Quantifying intrinsic and extrinsic factors affecting soil erodibility

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How to measure erodibility?

- Long term average from USLE unit-plot?

- Temporal variability?

How to measure erodibility?

- Field rainfall simulation (WEPP)?
- When?

How to measure erodibility?

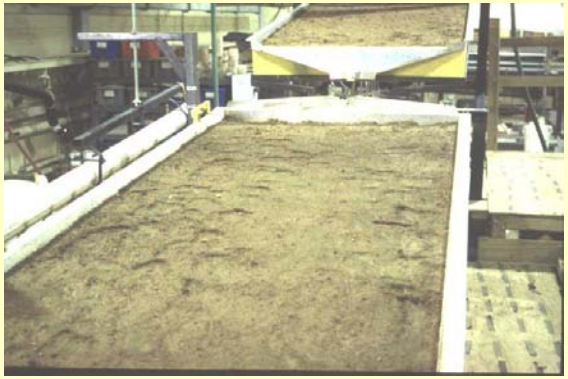
- Lab rainfall simulation?

- What subsurface hydrology?
  - Saturation?
  - Drainage?

Impact of subsurface hydrology

Seepage

Drainage



Impact of subsurface hydrology

Summer gully:

wide and shallow

Photos: I. Takken, K.U. Leuven Belgium

Winter gully:

narrow and deep

Objective

- Partition experimentally-measured erodibility and critical shear stress into intrinsic component and extrinsic component

- Intrinsic = f(soil physio-chemical properties)

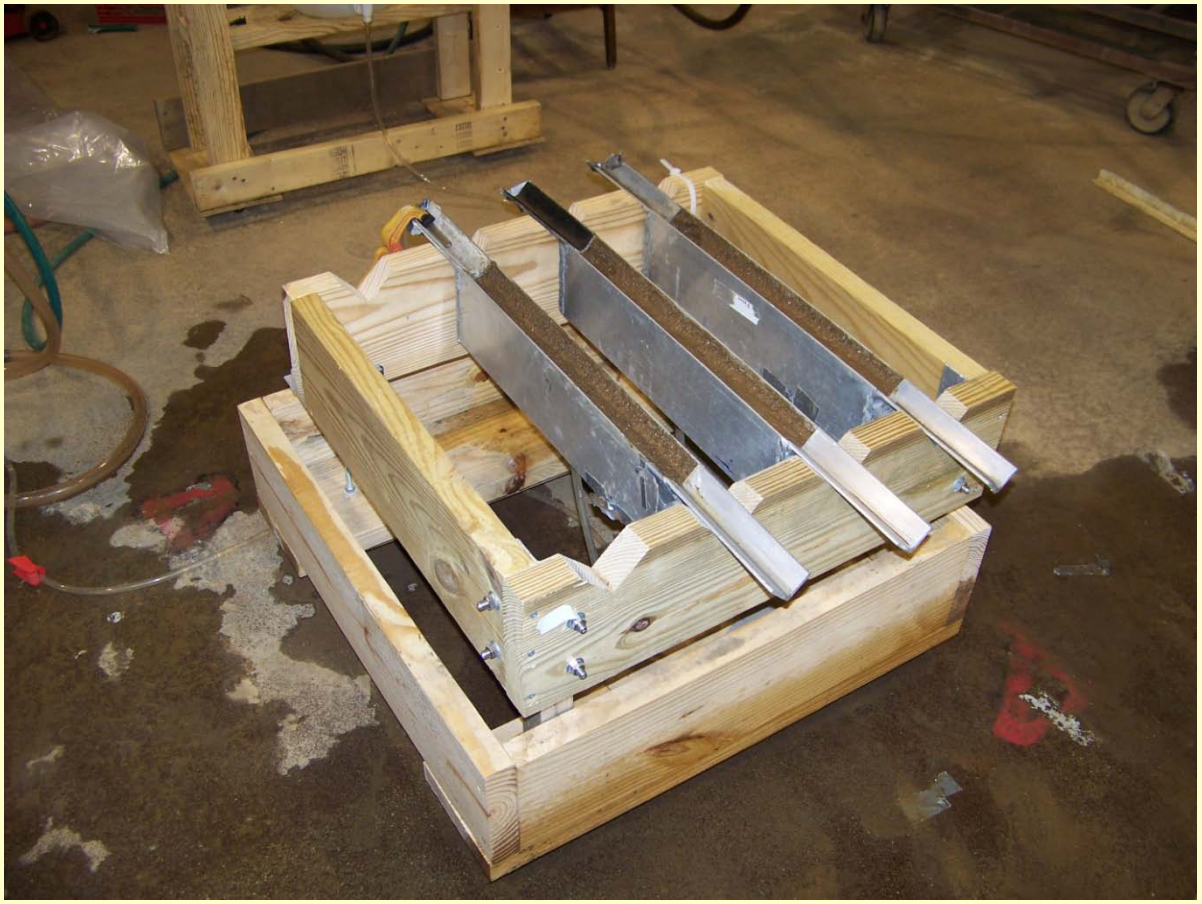
- Extrinsic = f(hydrologic condition during measurement)

