Lecture 4

Evaluation of Strength of Bimrocks

BIMROCKS SHORT COURSE

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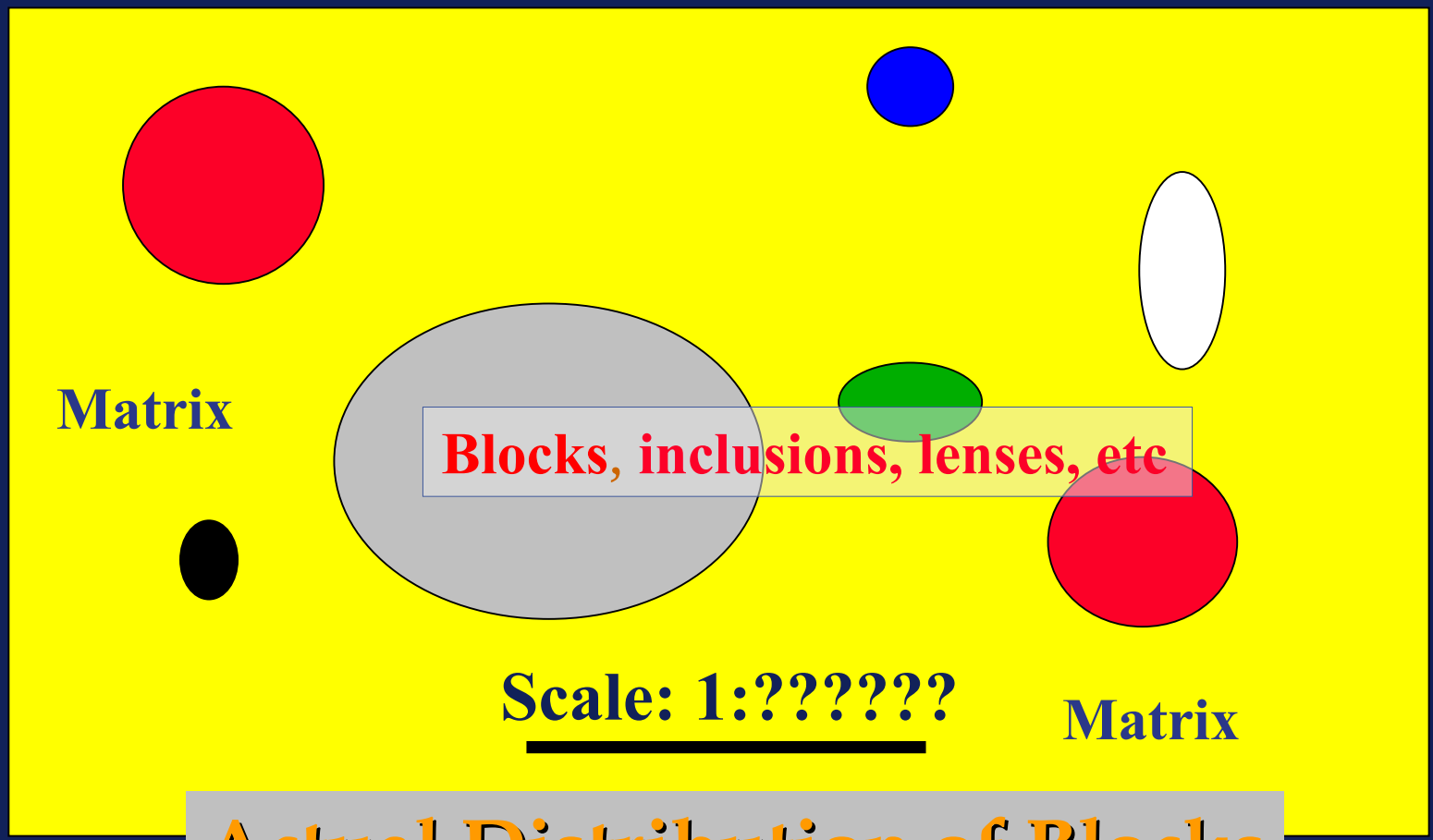
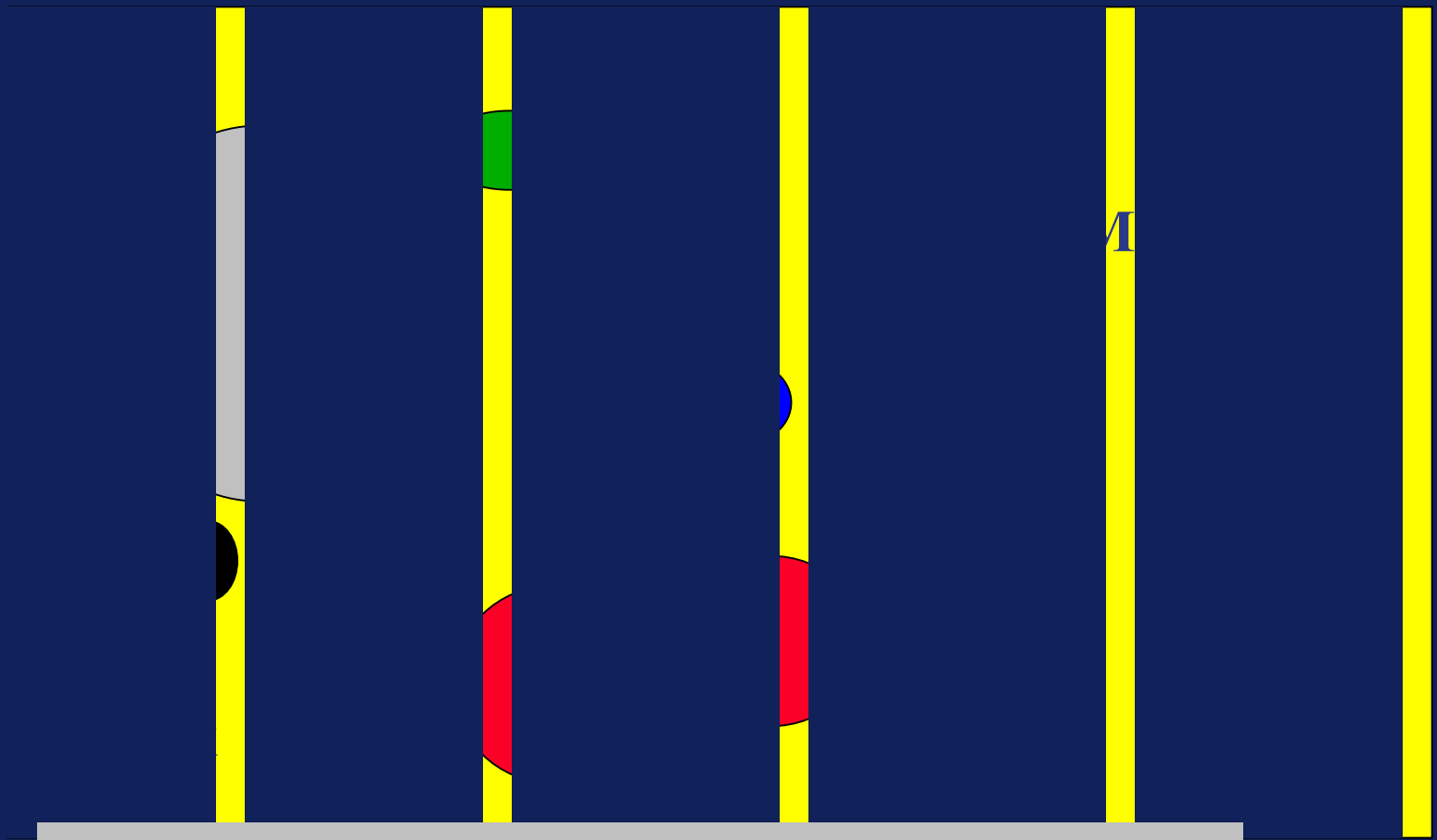
BIG CONCLUSION 1:
Remember this picture!!!



Medley, 2000

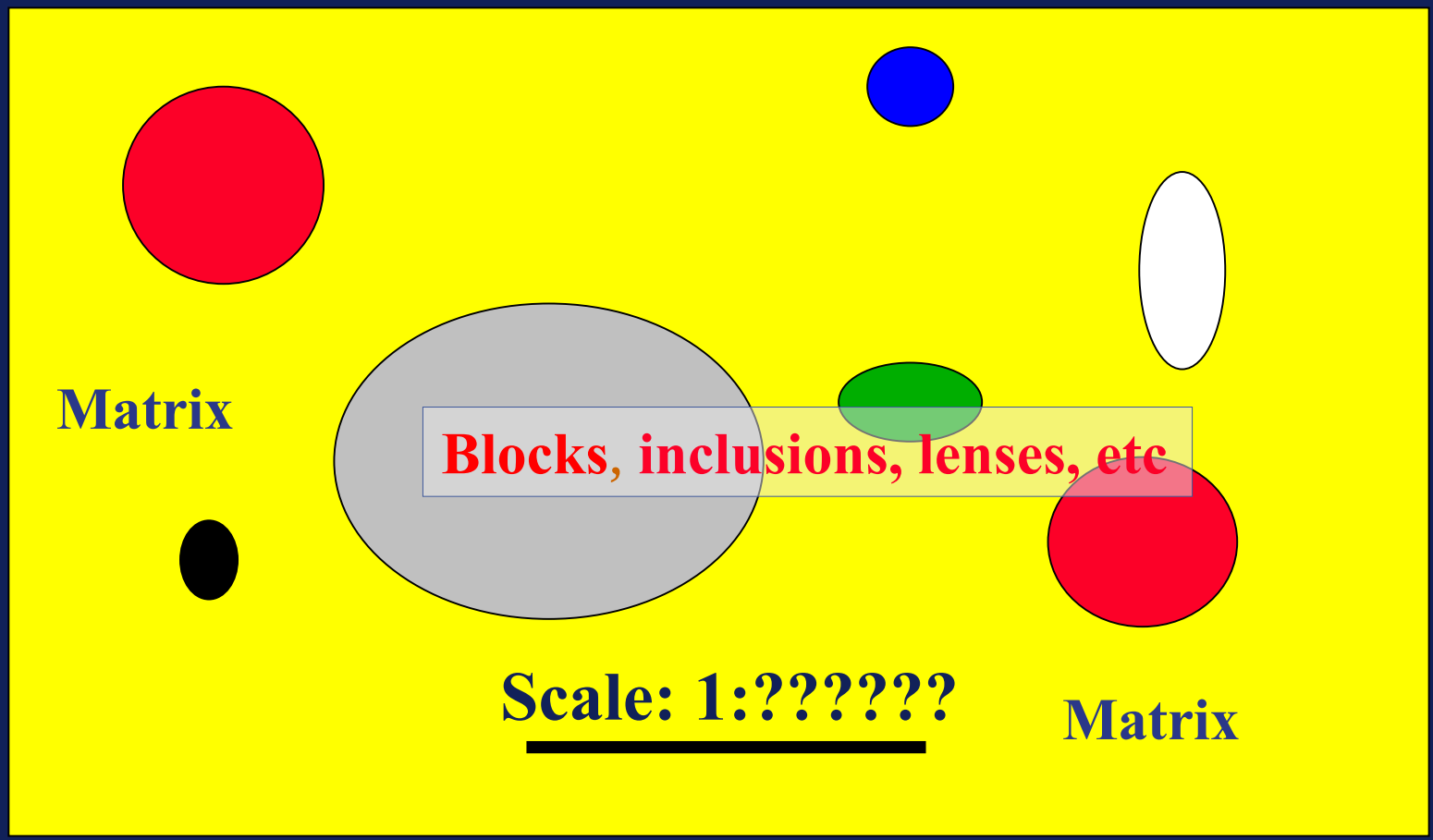
BIG CONCLUSION 2:
Remember this picture as well!!!



Apparent Distribution of Blocks

Willis, 2000

What is the strength of this mix?



Medley, 2000

Fundamental Questions

- 1. What is the strength of a geological mixture composed of strong blocks within a weaker matrix??
- 2. How much stronger do blocks have to be compared to matrix?
- 3. Does the strength of the blocks matter?
- 4. Is strength influenced by block geometries; orientations, and so on?
- 5. Why not just use the strength of the weak matrix and be “conservative”?
- 6. Does scale matter?

