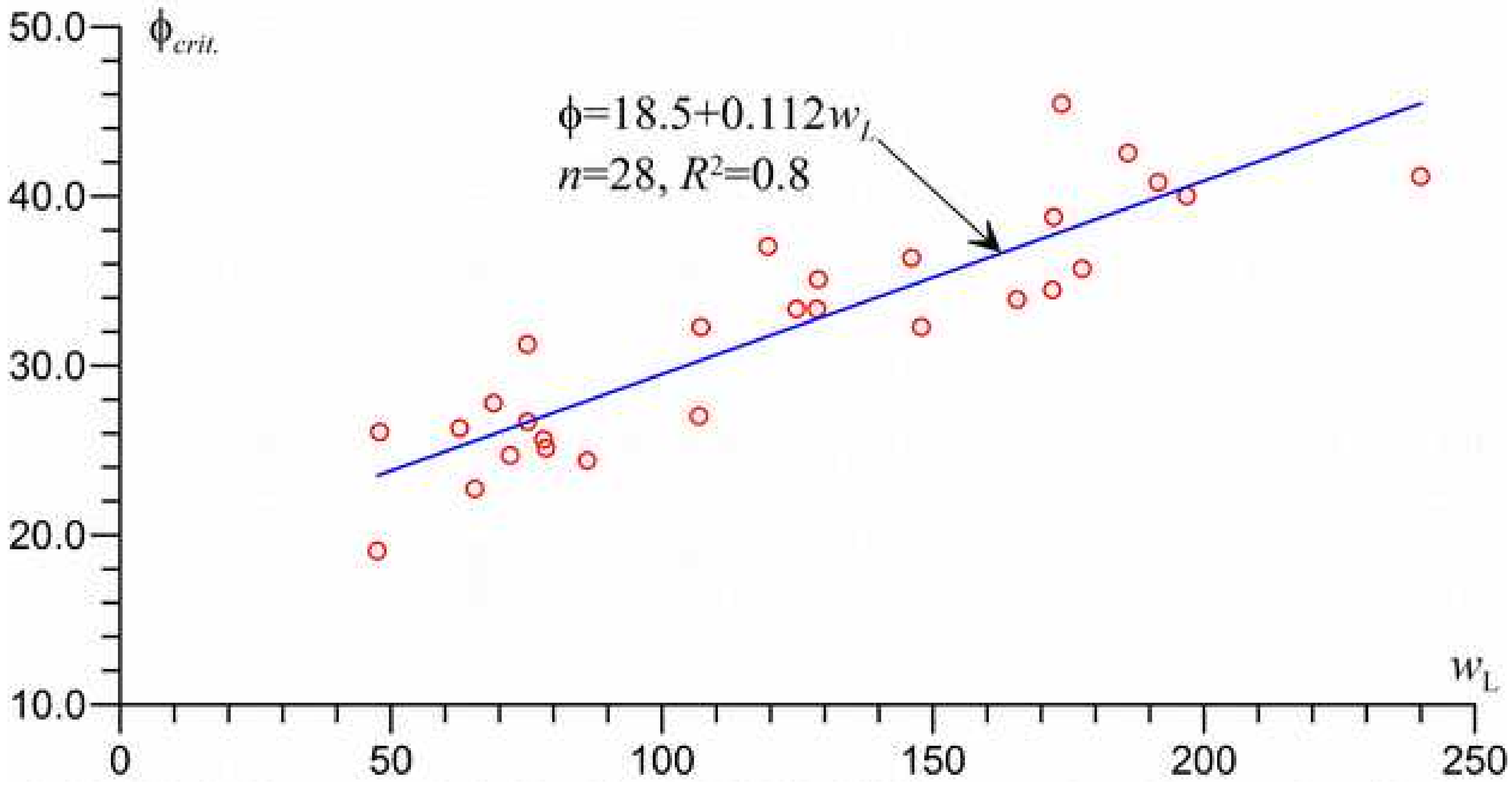
POSITION OF THE COMPRESSIBILITY CURVE



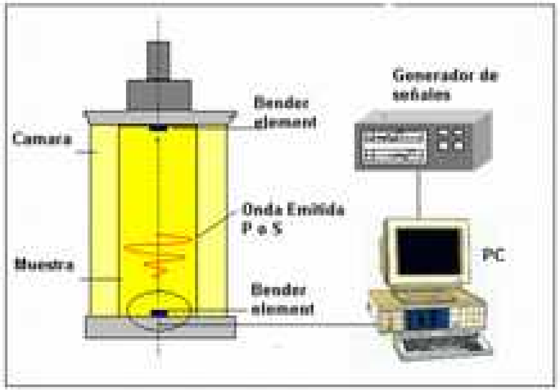
SHEAR STRENGTH

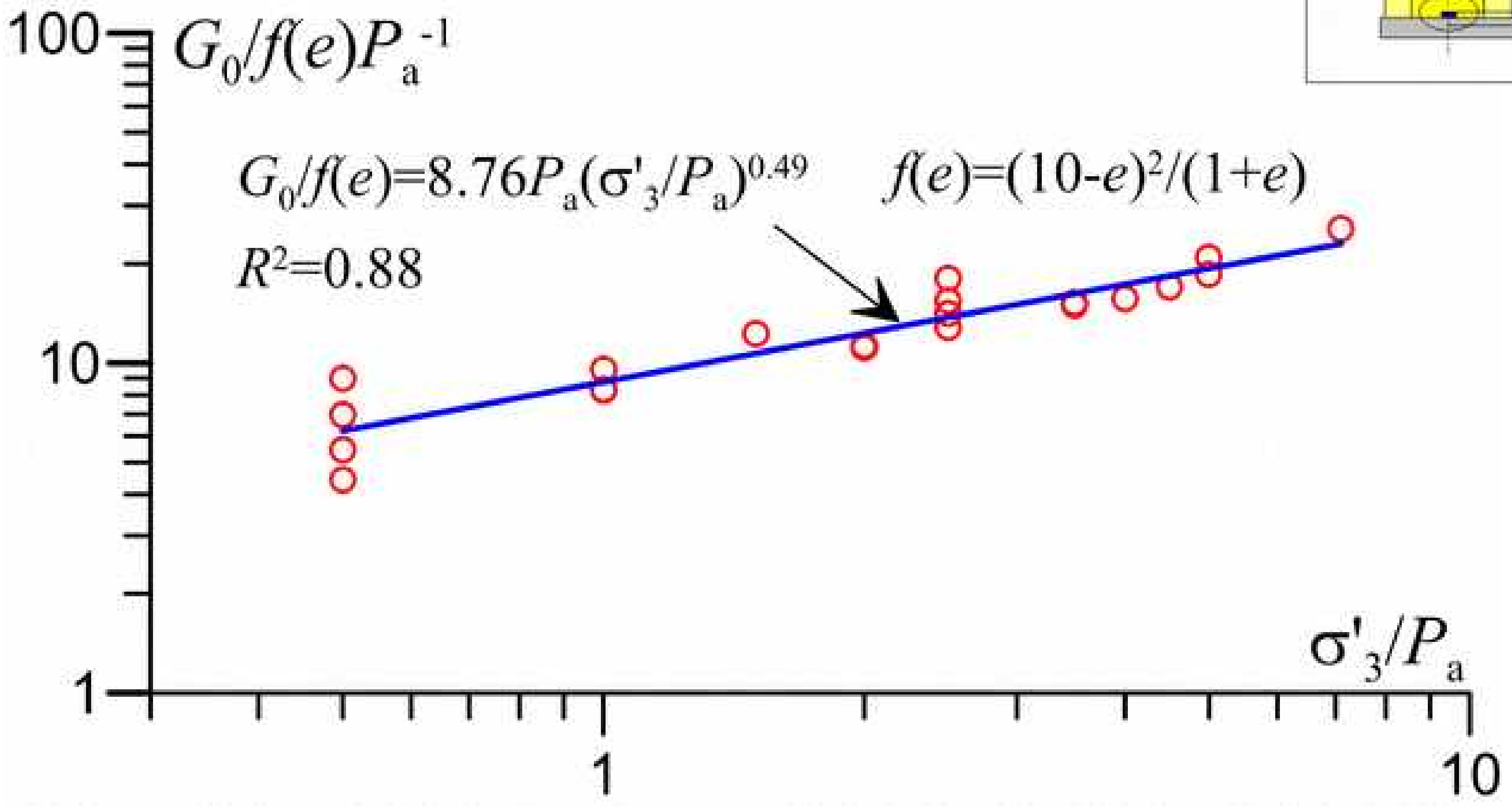


FRICTION ANGLE

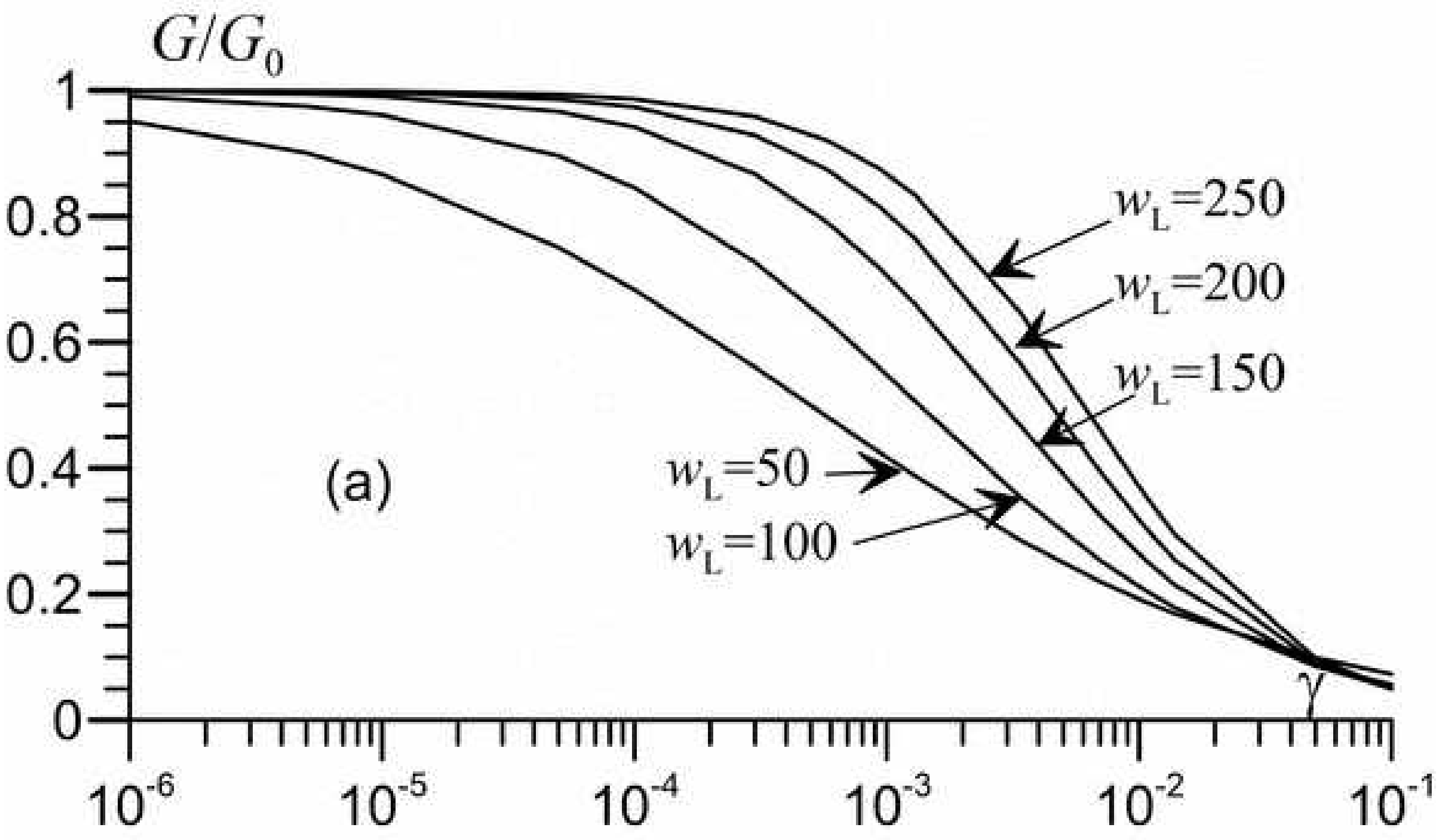


DYNAMIC RESPONSE





DEGRADATION OF THE SHEAR MODULUS

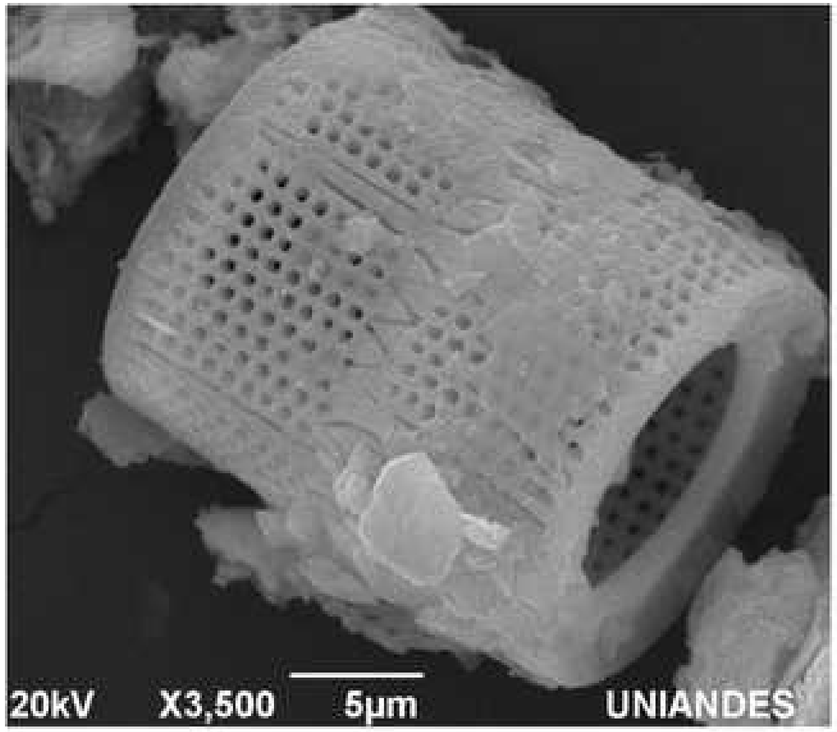


REMOULDED SOILS

WITH DIATOMS

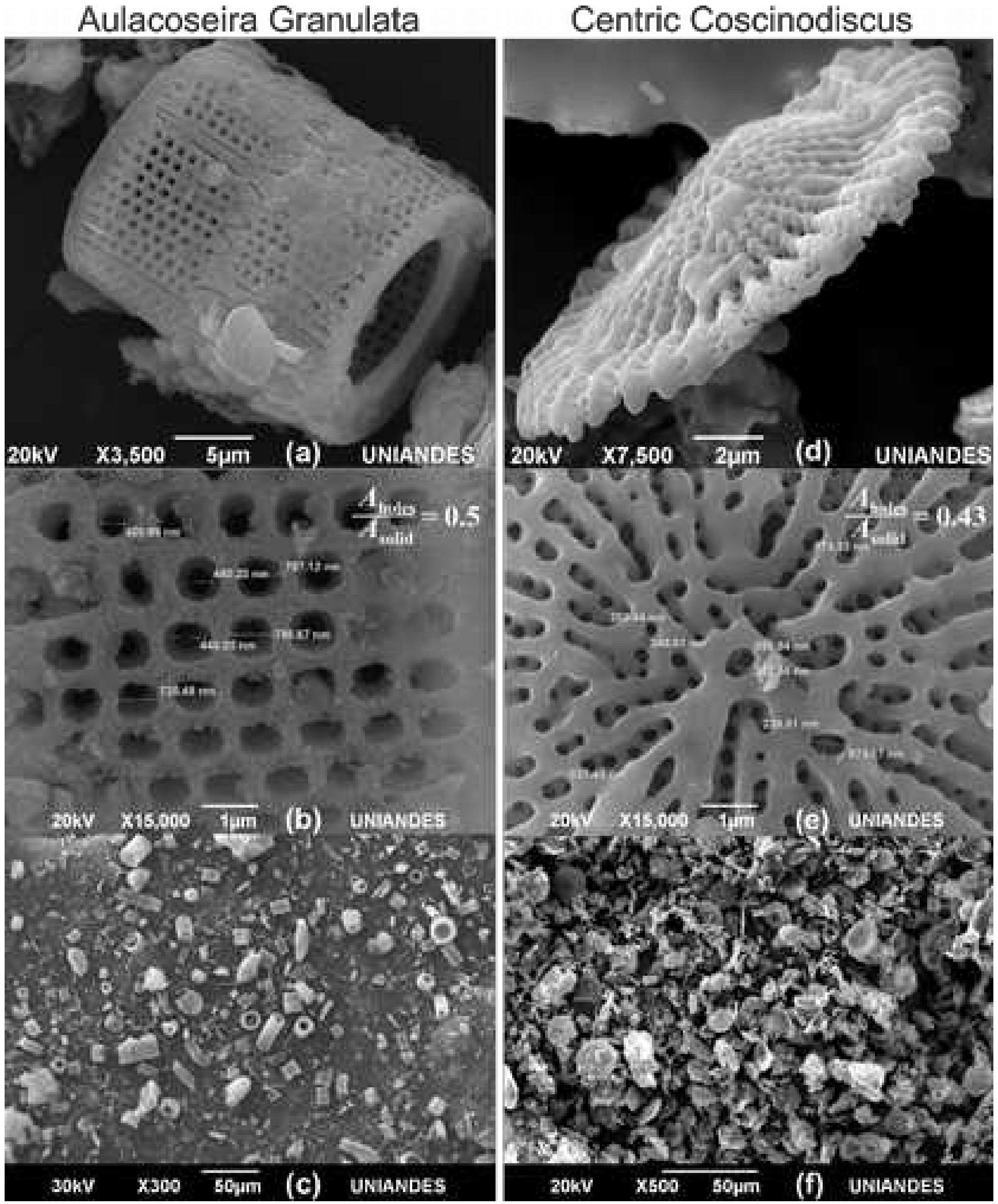
TYPE OF DIATOMS

Cota