Materials and methods

- Concentrated flow experiment in mini-flumes

$$D_r = K_r \cdot (\tau - \tau_{cr})$$

Vary τ and measure D_r



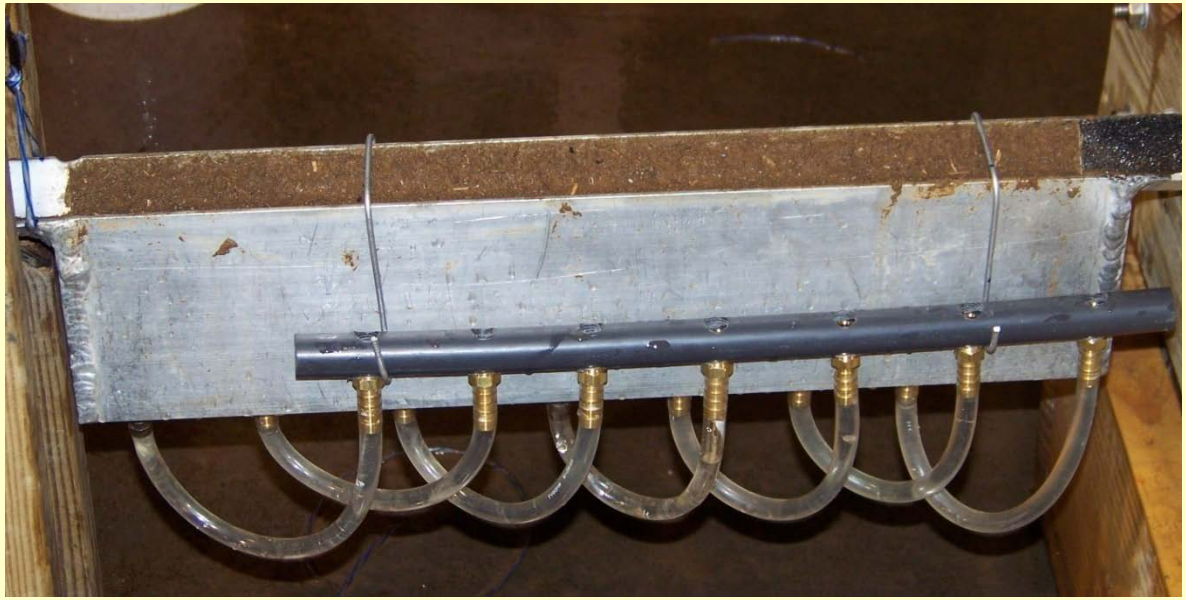
Materials and methods

- Treatments: 5 hydraulic gradients applied
- Drainage:

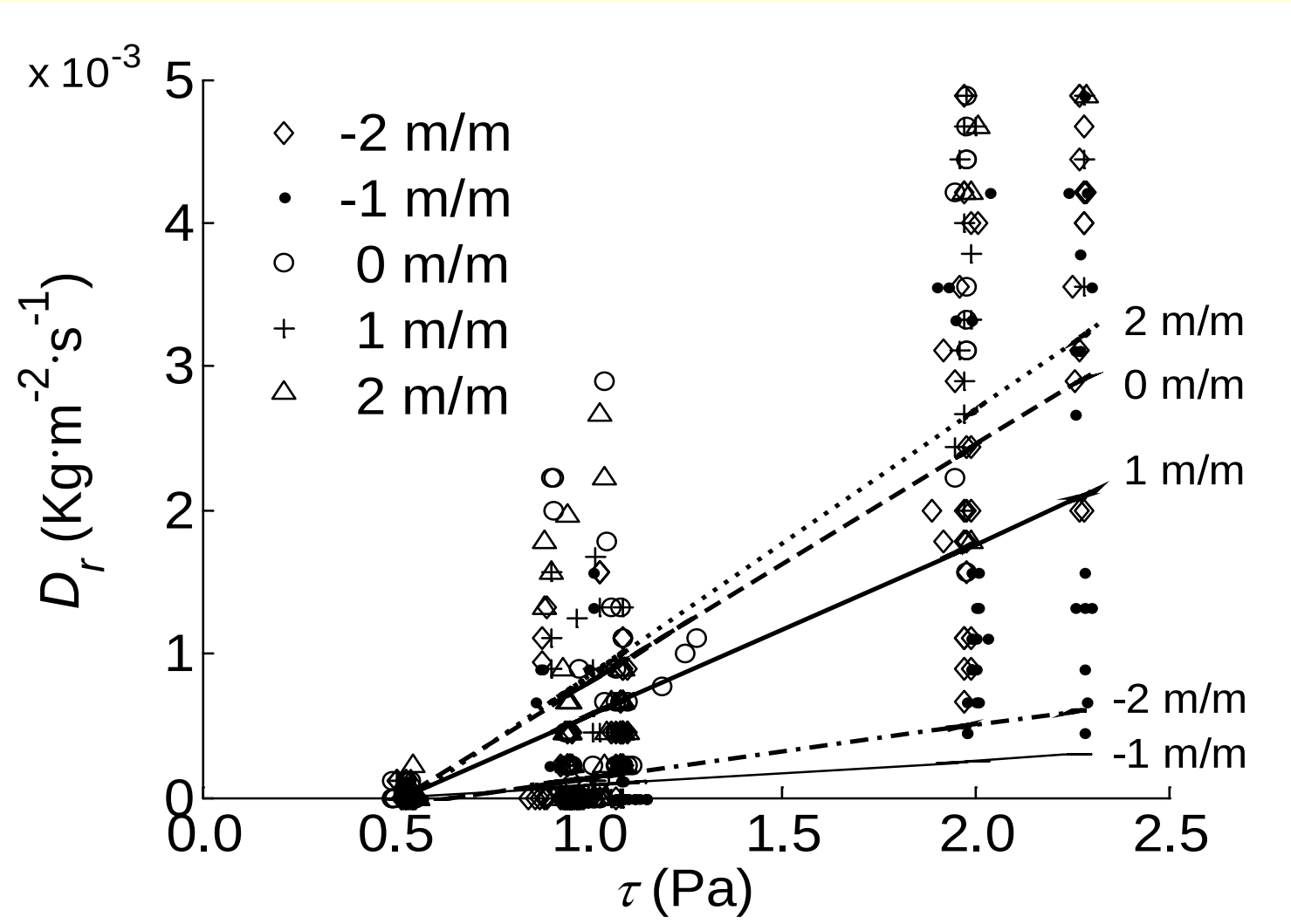
  -2 , -1 m/m
- Saturation:

  0 m/m
- Seepage:

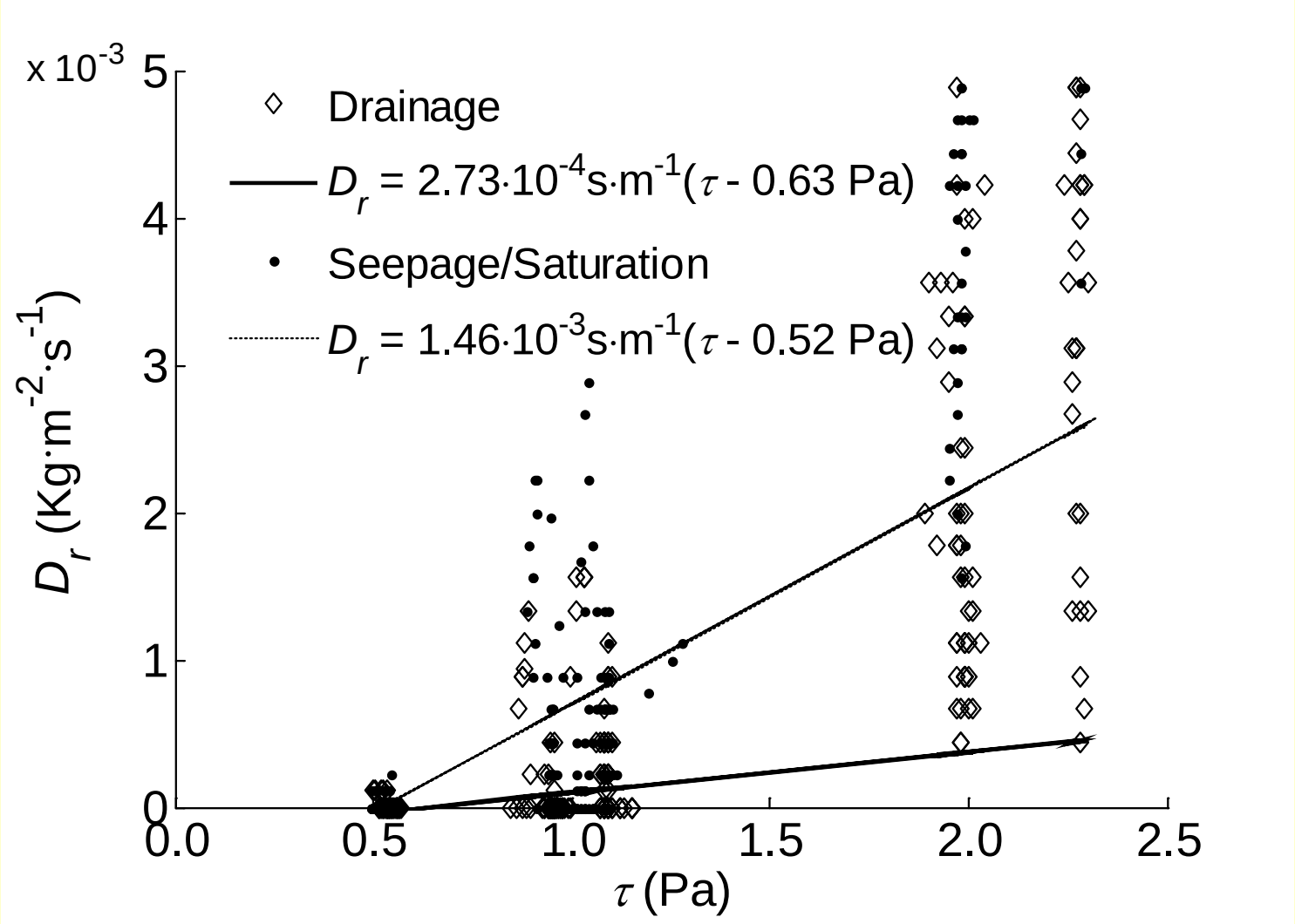
  +1, +2 m/m



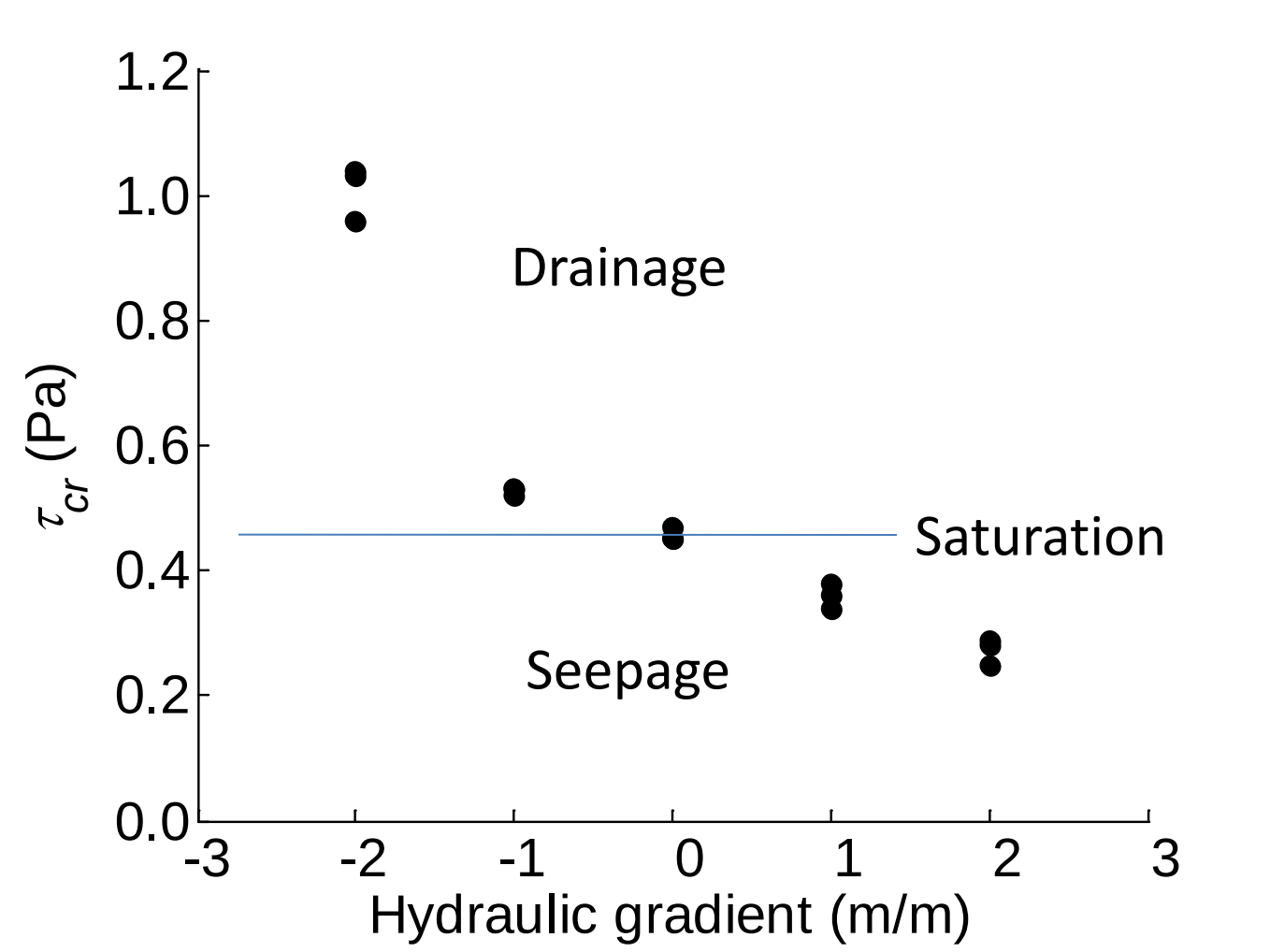
Results


x 10-3
5
4
3
2
1
0
0.0
0.5
1.0
1.5
2.0
2.5
Dr (Kg·m-2·s-1)
τ (Pa)
-2 m/m
-1 m/m
0 m/m
1 m/m
2 m/m
2 m/m
0 m/m
1 m/m
-2 m/m
-1 m/m