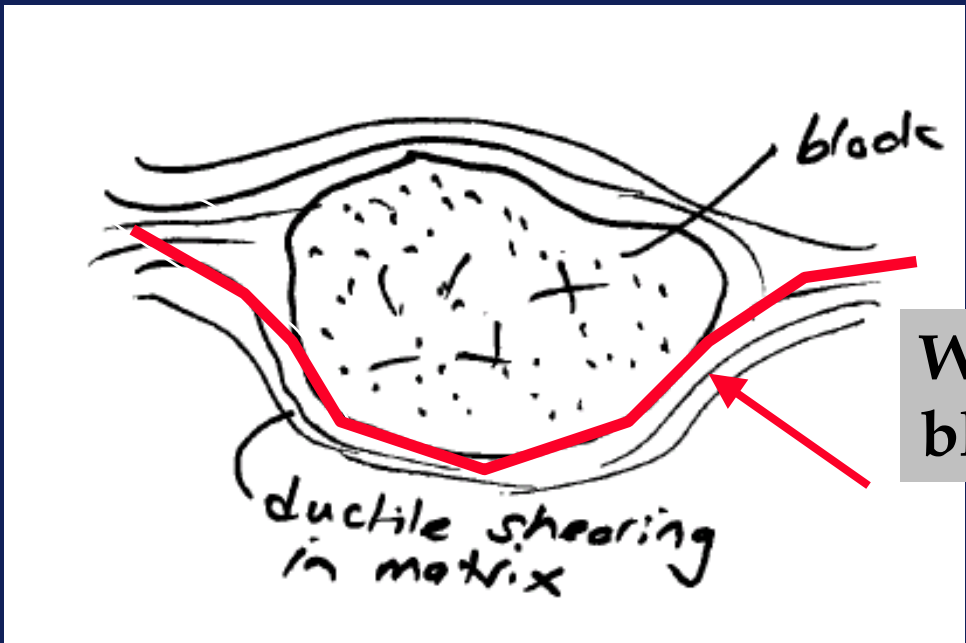
Fundamental Answers

Some are answered here and some have yet to be answered: some of you will one day answer them???

Block/matrix strength contrasts

- Simple criterion by Medley, 1994:
  - $\varphi_{block}/\varphi_{matrix}$ => 1.5-2.0
  - **Stiffness ratio** => 2.0
- UCS ratio
- Strength ratio (**c**, φ)

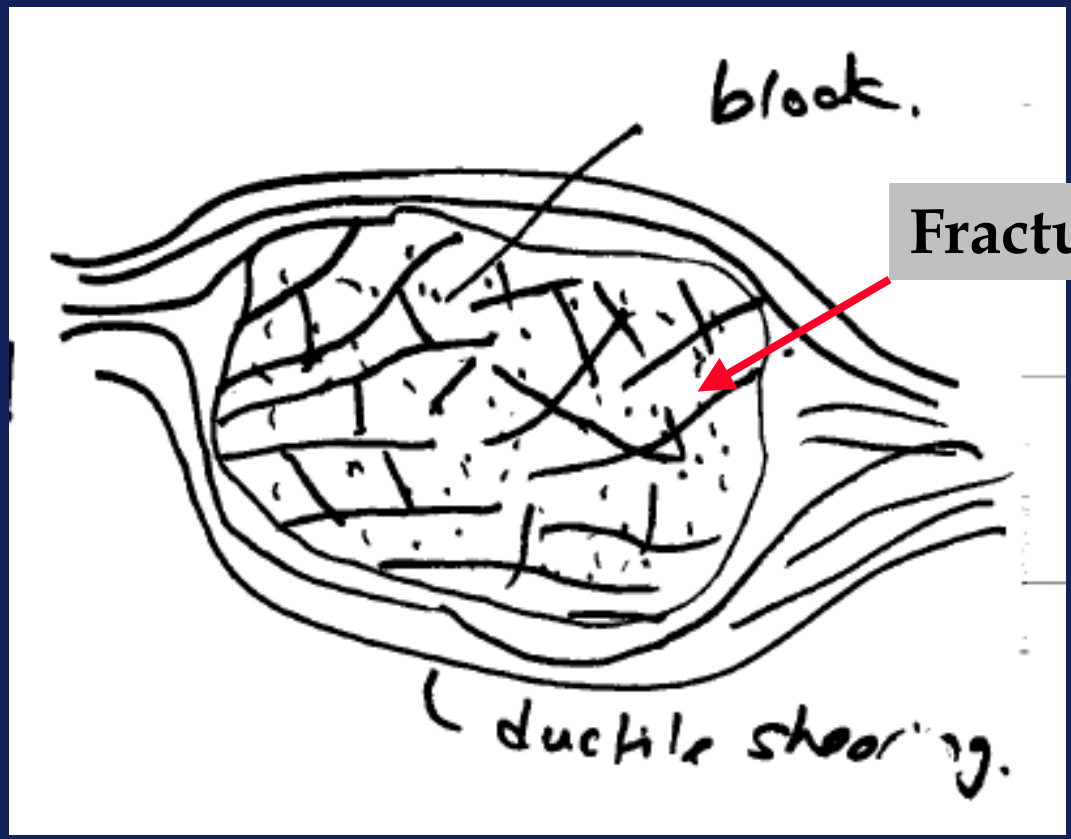
Shearing around block



Weakest element is block/matrix contact

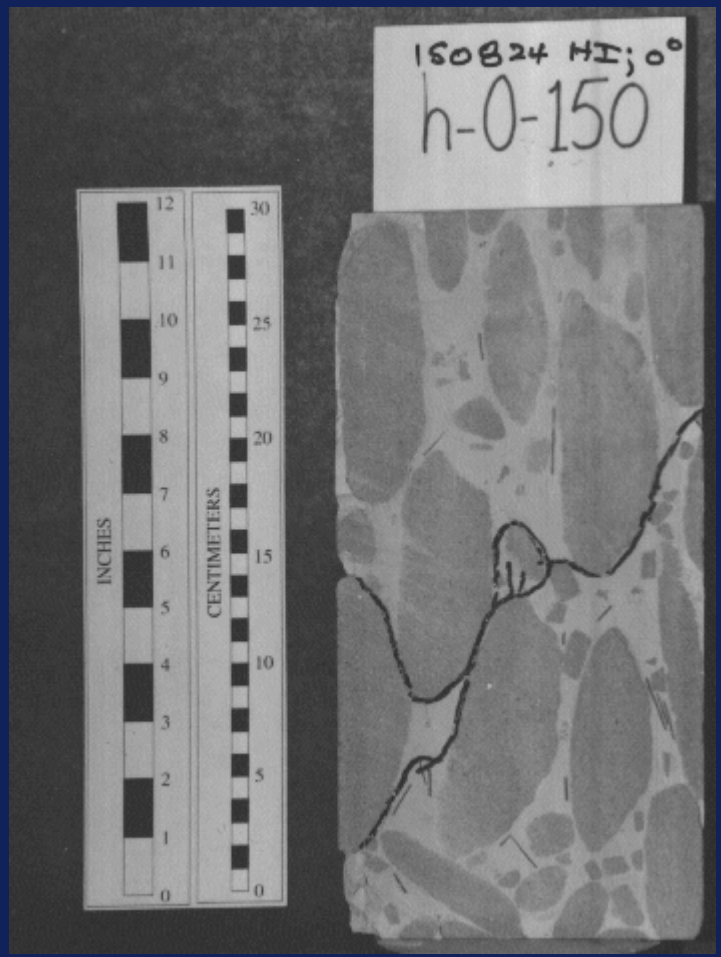
block/matrix contacts

A fractured block may be weak block: assign it to the matrix..