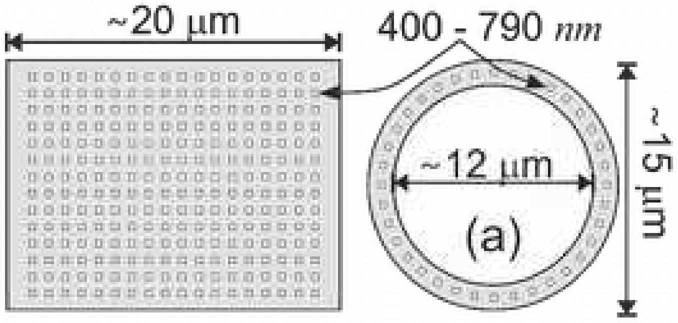


Aulacoseira Granulata

Daniel Zuloaga & Carlos Slebi 2016

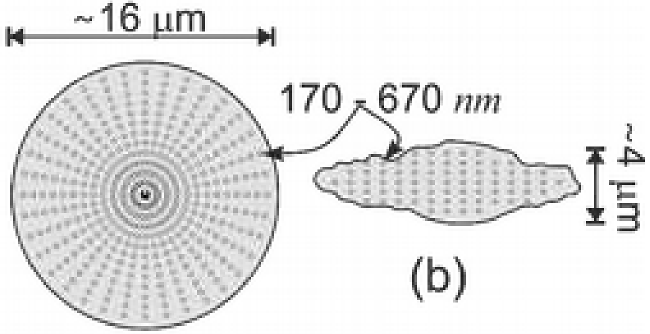

Aulacoseira Granulata
Centric Coscinodiscus
20kV X3,500 5µm (a) UNIANDES
20kV X7,500 2µm (d) UNIANDES
$\frac{A_{holes}}{A_{solid}} = 0.5$
$\frac{A_{holes}}{A_{solid}} = 0.43$
20kV X15,000 1µm (b) UNIANDES
20kV X15,000 1µm (e) UNIANDES
30kV X300 50µm (c) UNIANDES
20kV X500 50µm (f) UNIANDES