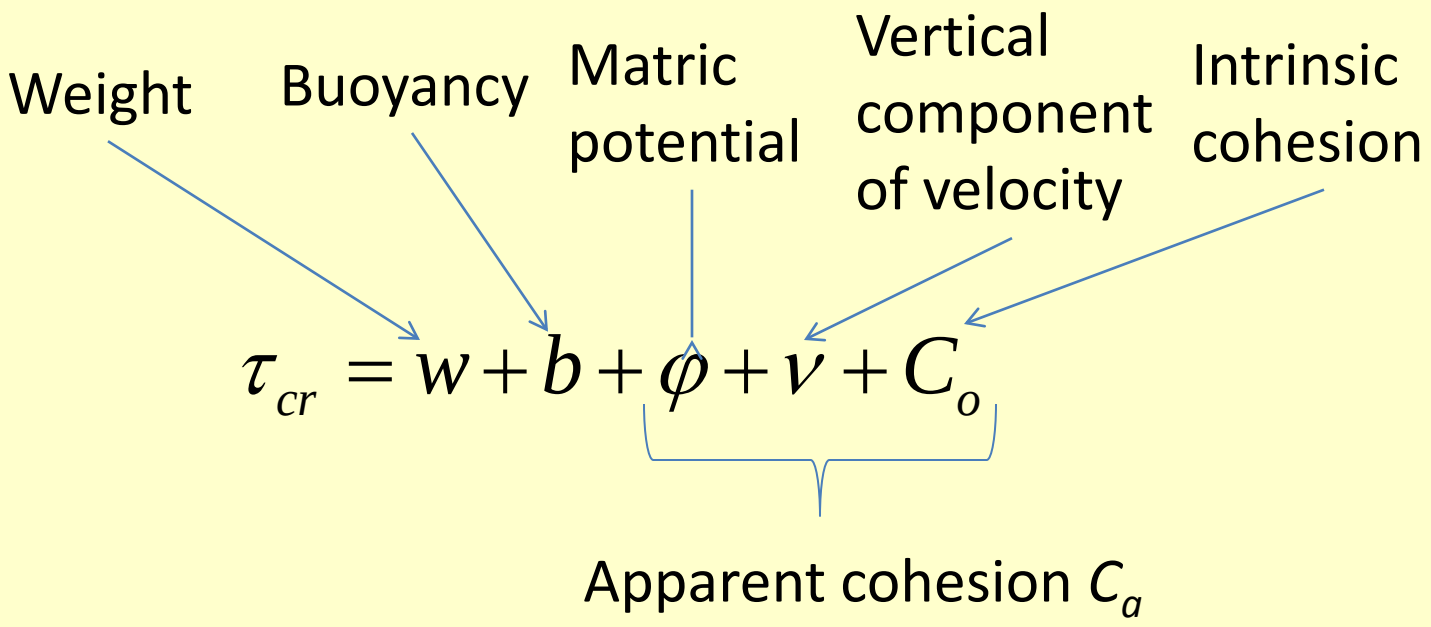
Results


x 10-3
5
4
3
2
1
0
Dr (Kg·m-2·s-1)
Drainage
Dr = 2.73·10-4s·m-1(τ - 0.63 Pa)
Seepage/Saturation
Dr = 1.46·10-3s·m-1(τ - 0.52 Pa)
0.0
0.5
1.0
1.5
2.0
2.5
τ (Pa)