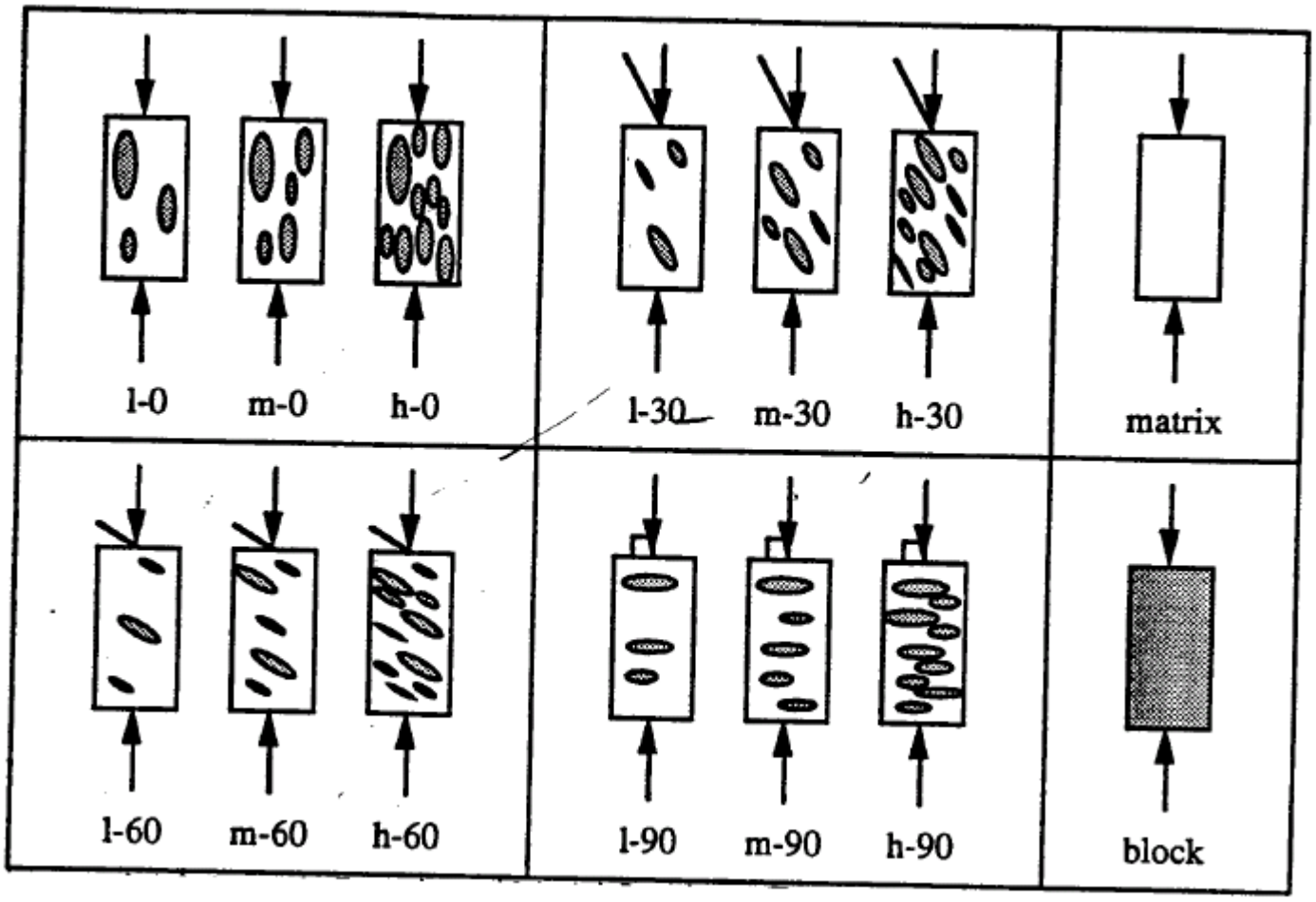


Strength of bimrocks

Lindquist (1994) tested >100 150 mm specimens of model melange



Different orientations and volumetric block proportions



Lindquist, 1994

Increase in friction angle with volumetric block proportion

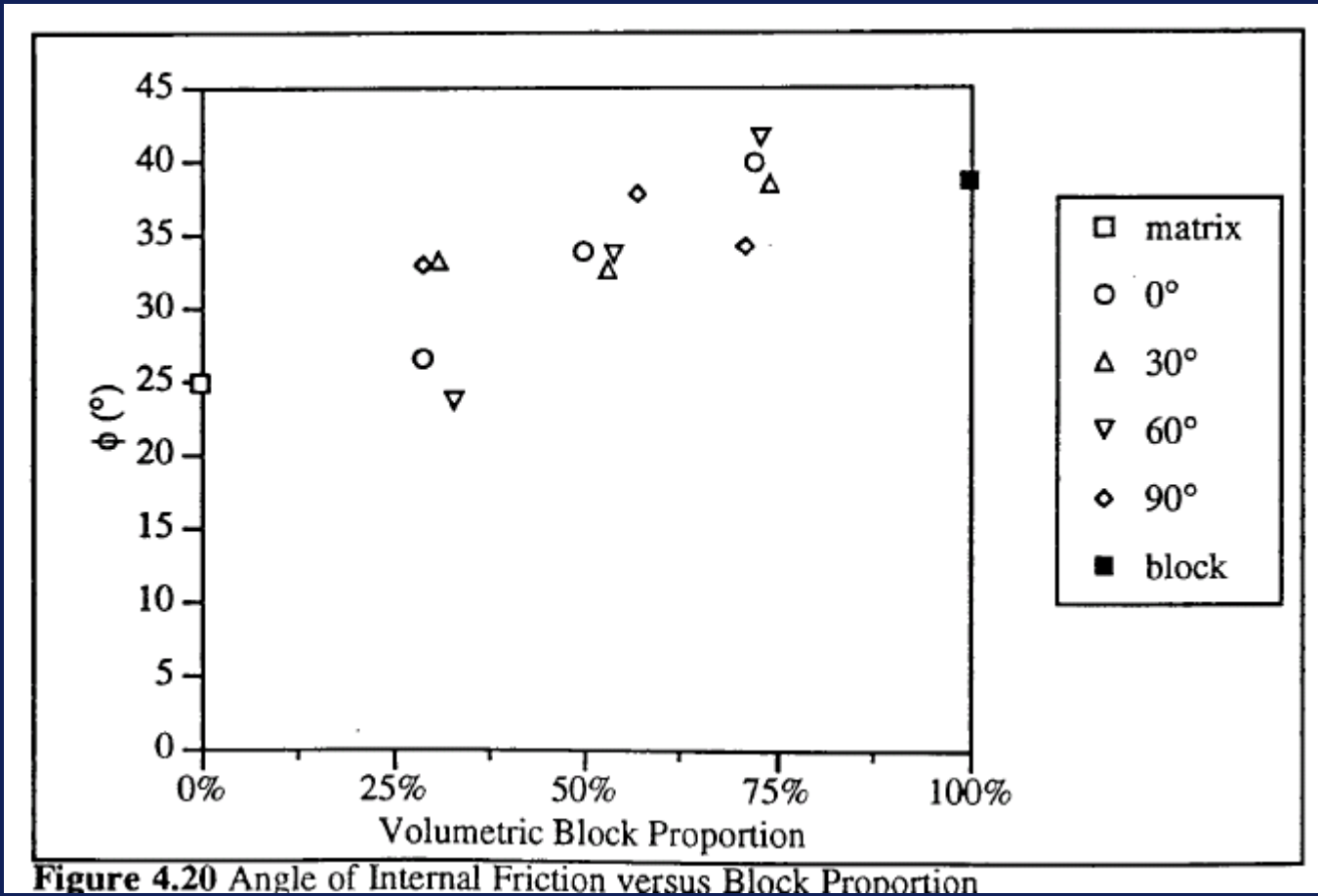


Figure 4.20 Angle of Internal Friction versus Block Proportion

Lindquist, 1994

Decrease in cohesion with volumetric block proportion

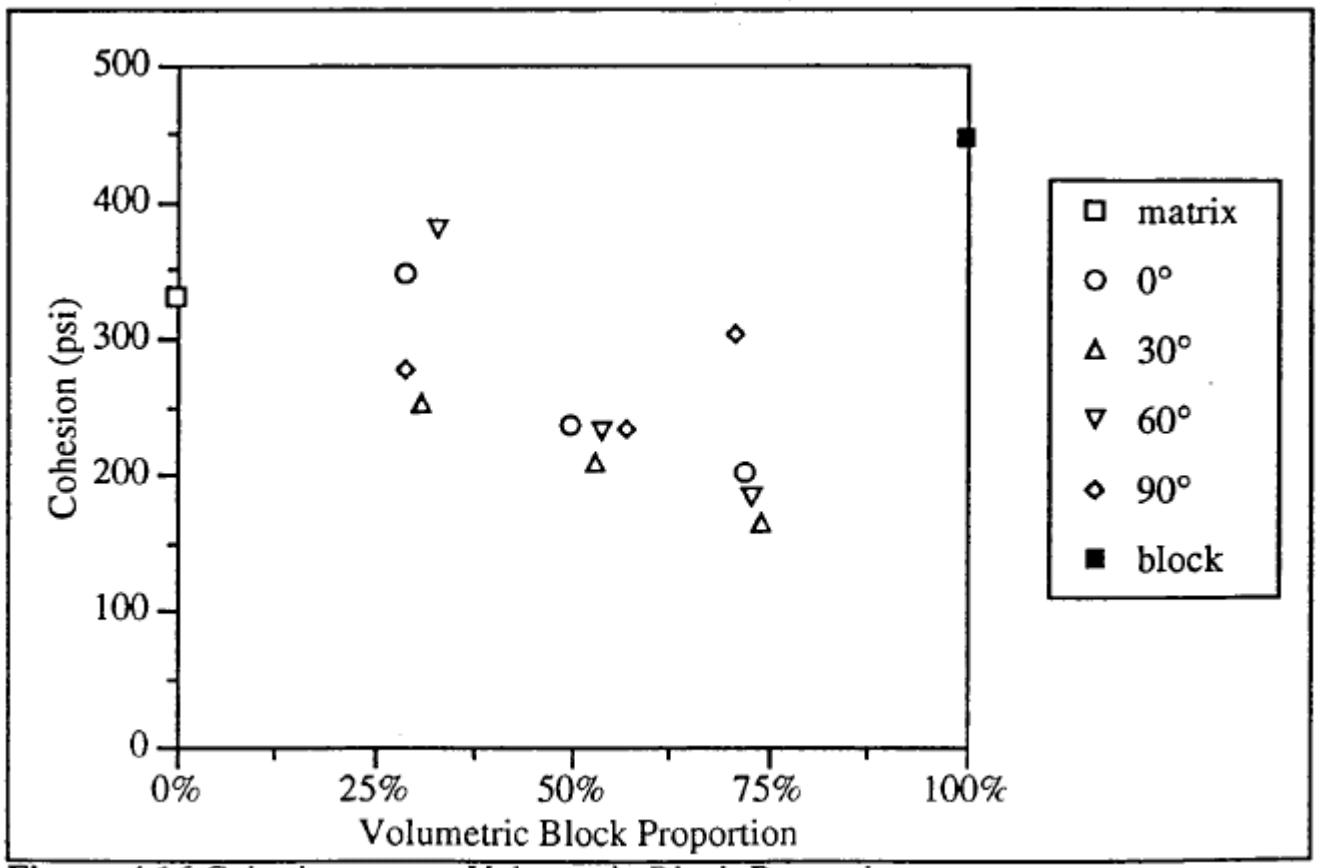


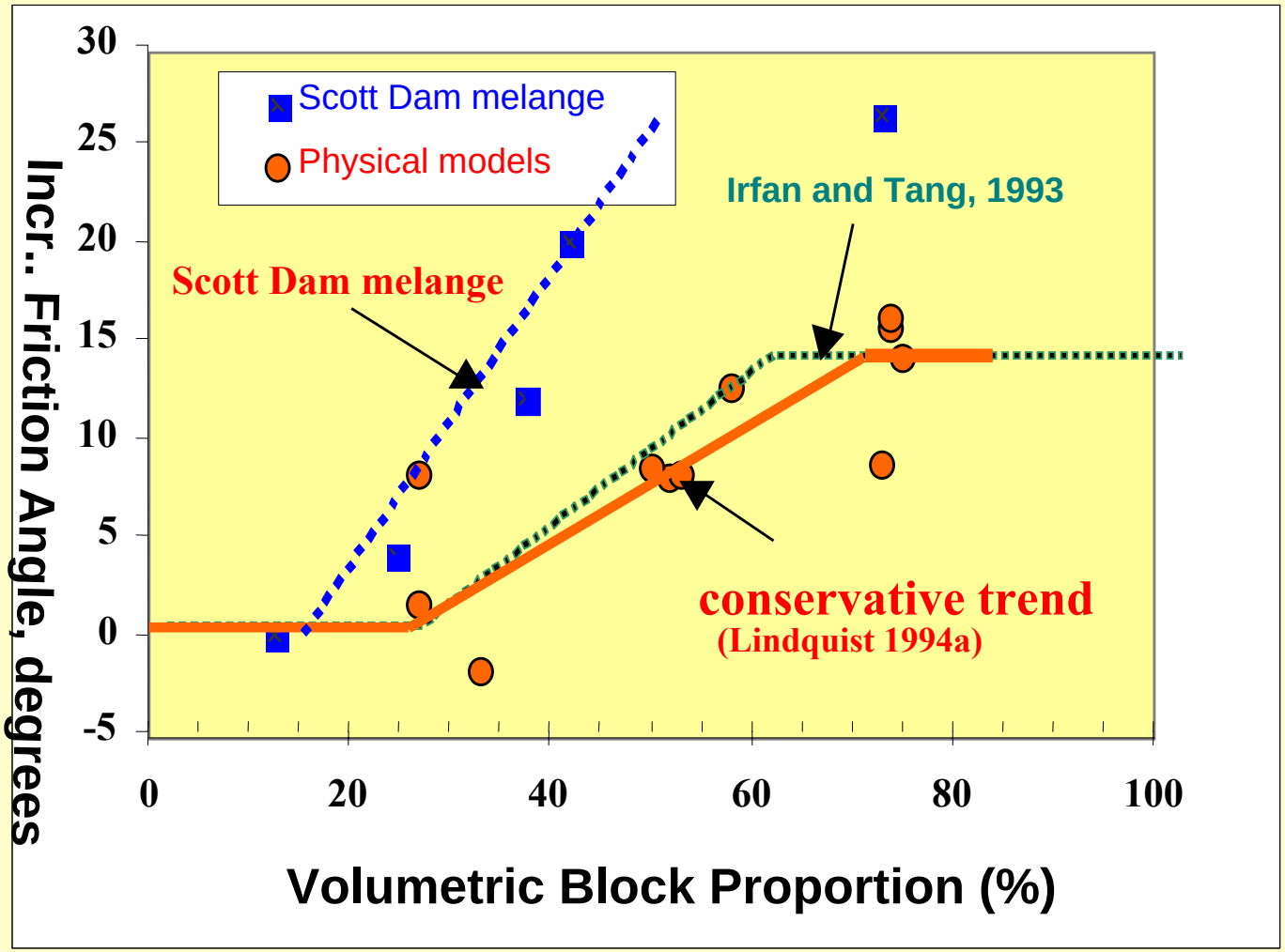
Figure 4.16 Cohesion versus Volumetric Block Proportion