Aulacoseira Granulata

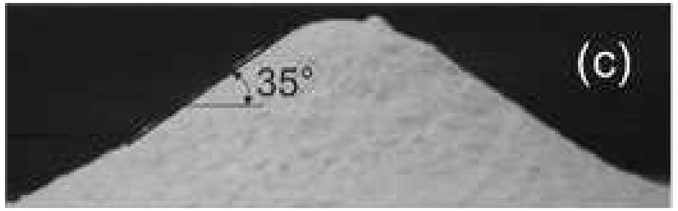


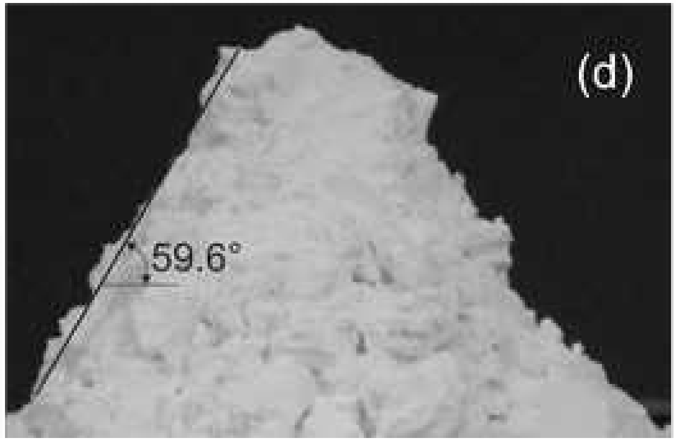
VOLUMES		
	Solid	600 μm^3
	Central cavity, accesible by kaolin	2650 μm^3
	Holes, accesible by water	300 μm^3
	Void ratio (holes)	0.5

Centric Coscinodiscus

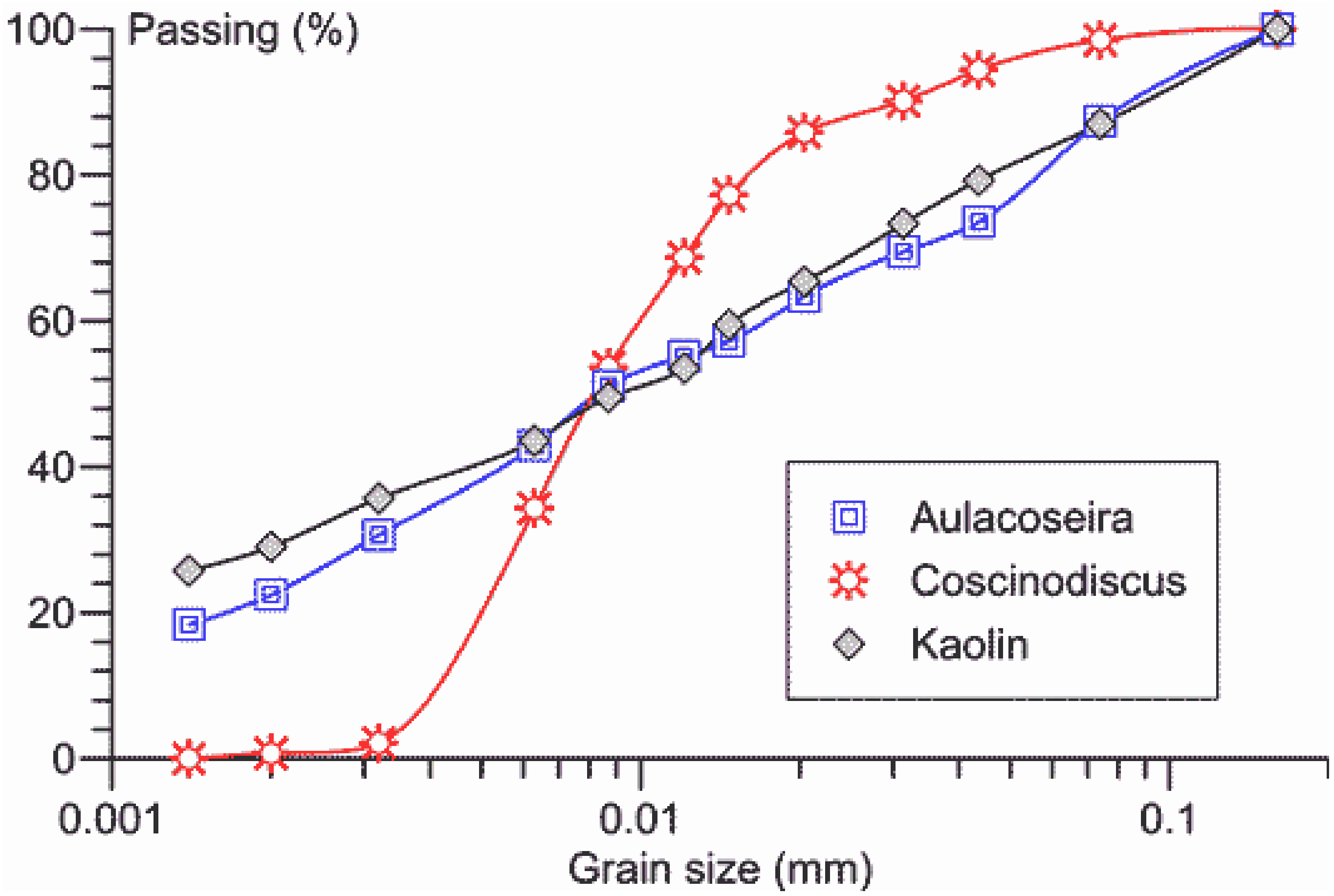


VOLUMES		
	Solid	194 μm^3
	Central cavity, accesible by water	205 μm^3
	Holes, accesible by water	138 μm^3
	Void ratio (holes+cavity)	1.77