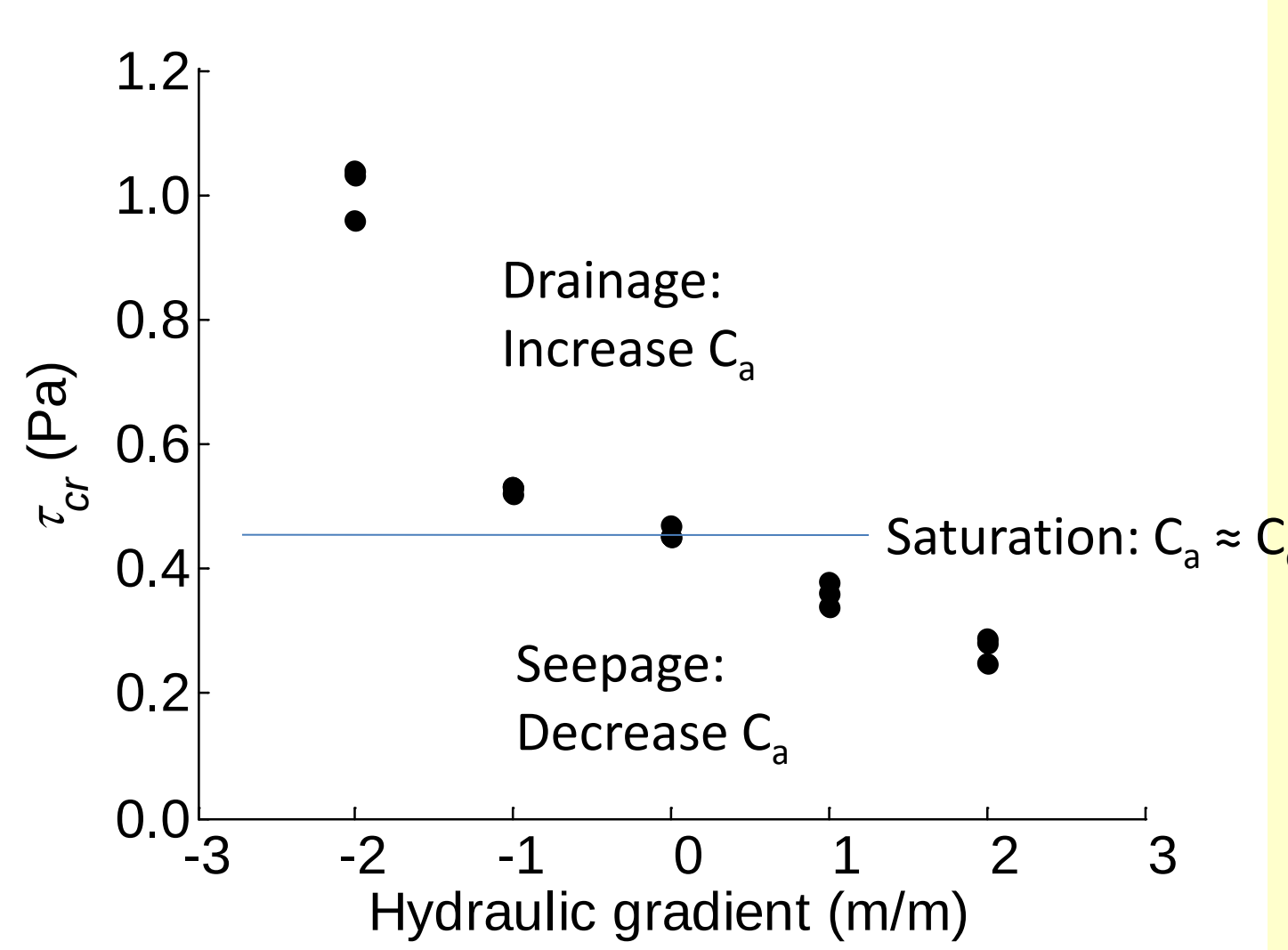
Results


1.2
1.0
0.8
0.6
0.4
0.2
0.0
τ_{cr} (Pa)
Drainage
Saturation
Seepage
-3
-2
-1
0
1
2
3
Hydraulic gradient (m/m)

Partitioning critical shear stress