Lindquist, 1994

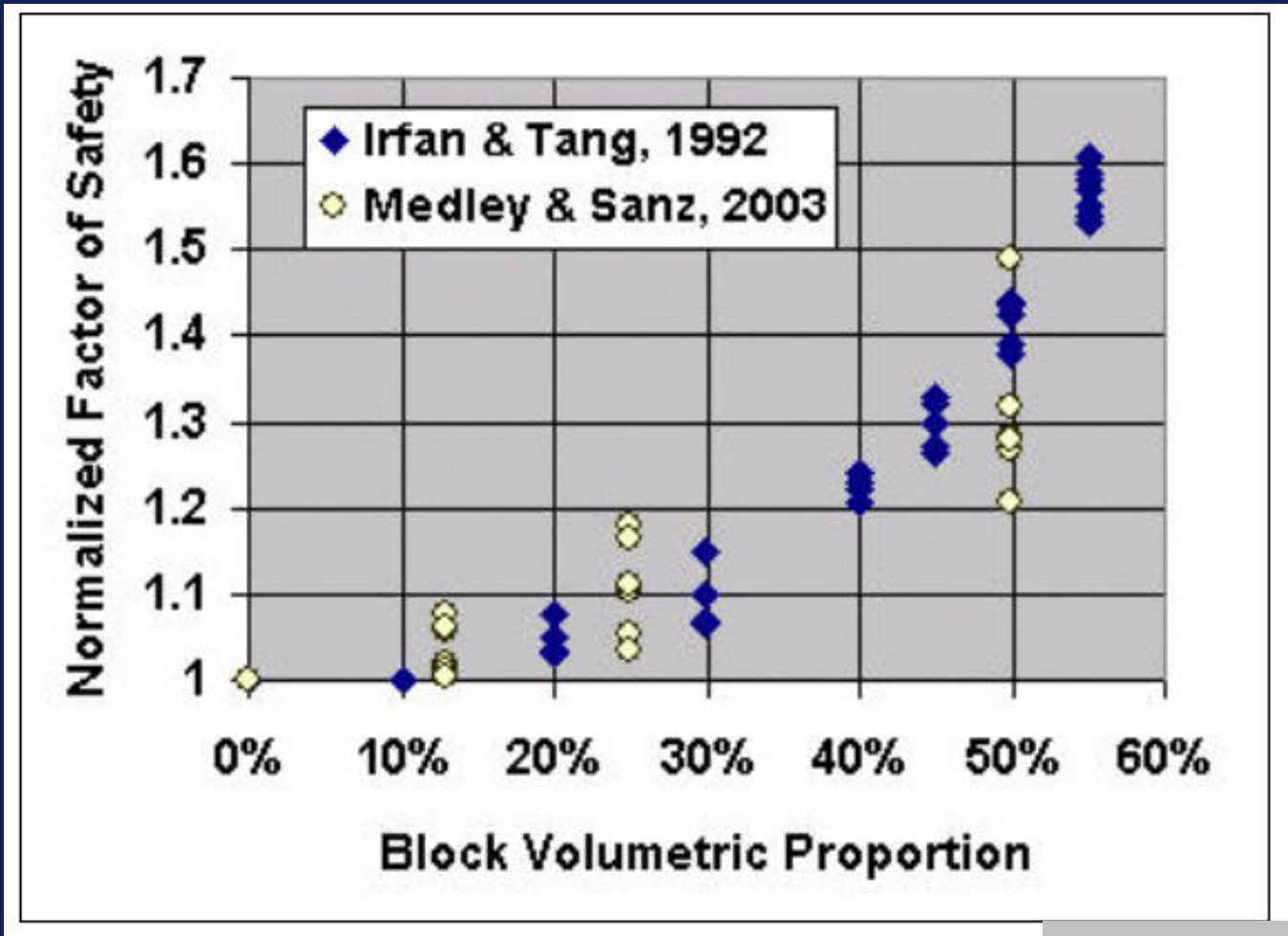
Strength and deformation properties of Melange Bimrocks

- Strength and deformation of melanges are independent of block strengths (Lindquist and Goodman,1994)
- Overall strength is directly related to volumetric block proportion
- Blocks adds friction, stiffen the mixture and reduce cohesion.
- Must perform geotech tests with blocks in specimens

Bimrock strength increases with block proportion (>~15%-25% V_v)



Compare with the relationship between volumetric proportion and FOS



Medley & Sanz, in press

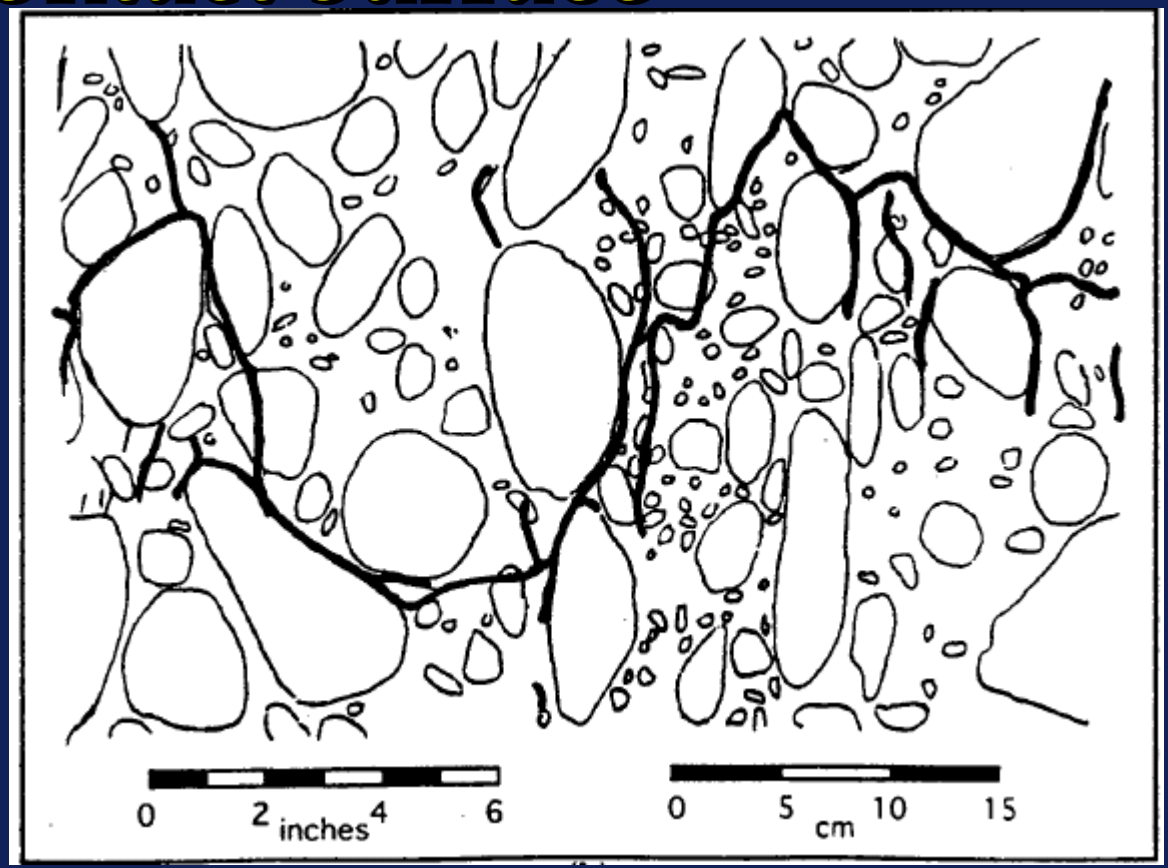
Strength of bimrocks depends on TORTUOSITY of failure surfaces negotiating around blocks

Failed physical model melanges

150 mm diameter Tx specimens (Lindquist, 1994)

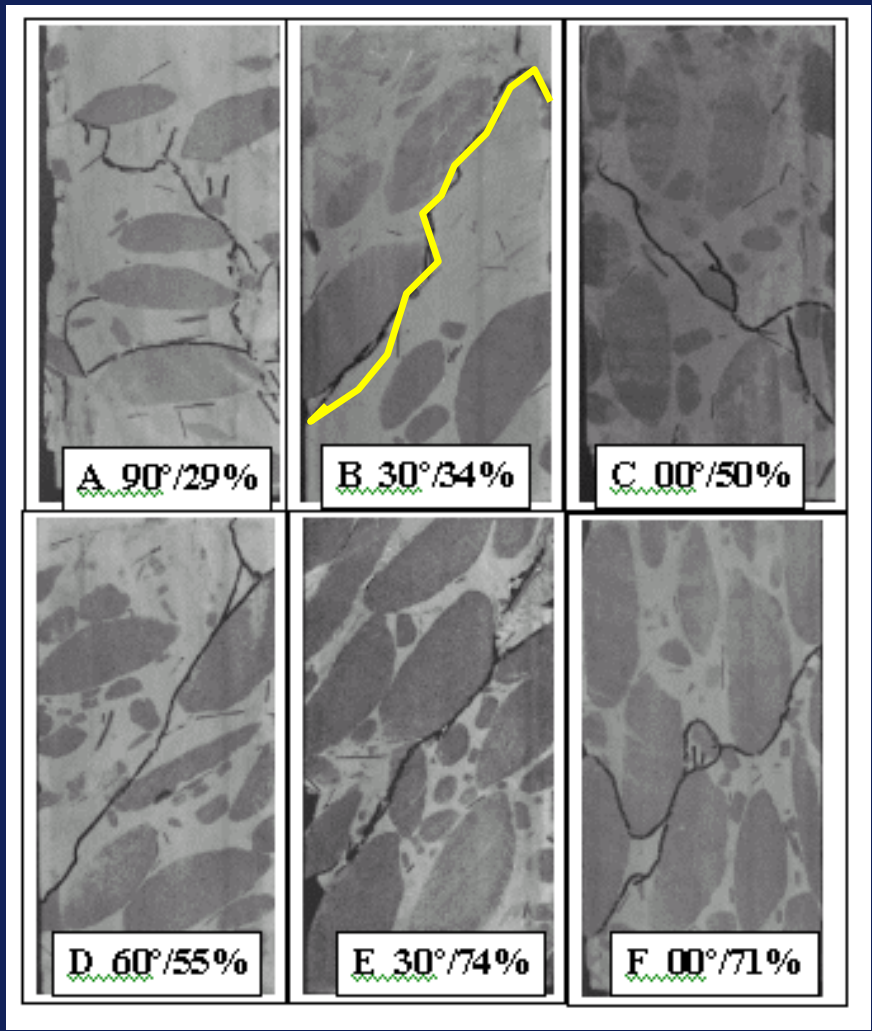
failure surfaces tortuously negotiate blocks