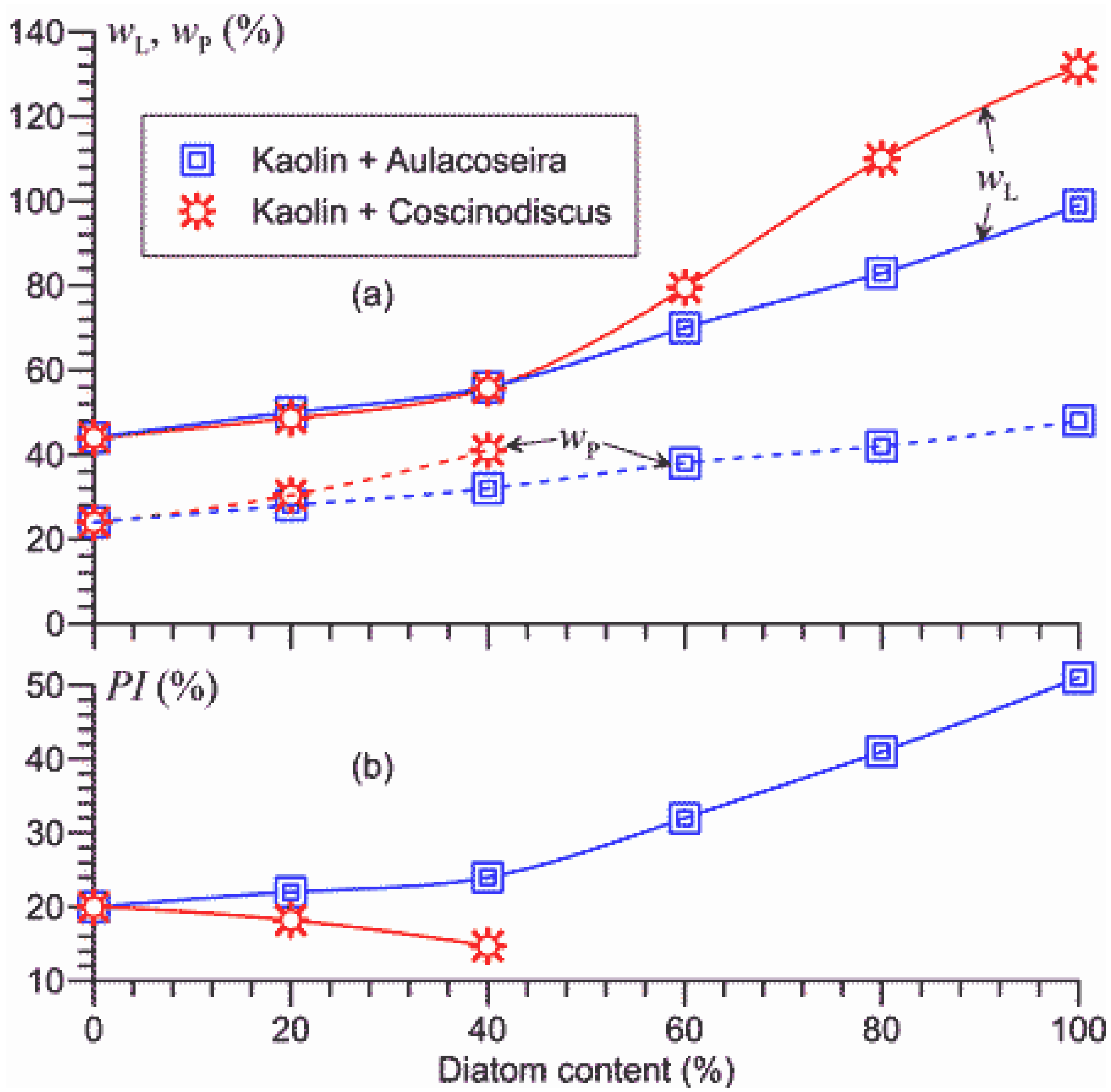




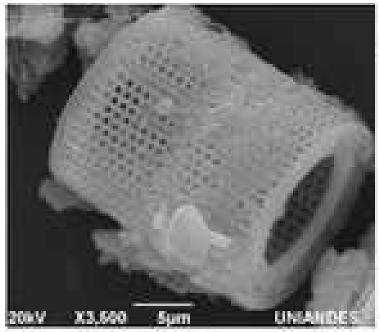
GRAIN SIZE DISTRIBUTIONS



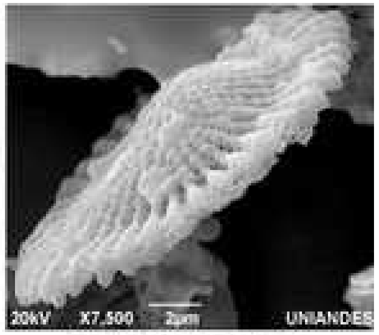
ATTERBERG LIMITS



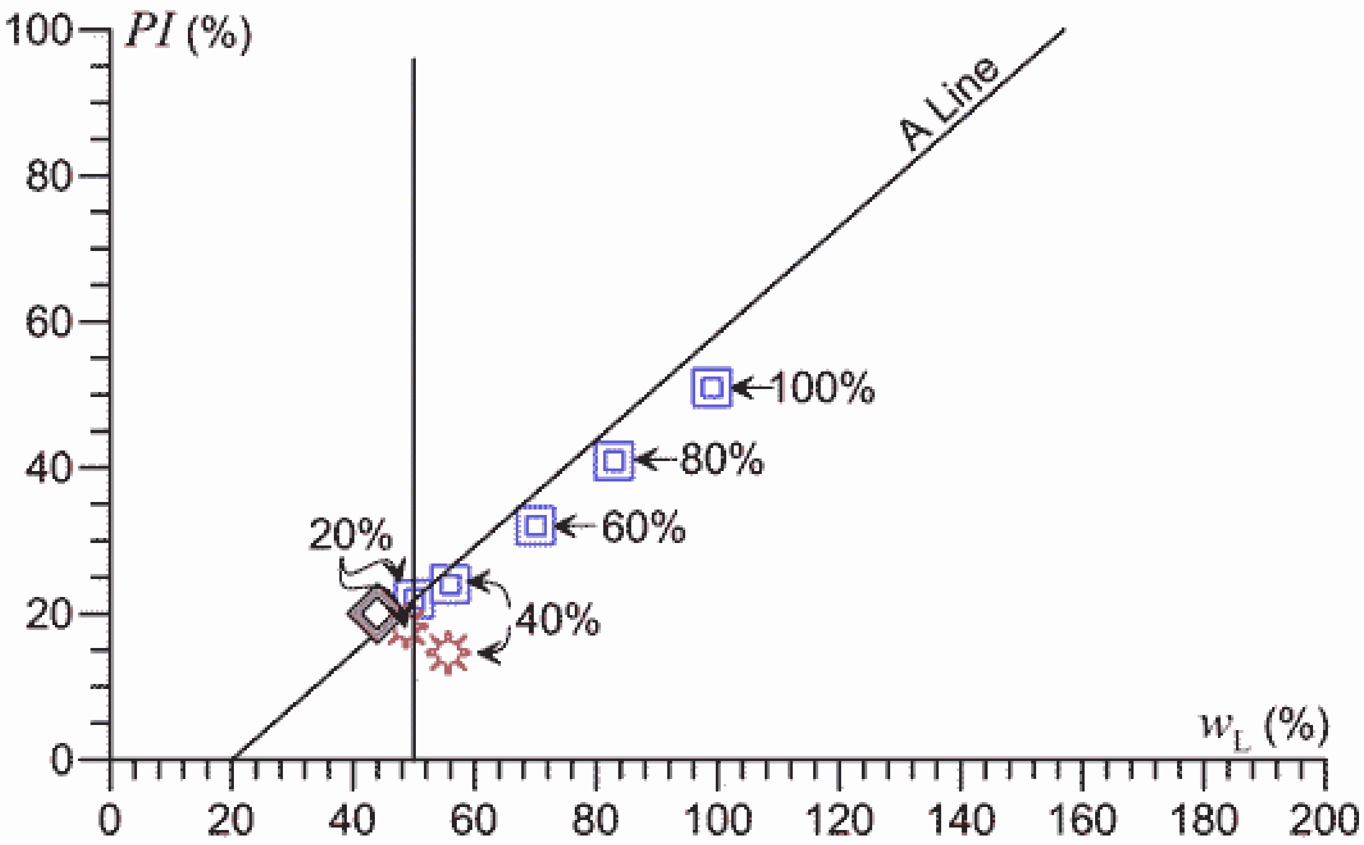
CASAGRANDE PLASTICITY CHART



Aulacoseira Granulata



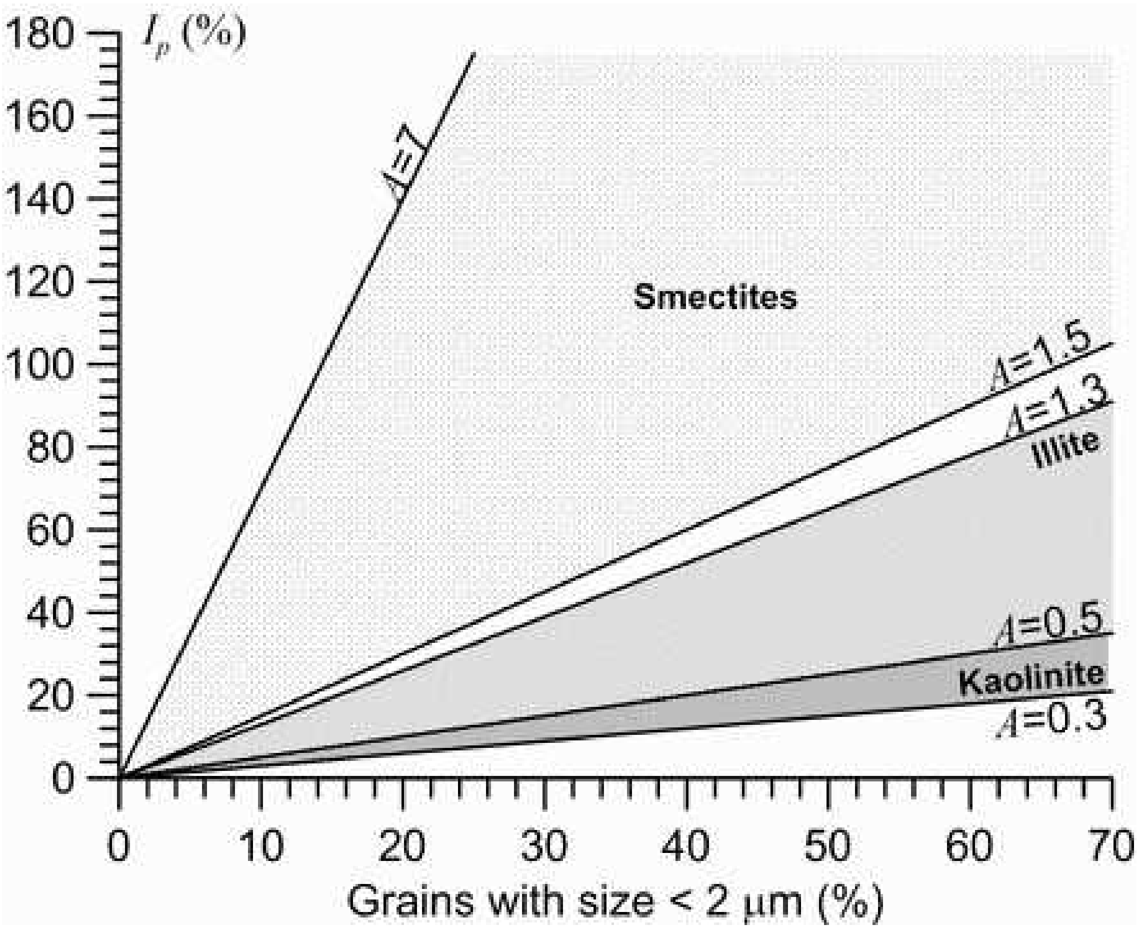
Centric Coscinodiscus



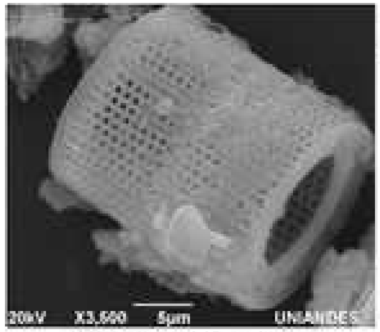
ACTIVITY

$$A = \frac{PI}{\%\ \text{particles} < 2mm}$$

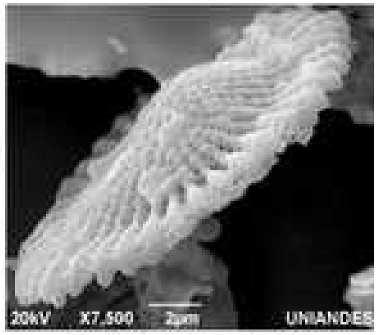
$$A_L = \frac{w_L}{\%\ \text{particles} < 2mm}$$