Partitioning critical shear stress



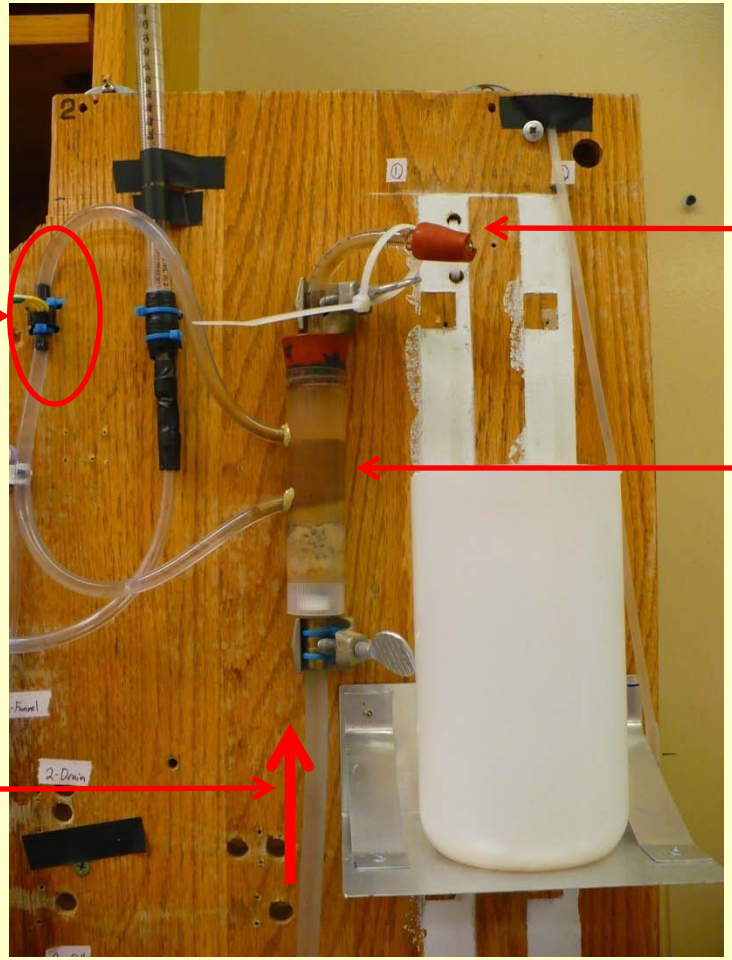
Partitioning erodibility

$$K = K_0 + K_E\left(i\right)$$

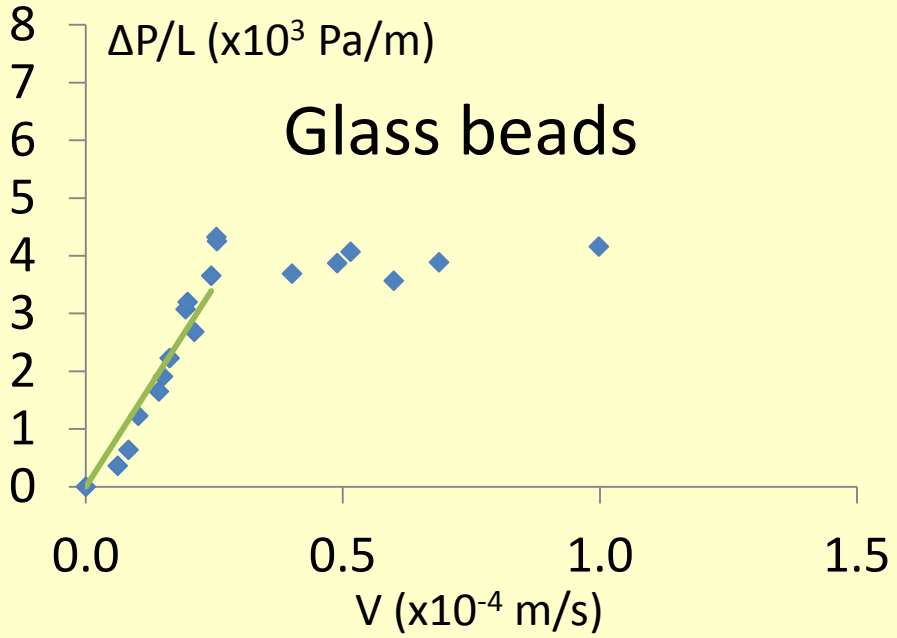
Measuring intrinsic values?