Tortuous surfaces negotiate around blocks at block/matrix contact surface

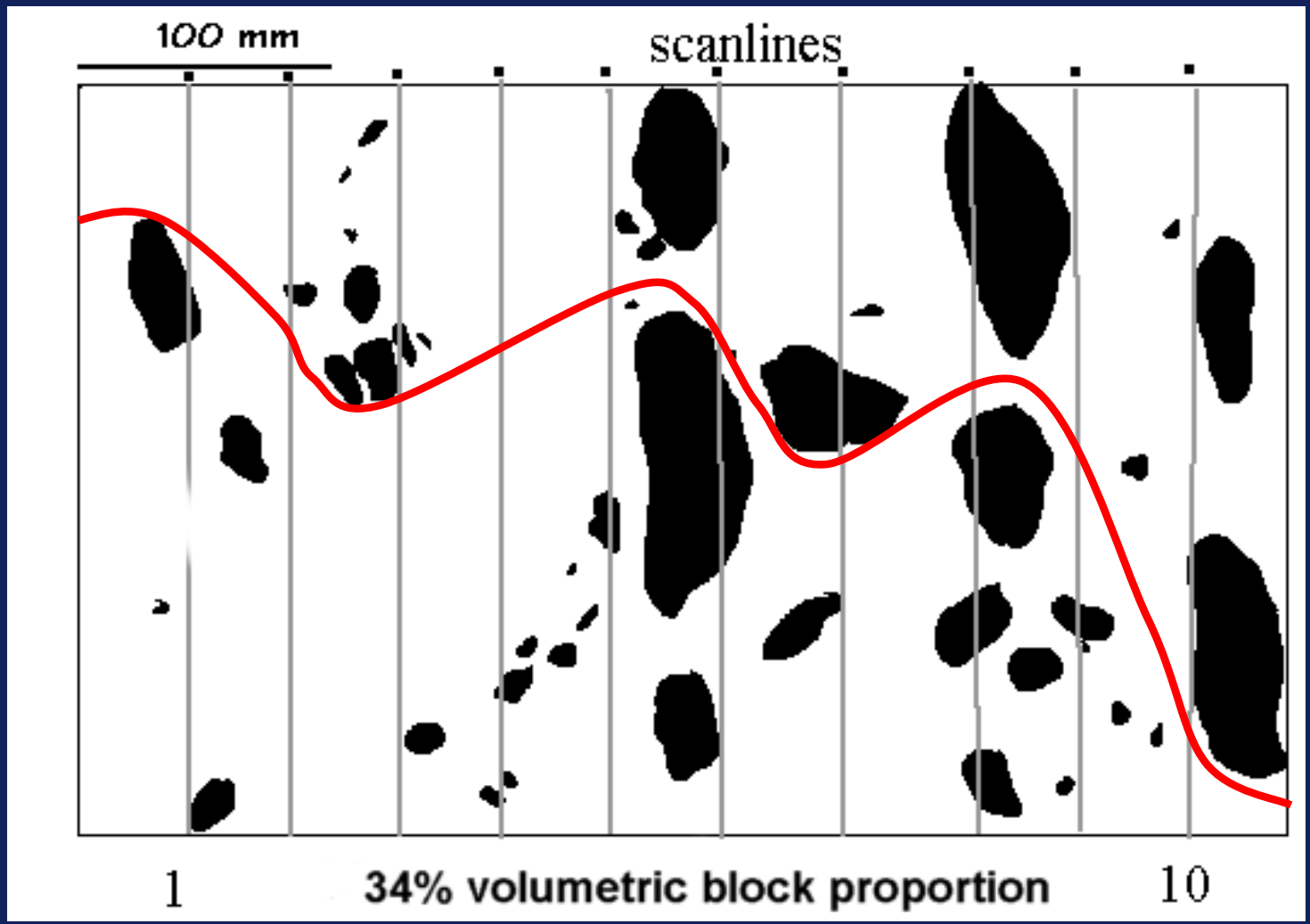


Lindquist, 1994

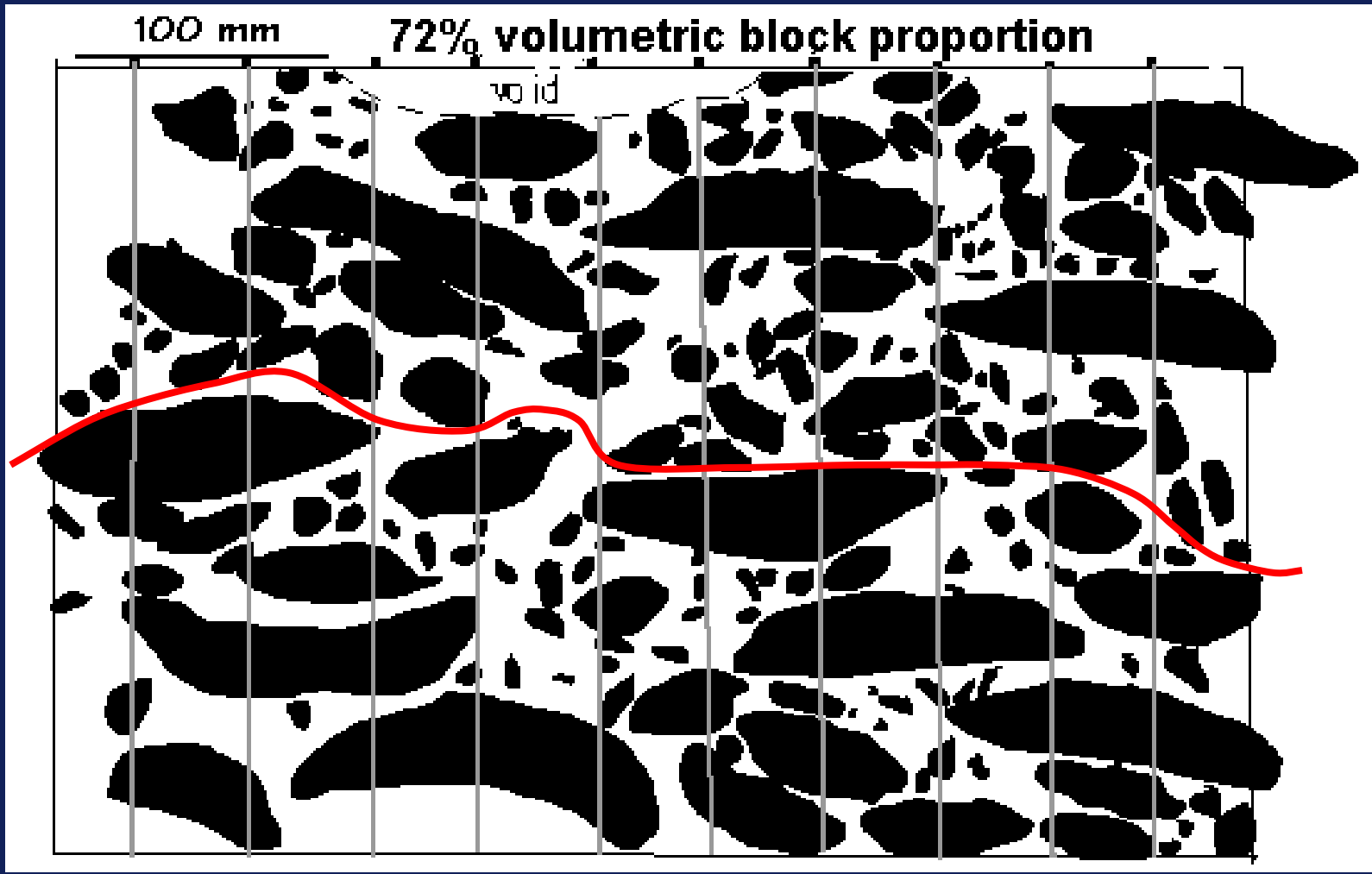
Tortuous surfaces within failed 150 mm diameter Tx specimens



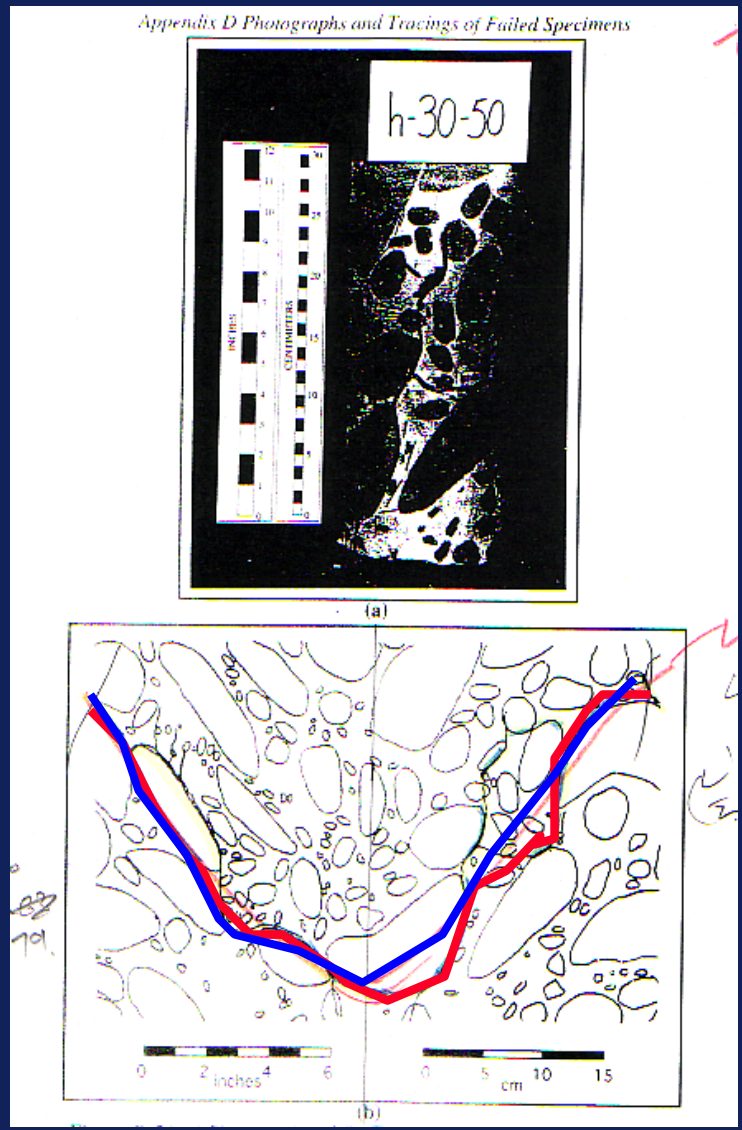
Tortuosity of failure surfaces influenced by low block proportion and vertical orientation



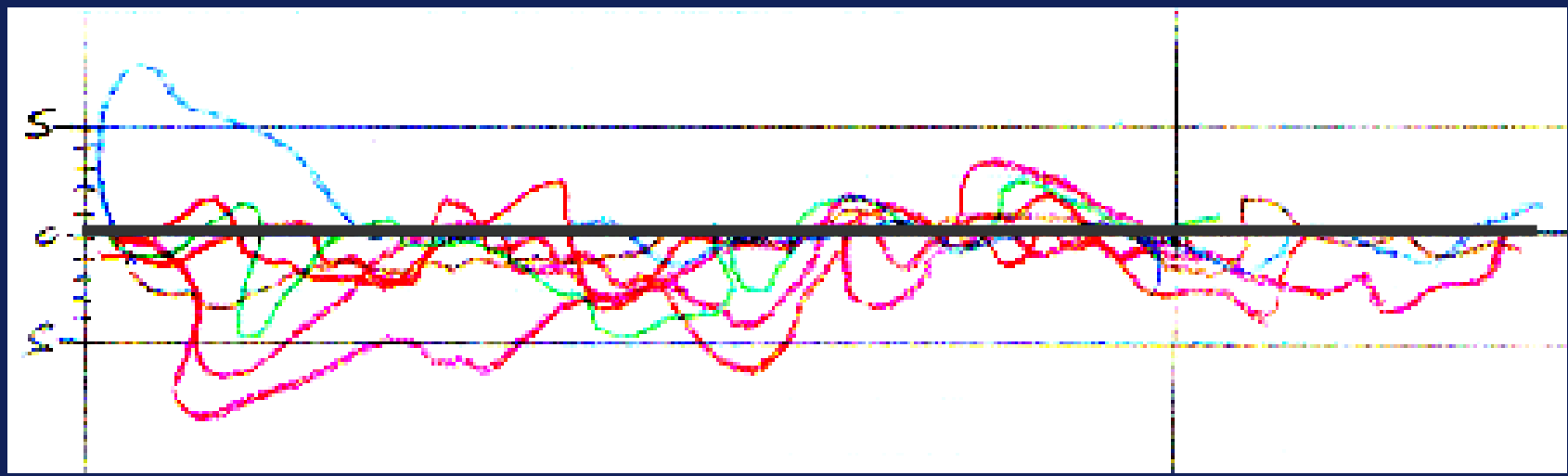
Tortuosity influenced by high proportion but horizontal orientation



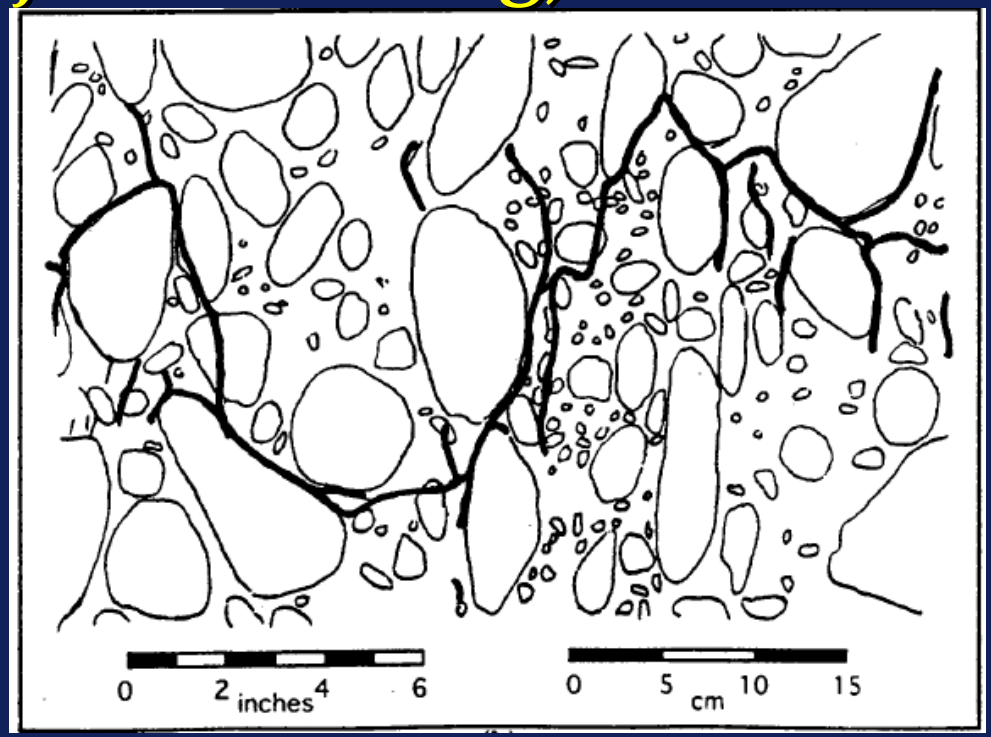
Measuring tortuousity (current work)



Tortuous surfaces unrolled (current work)



Block strengths seem to matter at high block proportion because at high block proportions blocks start touching (consider as blocky rock mass with wide joint infilling)