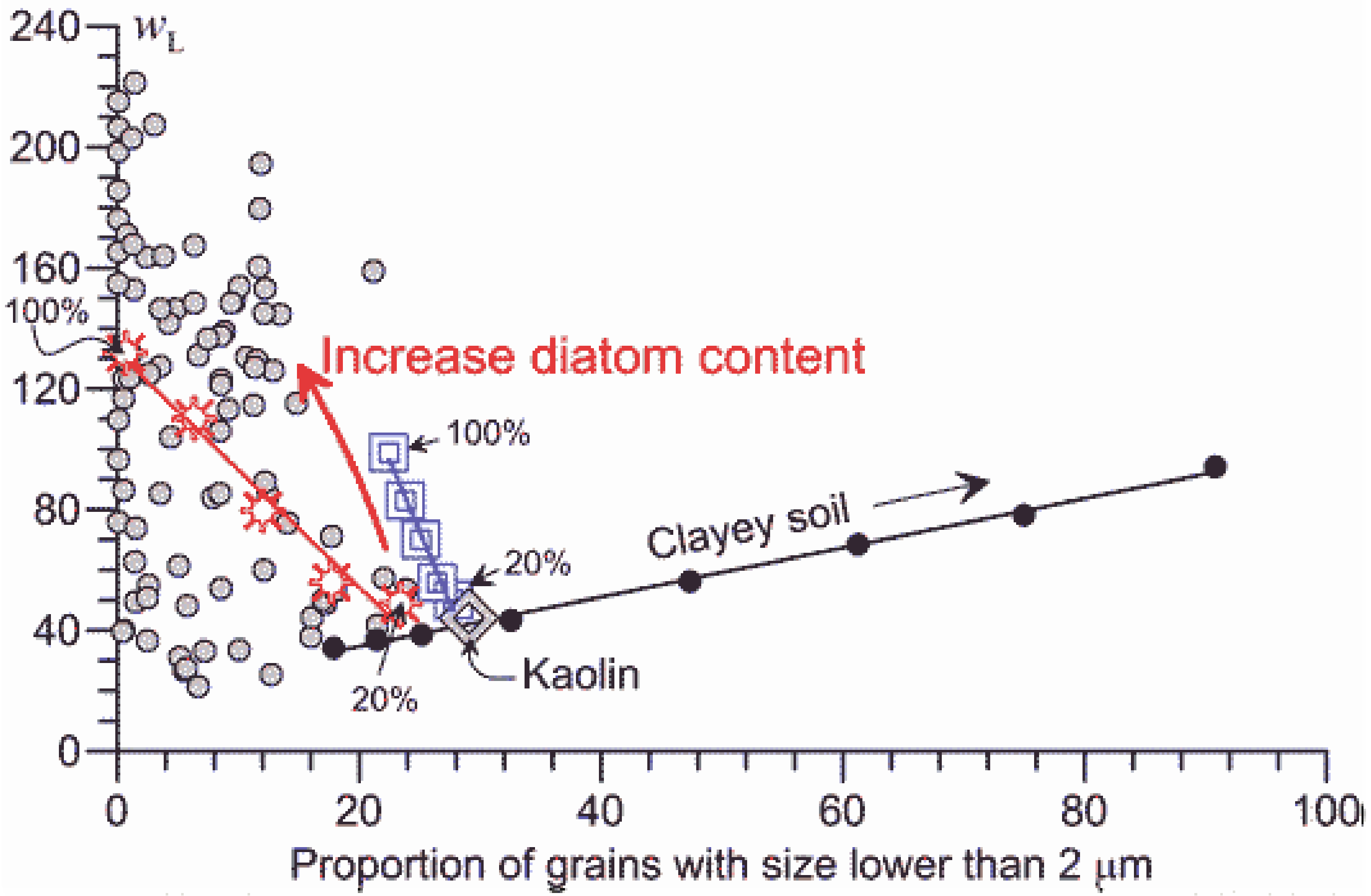
ACTIVITY A_L



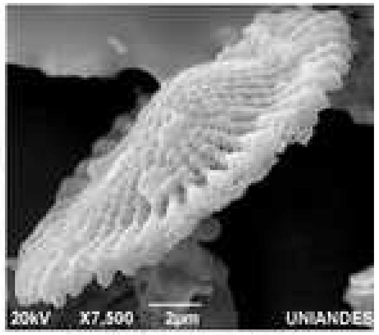
Aulacoseira Granulata



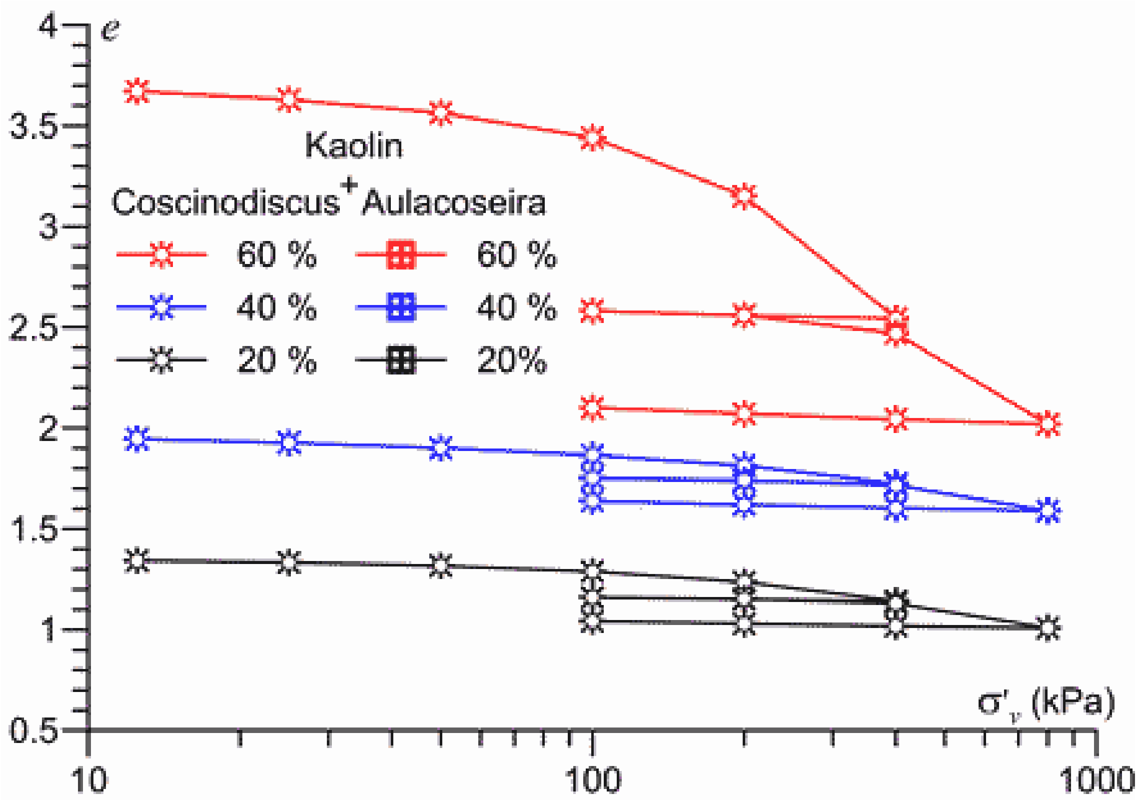
Centric Coscinodiscus

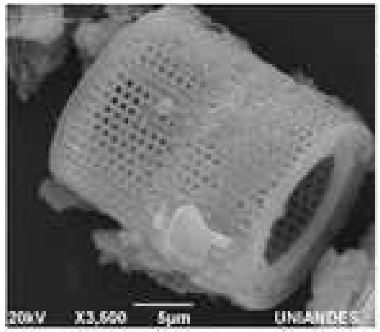


COMPRESSIBILITY

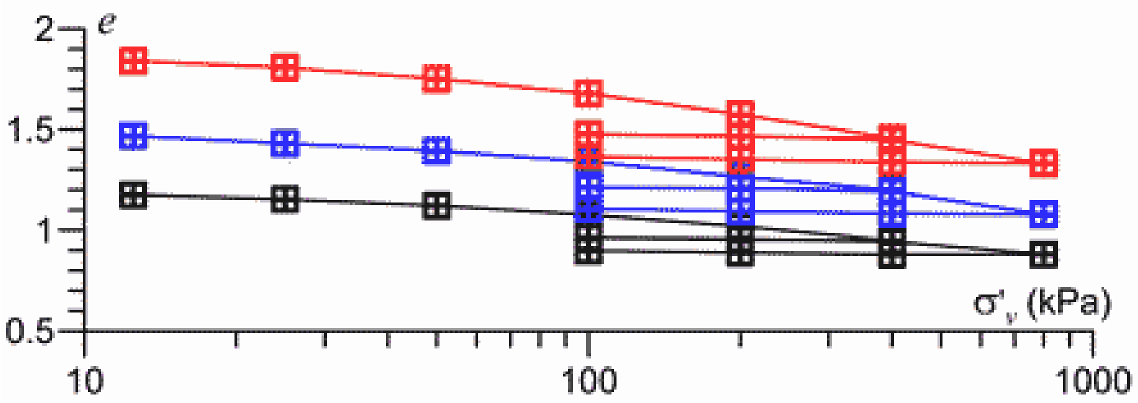