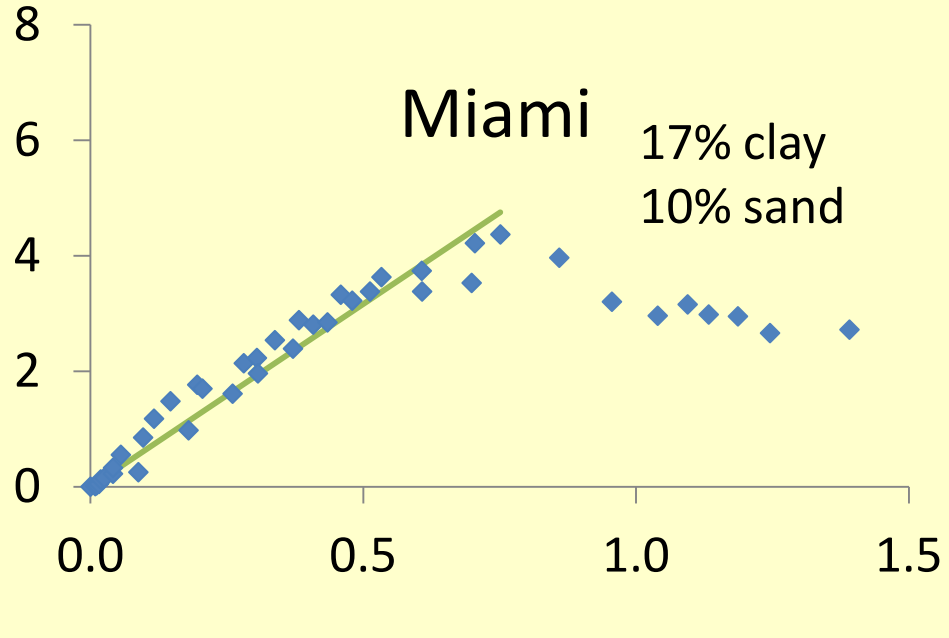
- Fluidized bed method
- Measure soil intrinsic cohesion without rainfall / runoff experiments
- Compare pressure drop required to fluidize the mass of a bed to the actual pressure drop measured at fluidization