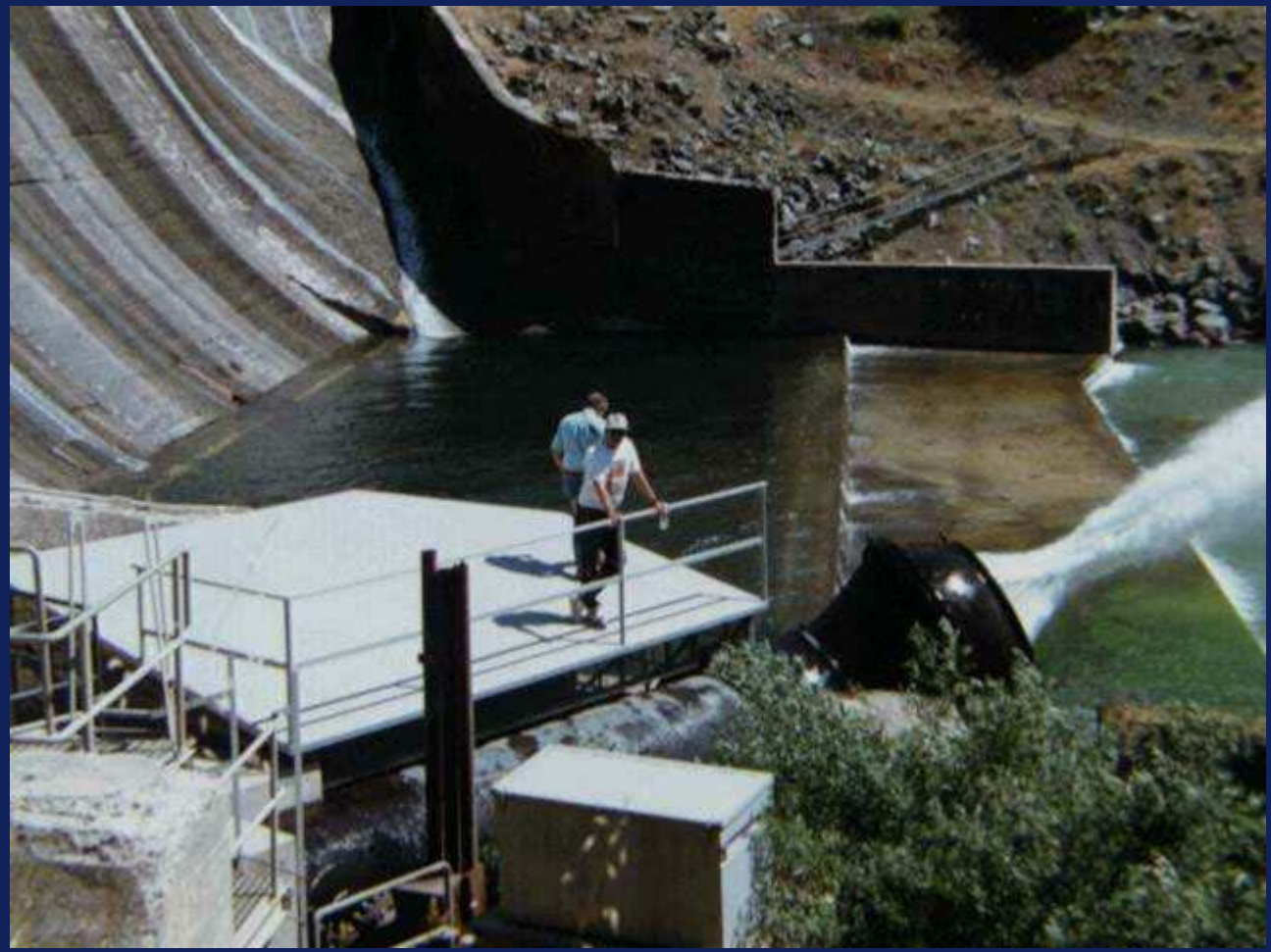
Lindquist, 1994

Example: SCOTT DAM, CA

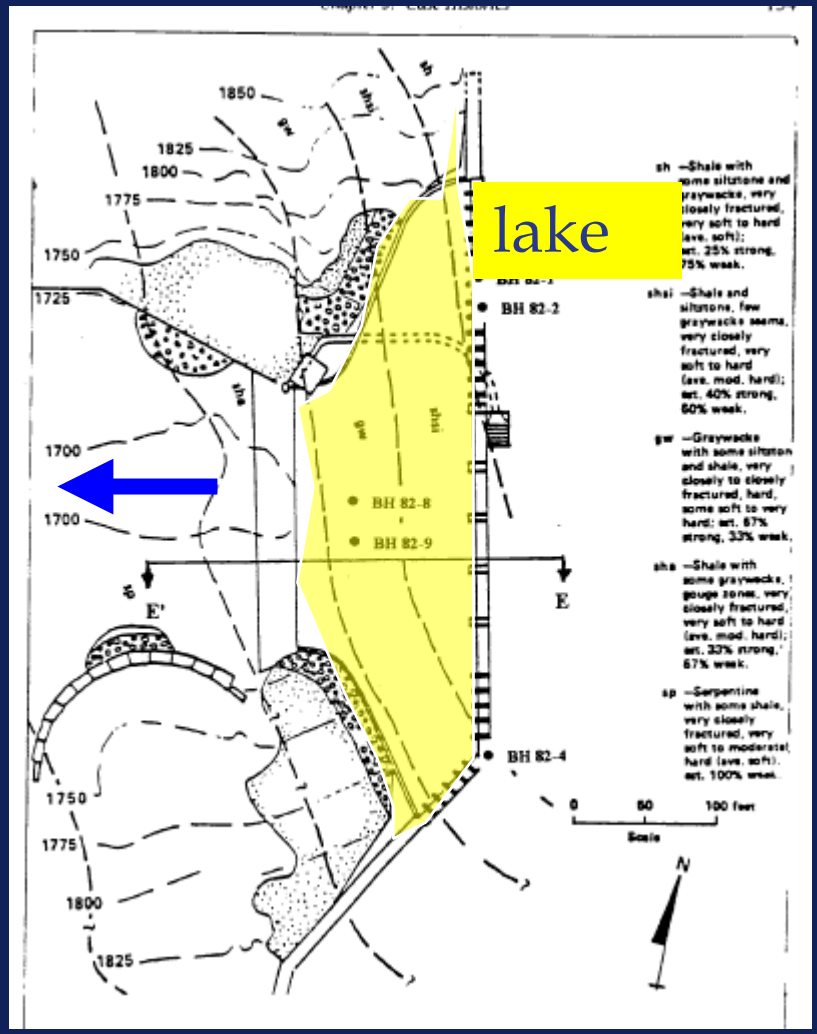
- Testing shows matrix ϕ = 25 deg.
- Measured linear proportion = 40%
- Adjusted vol. block proportion = 32%
- Rockmass ϕ = 39 degrees