Centric Coscinodiscus

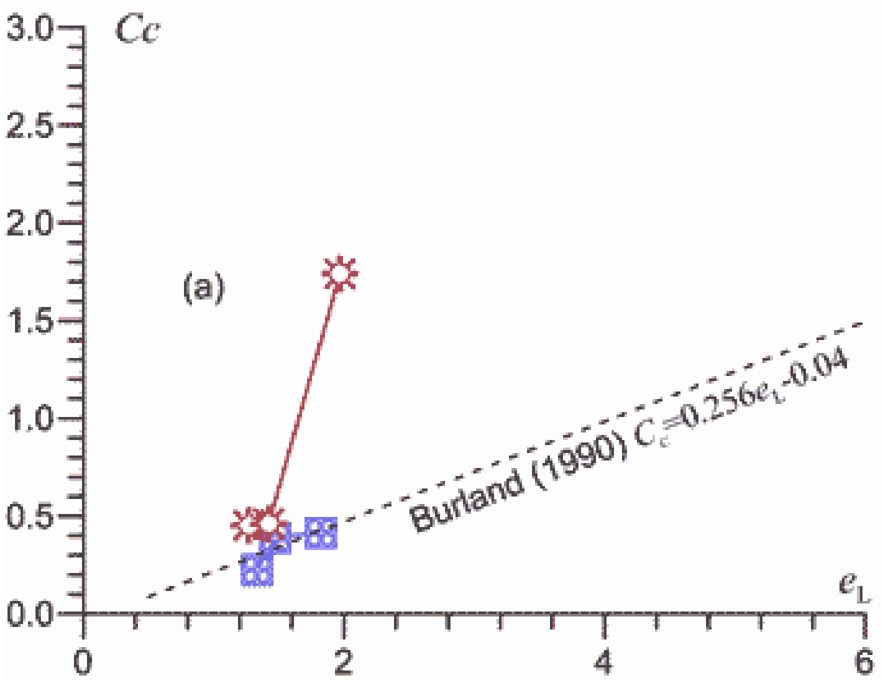


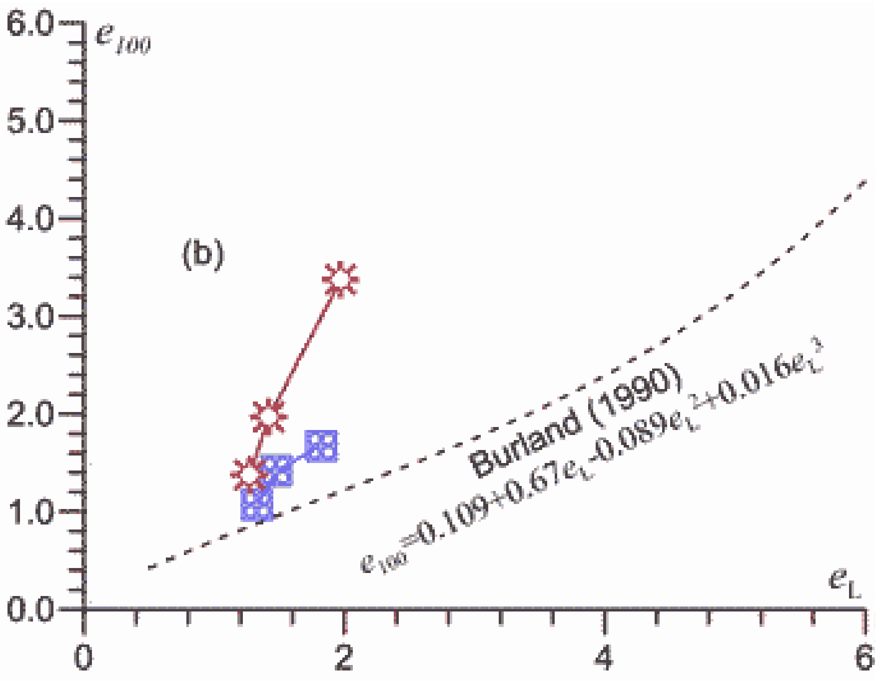


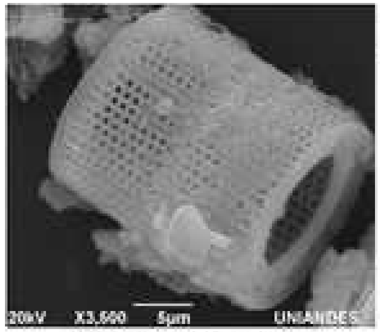
Aulacoseira Granulata



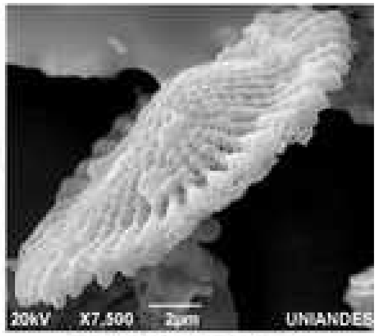
COMPRESSIBILITY COEFFICIENT Cc AND e_{100}