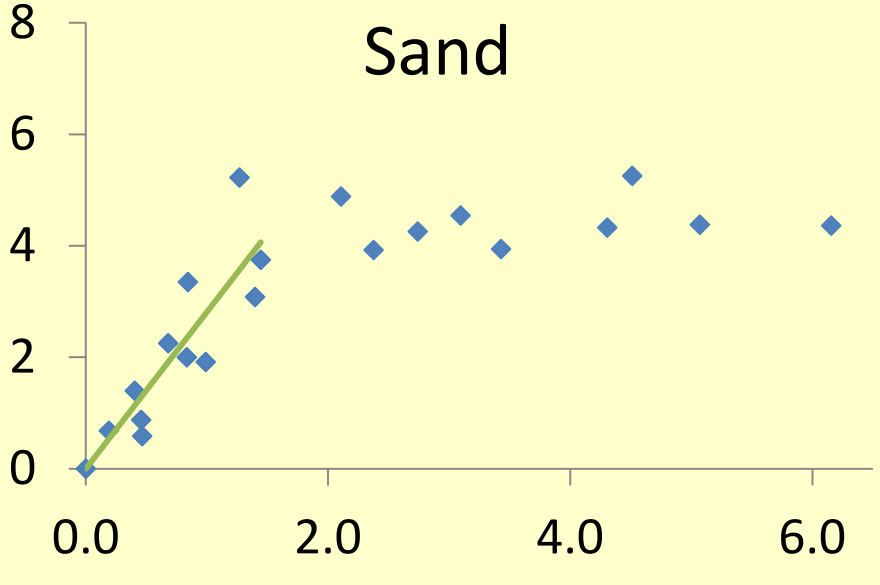
Fluidized bed experiment

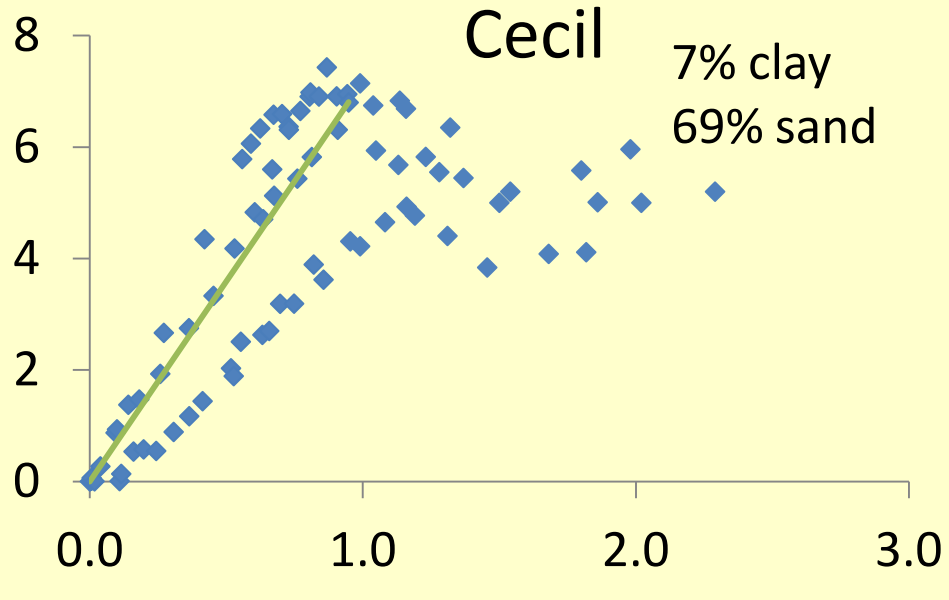


Some test results

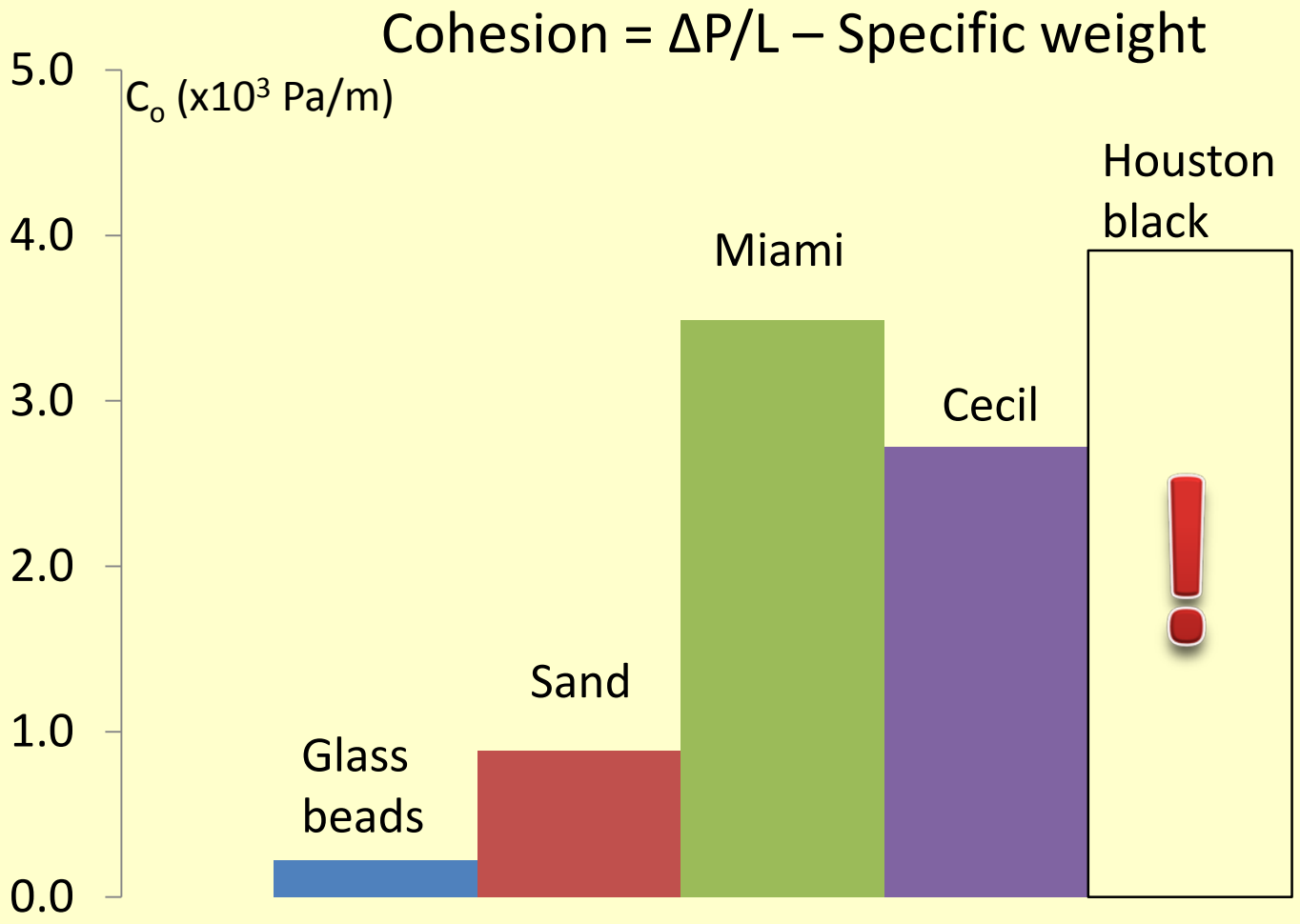








Some test results



Conclusions

- Soil under drainage condition 5.64 times less erodible than soil under seepage or saturation condition
- Soil erodibility and critical shear stress can be partitioned into an intrinsic term and an extrinsic term
- Extrinsic term is function of the subsurface hydrology during the measurement

Conclusions

- Intrinsic term is conceptually equal to soil erodibility measured under saturation conditions
- It is possible to determine intrinsic soil cohesion using fluidized bed approach

Thank you