Goodman and Ahlgren, 2000;
Medley, 2001

Foundation of dam is melange

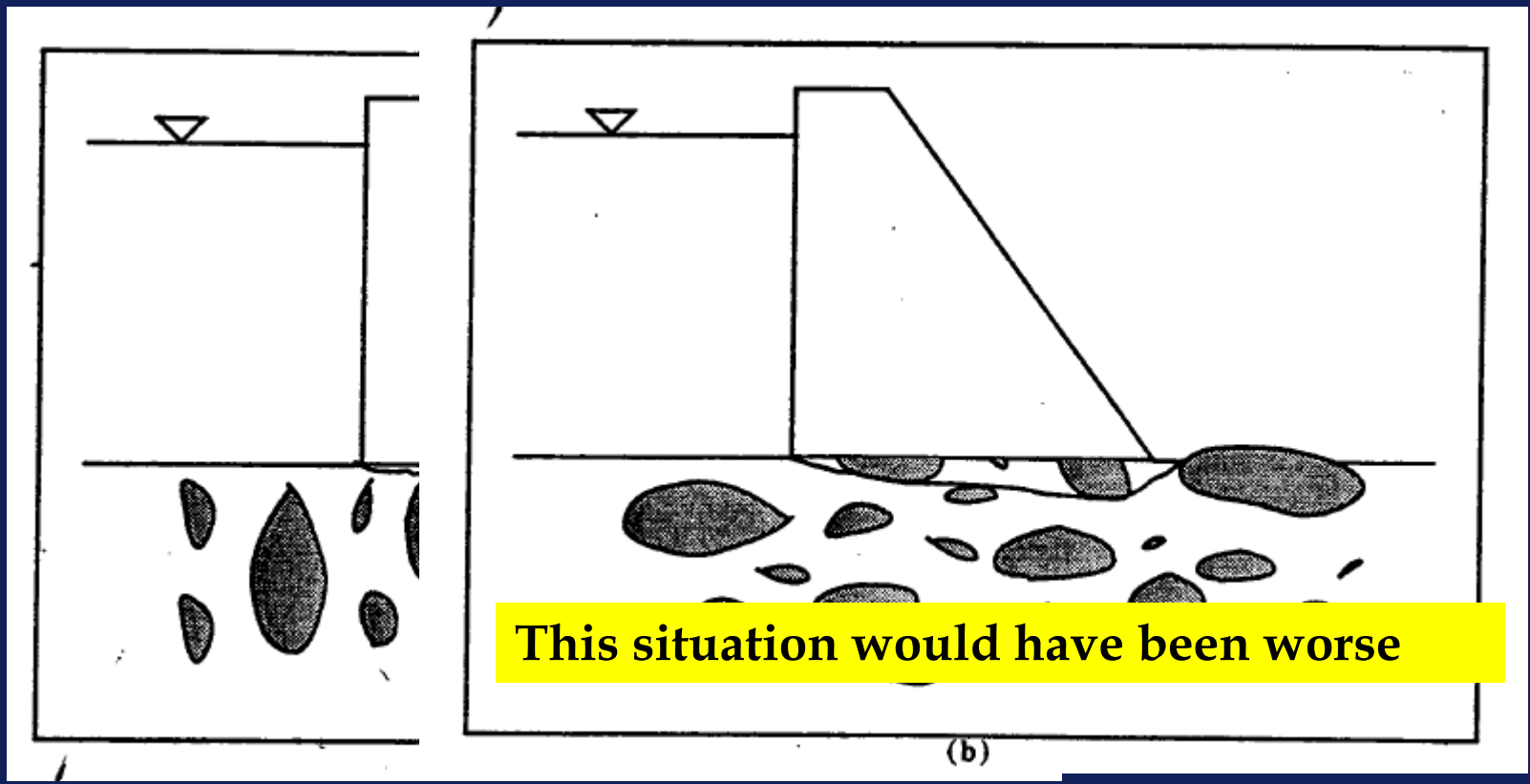


Foundation is bands of Franciscan melange

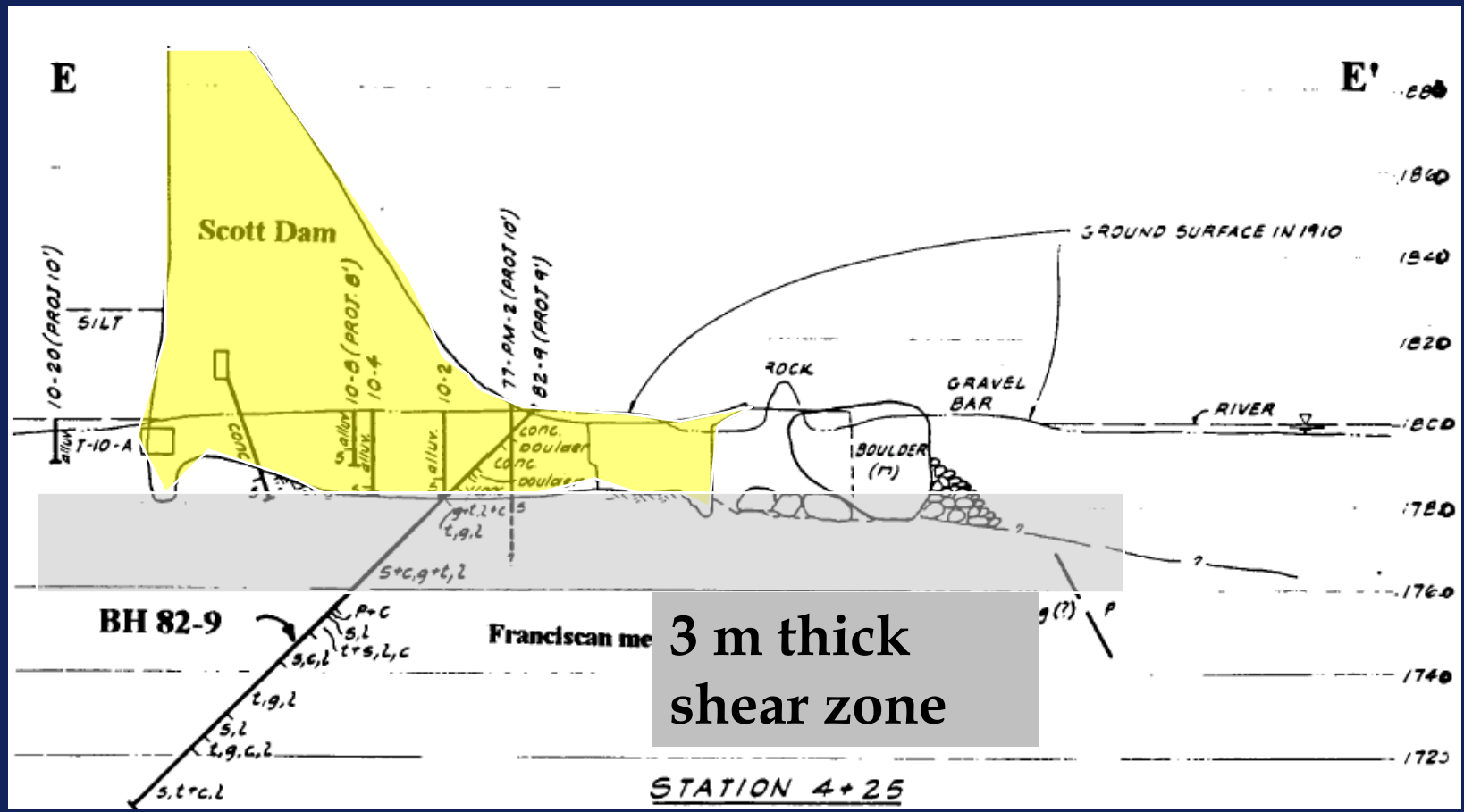


Medley, 1994

Melange blocks observed to be oriented at high angles in local outcrops



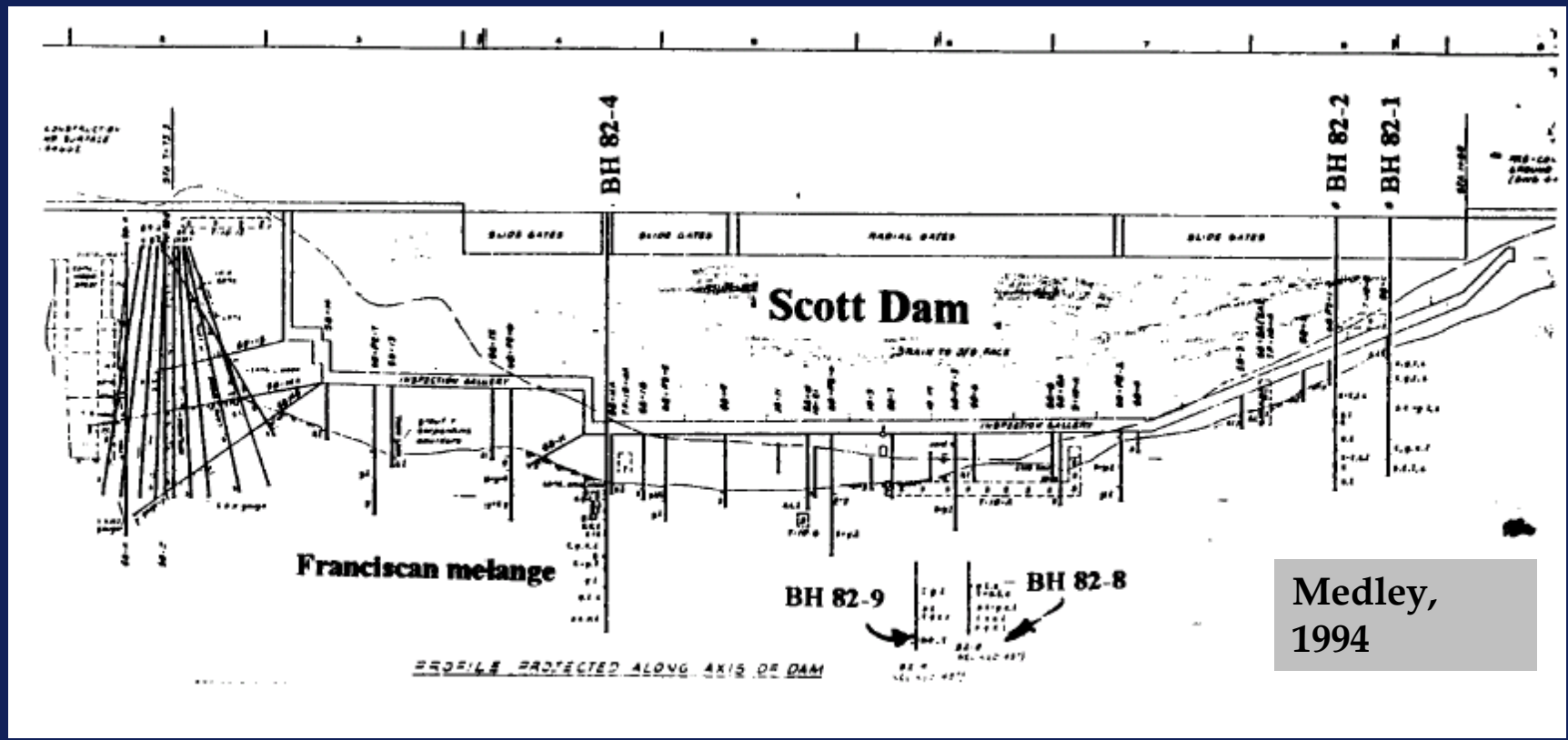
Assumed Characteristic Engineering dimension was thickness of a sliding shear below dam (3m thick)



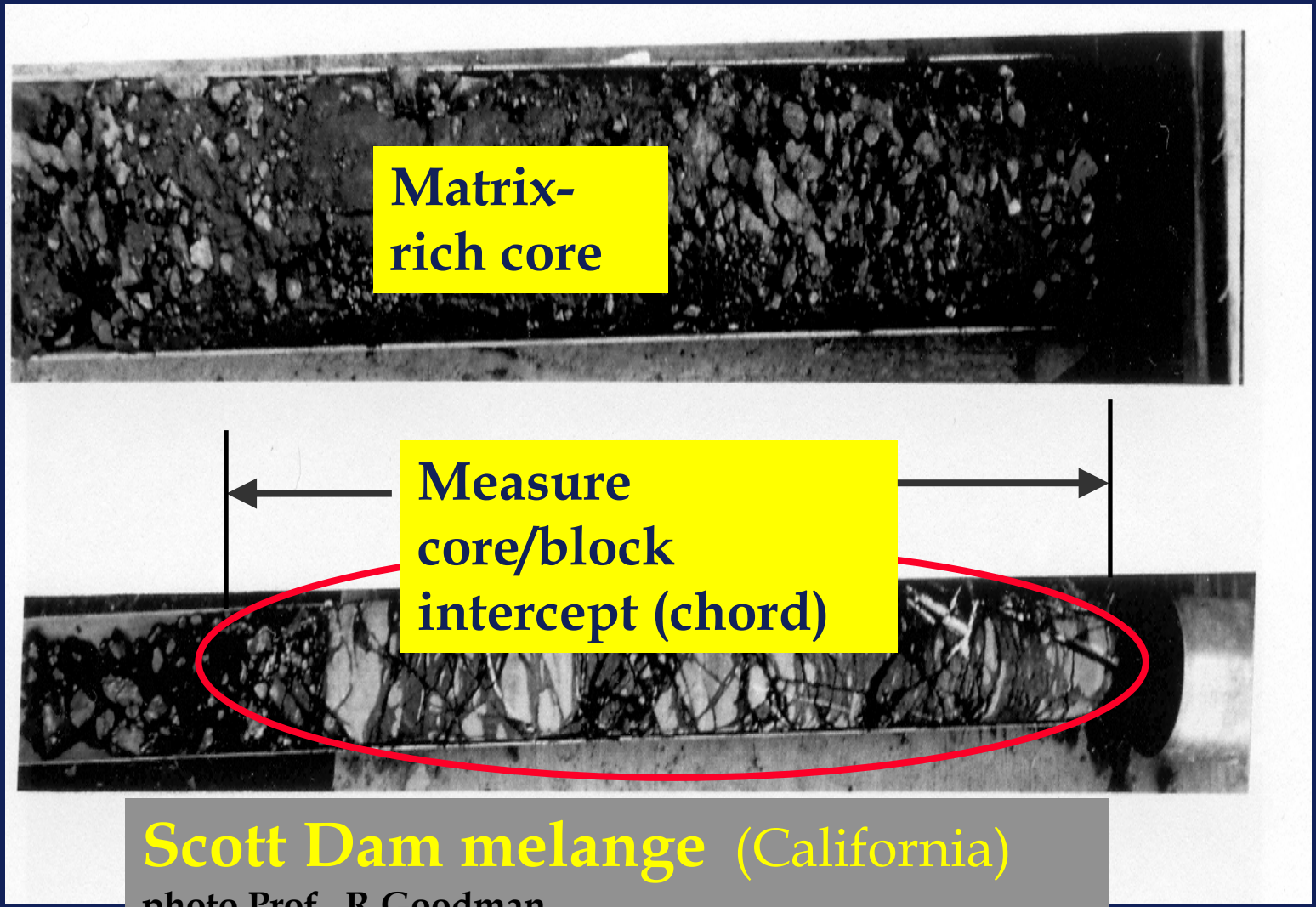
Estimating volumetric block proportion

- Since characteristic engineering dimension was 3m, block/matrix threshold selected at 0.05(3m)=0.15m
- Drill core photographs and boring logs reviewed to estimate overall volumetric block proportion
- Accepted all chords (core/block intercepts) >0.10m and used them to calculate block linear proportion

Linear block proportions estimated form many boring logs and photos of core



Measure block linear proportion



Scott Dam melange (California)
photo Prof . R Goodman

RECALL: from Lecture 2

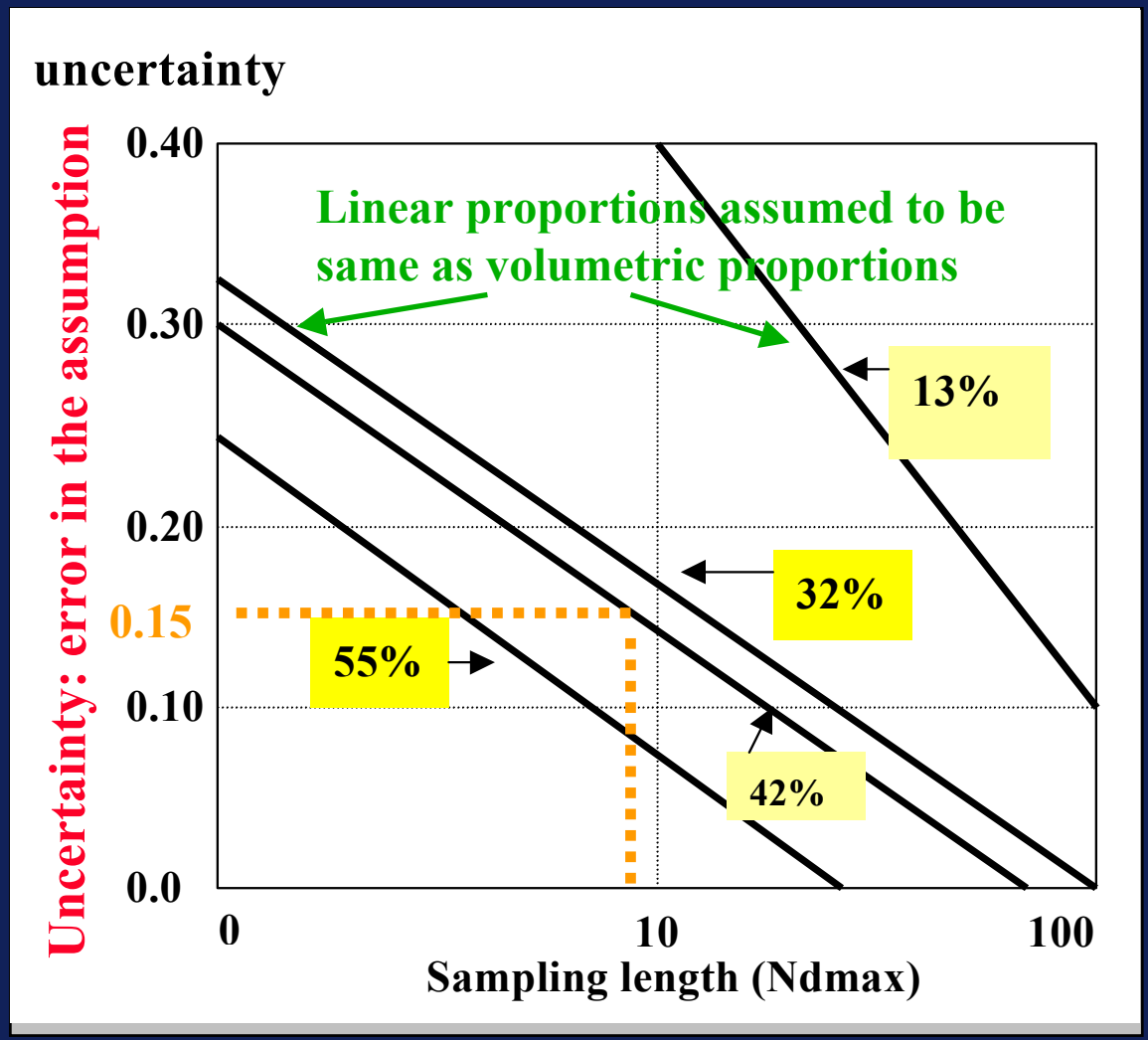
- Application of stereological principle:

linear proportion = volumetric proportion

Determined linear proportion from Scott Dam drill core: 40%

RECALL: Warnings!!!!