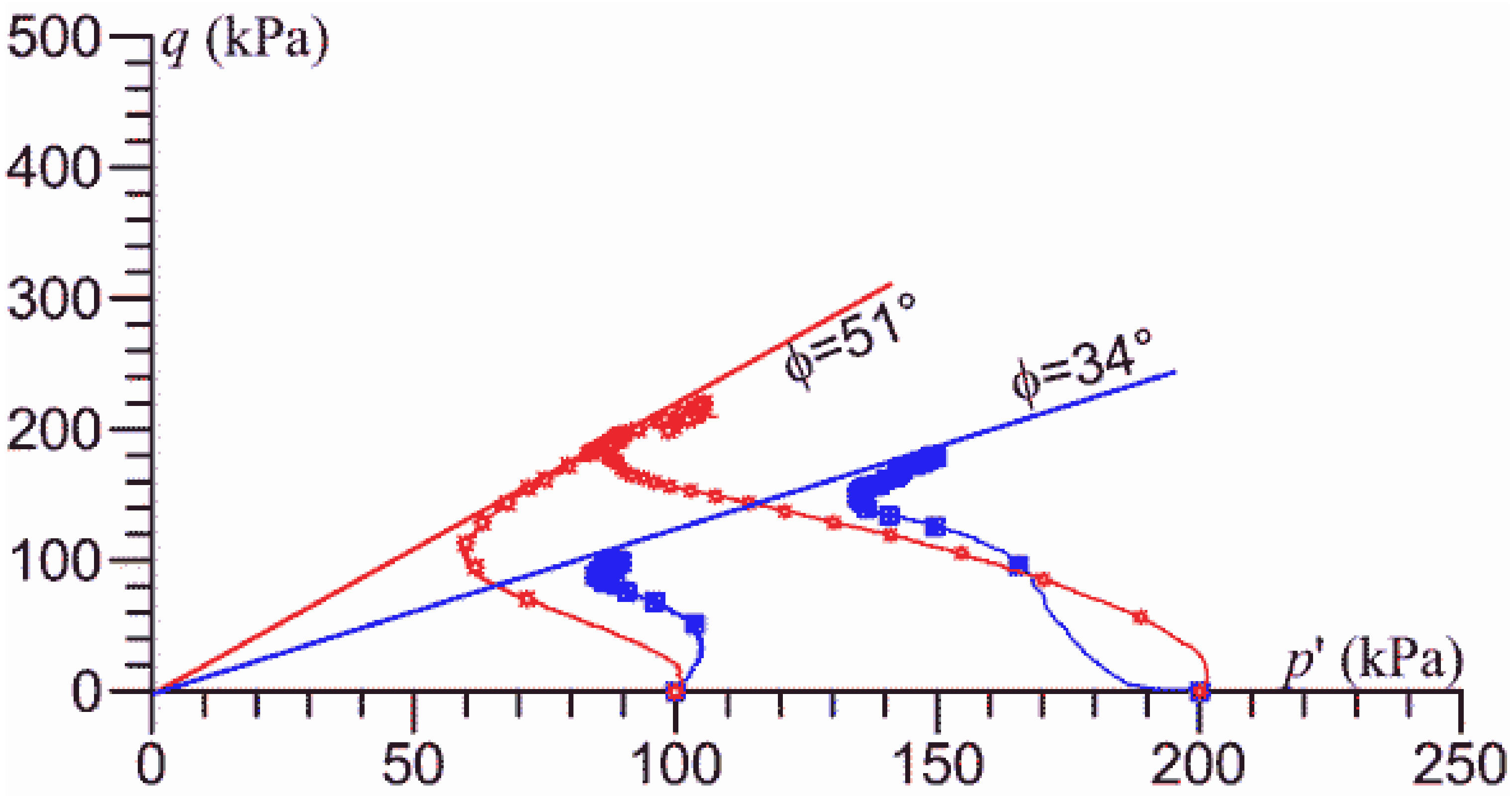


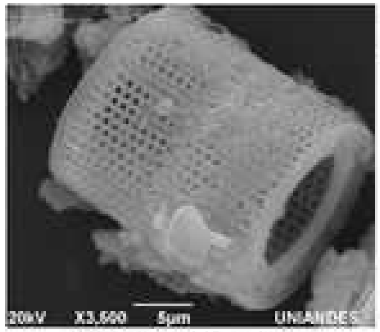
Aulacoseira Granulata



Centric Coscinodiscus

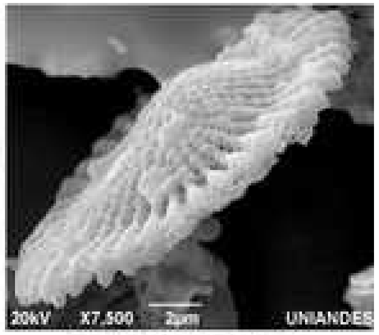
SHEAR STRENGTH





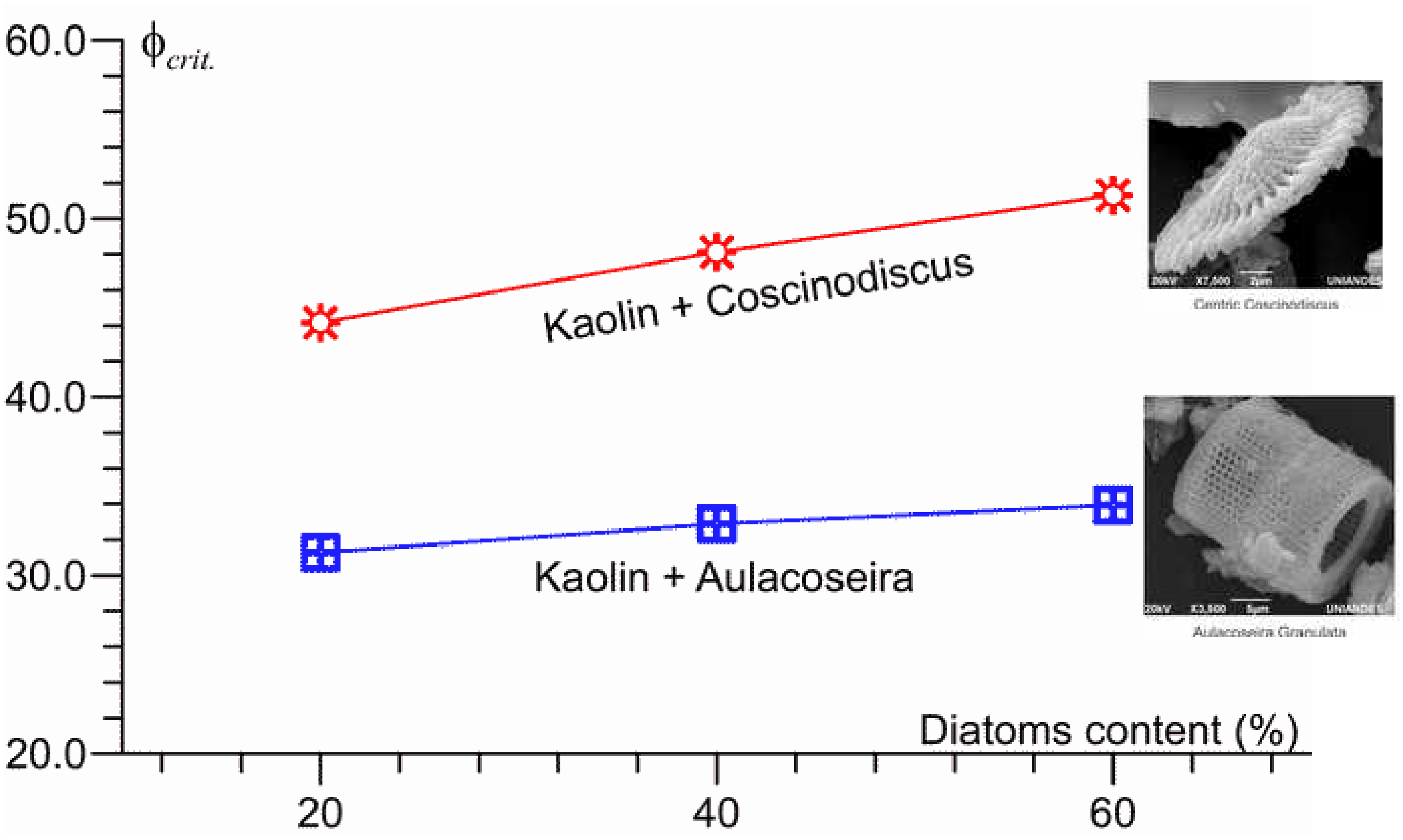
Aulacoseira Granulata

60%

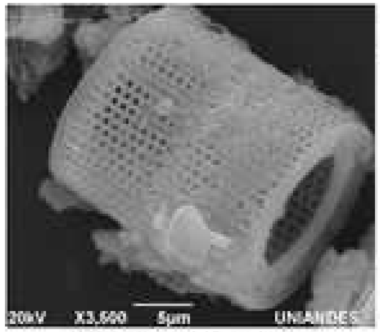


Centric Coscinodiscus

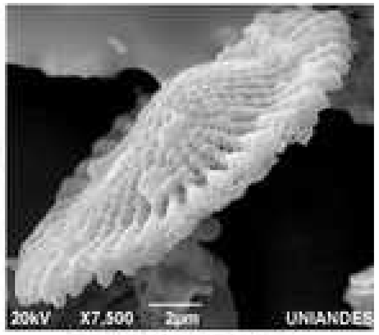
FRICTION ANGLE



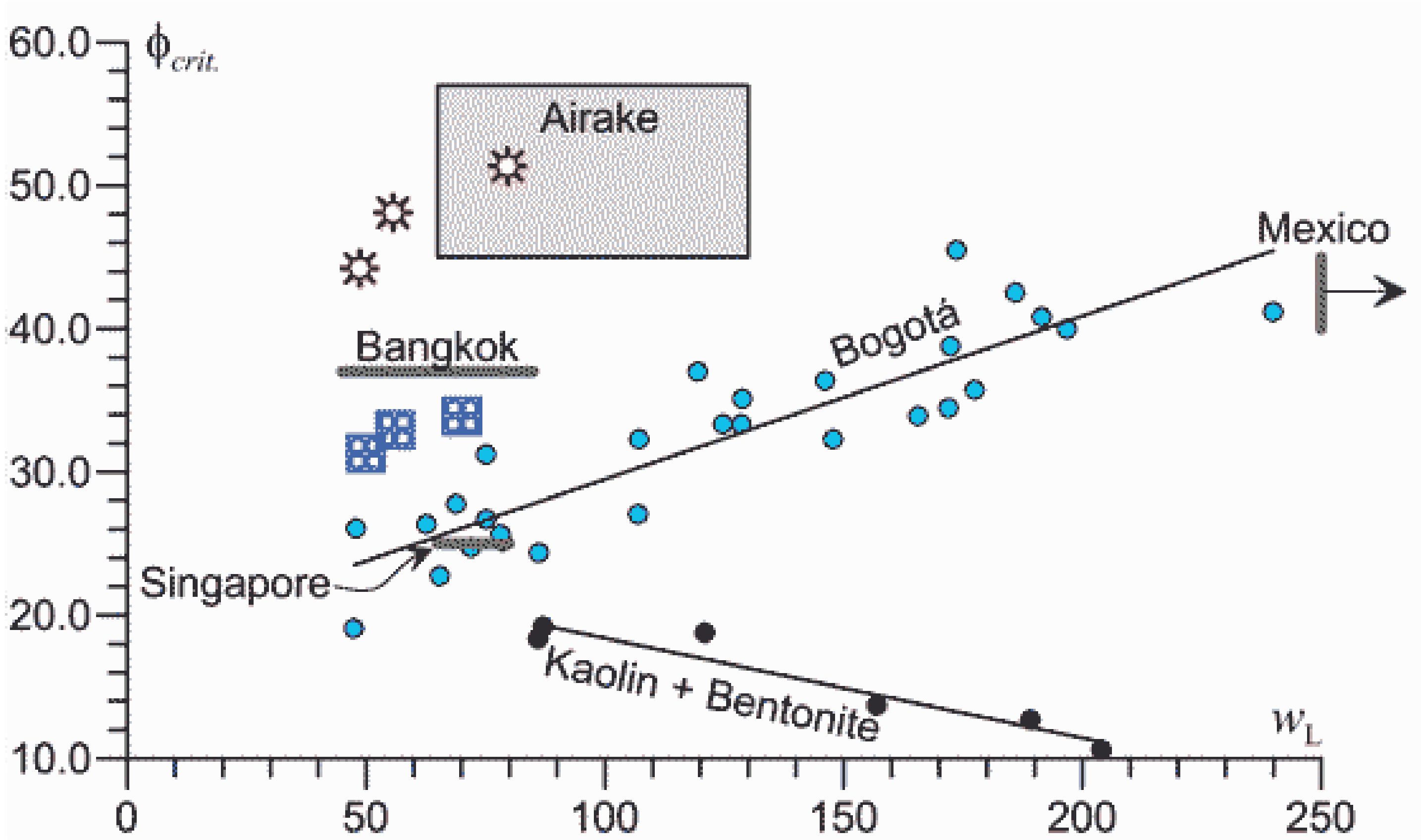
SHEAR STRENGTH, NATURAL AND MIXTURES



Aulacoseira Granulata



Centric Coscinodiscus



CONCLUDING REMARKS

- Diatoms seems to be a common feature in lacustrine and marine soft soils.
- Diatoms in soils can have an effect as important as the presence of clayey particles.
- However their effect is different compared with the presence of clays:
  - Plasticity grows (liquid limit).
  - Compressibility increases as well.
  - Time dependent behaviour is more pronounced.
  - The friction angle can reach very high values (40° or 45°).

QUESTIONS

- Which kind of interactions between particles lead to very high friction angles?
- Which is the role of the trapped water inside their bivalve structure?
- At the microscopic level how the shape of the diatoms specie affect the friction angle?
- How the diatoms affect the time dependant response of the soil?

CHALLENGES

- The size of the diatoms.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