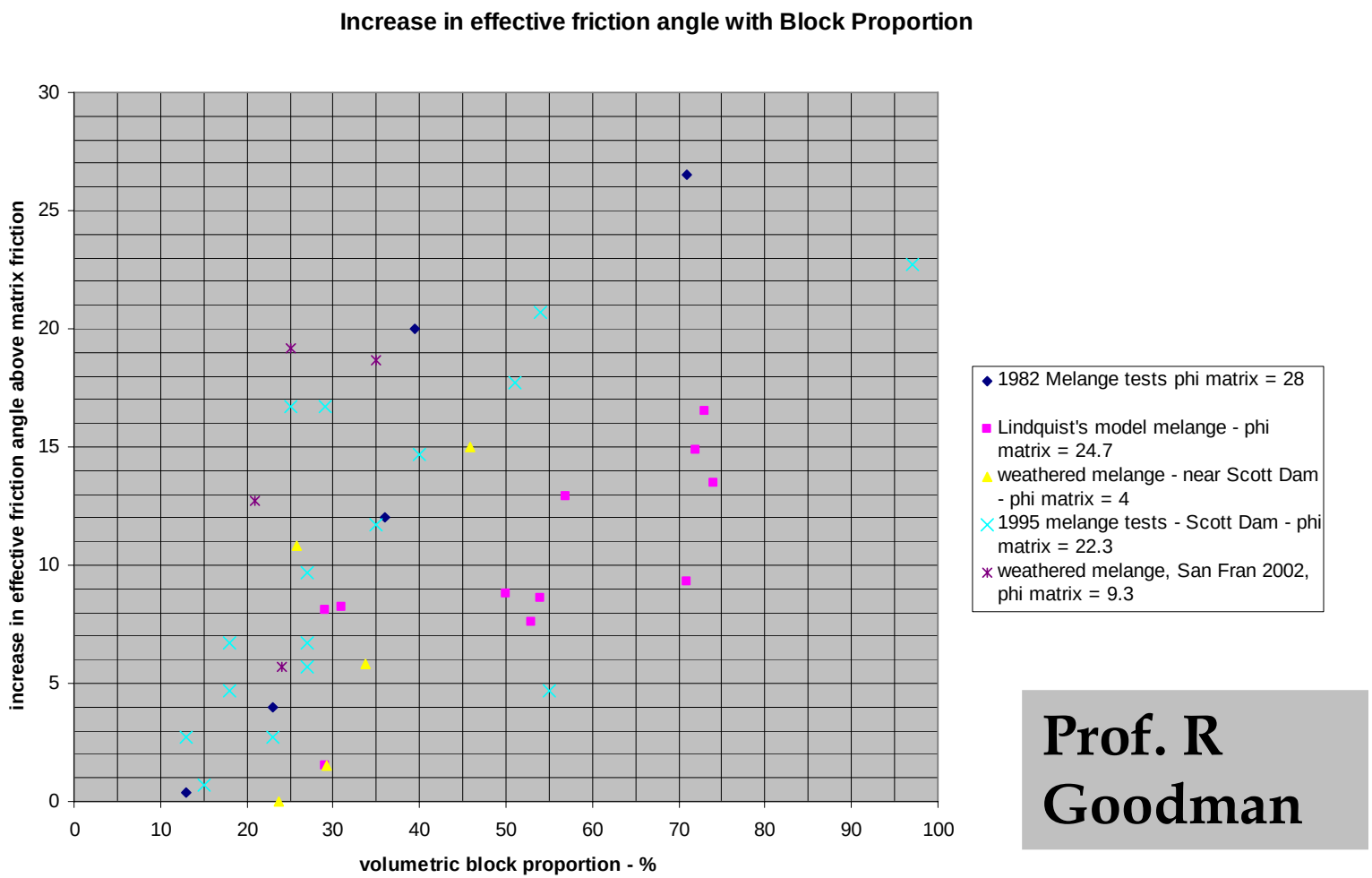
- So, although stereology says that volumetric % = linear %
- It is TRUE ONLY when you have sufficient linear measurements!! (lots of $$$ drilling!!)
- Hence adjusted Scott Dam linear proportion to account for uncertainty



Estimated volumetric properties on the basis of Scott Dam linear boring measurements

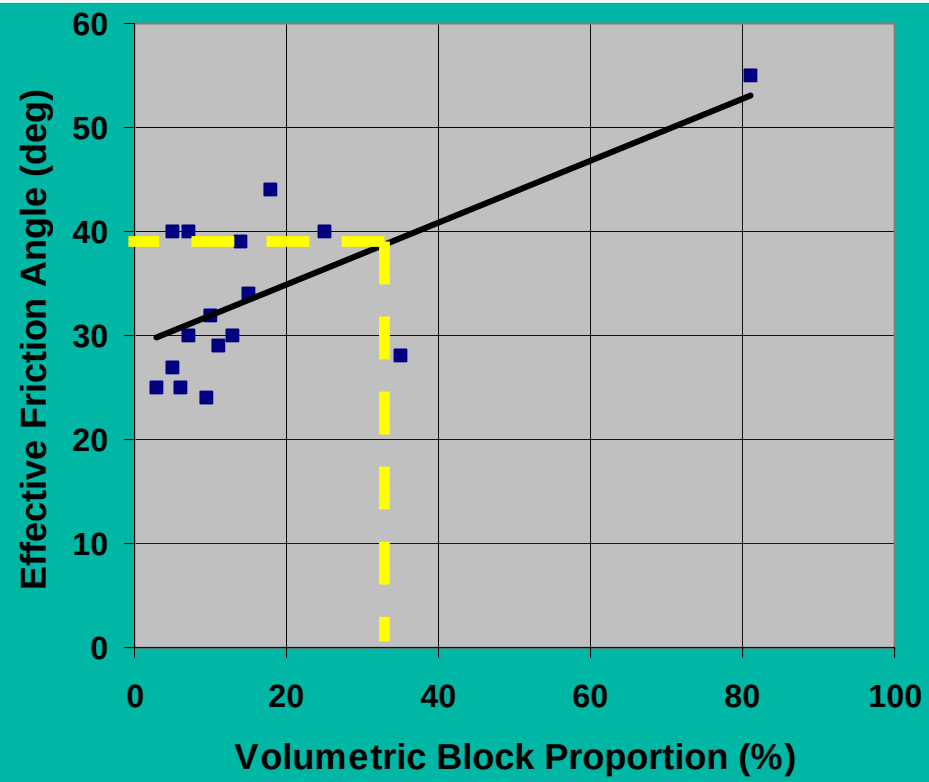
0.15x40% = 6%: use 34% block proportion

Scott Dam melange strength testing results



Prof. R Goodman

Strength of Franciscan below Scott Dam



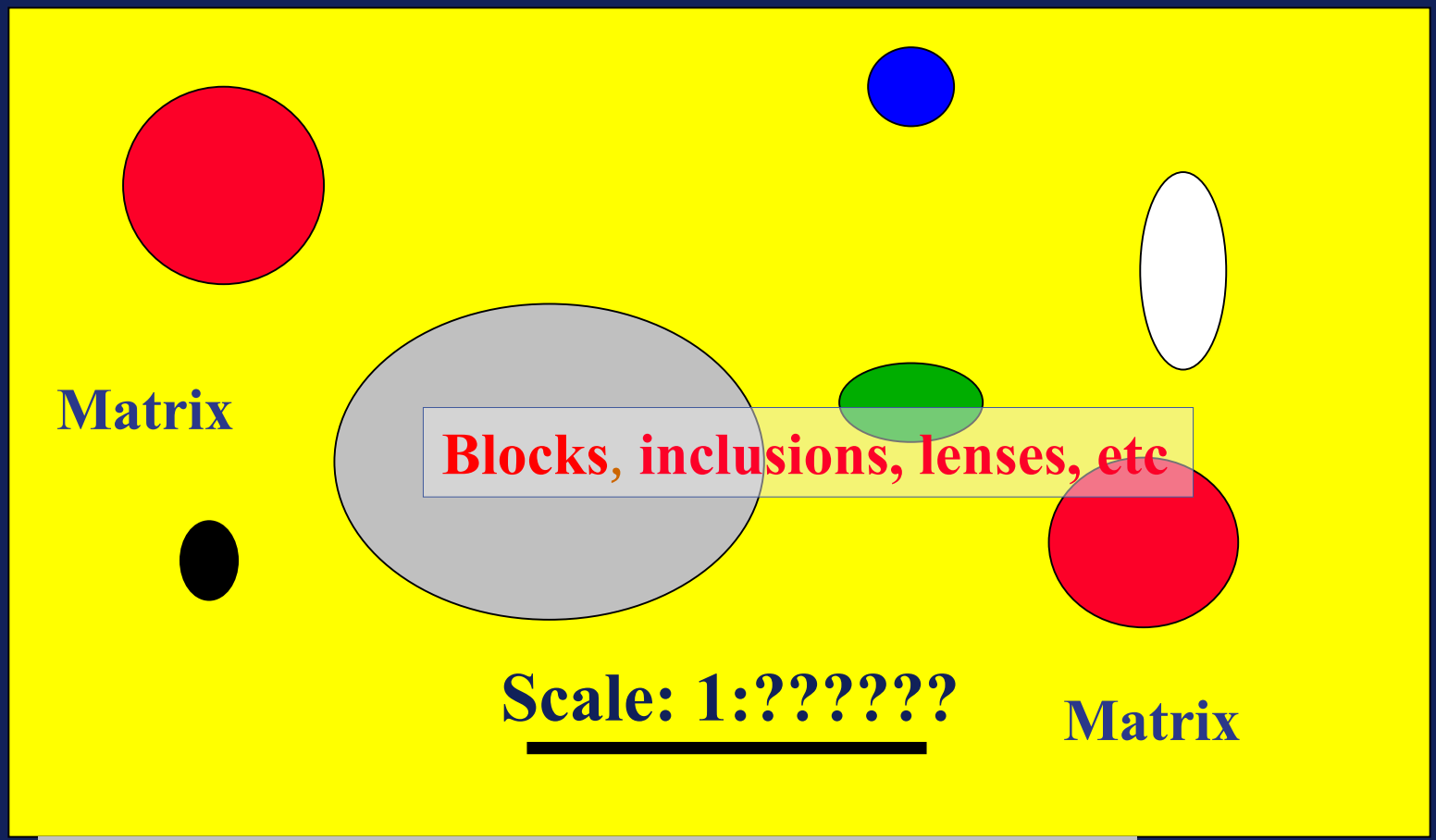
Approx 39% friction for 34% volumetric block proportion

Medley, 2002; after Goodman and Ahlgren, 2001

SO: Using the strength of the weak matrix as representative of the strength of the bimrock may be too conservative in some cases .

Ignoring blocks does nothing to help the contractor who must struggle with them; nor the Owner who must pay for the extra work

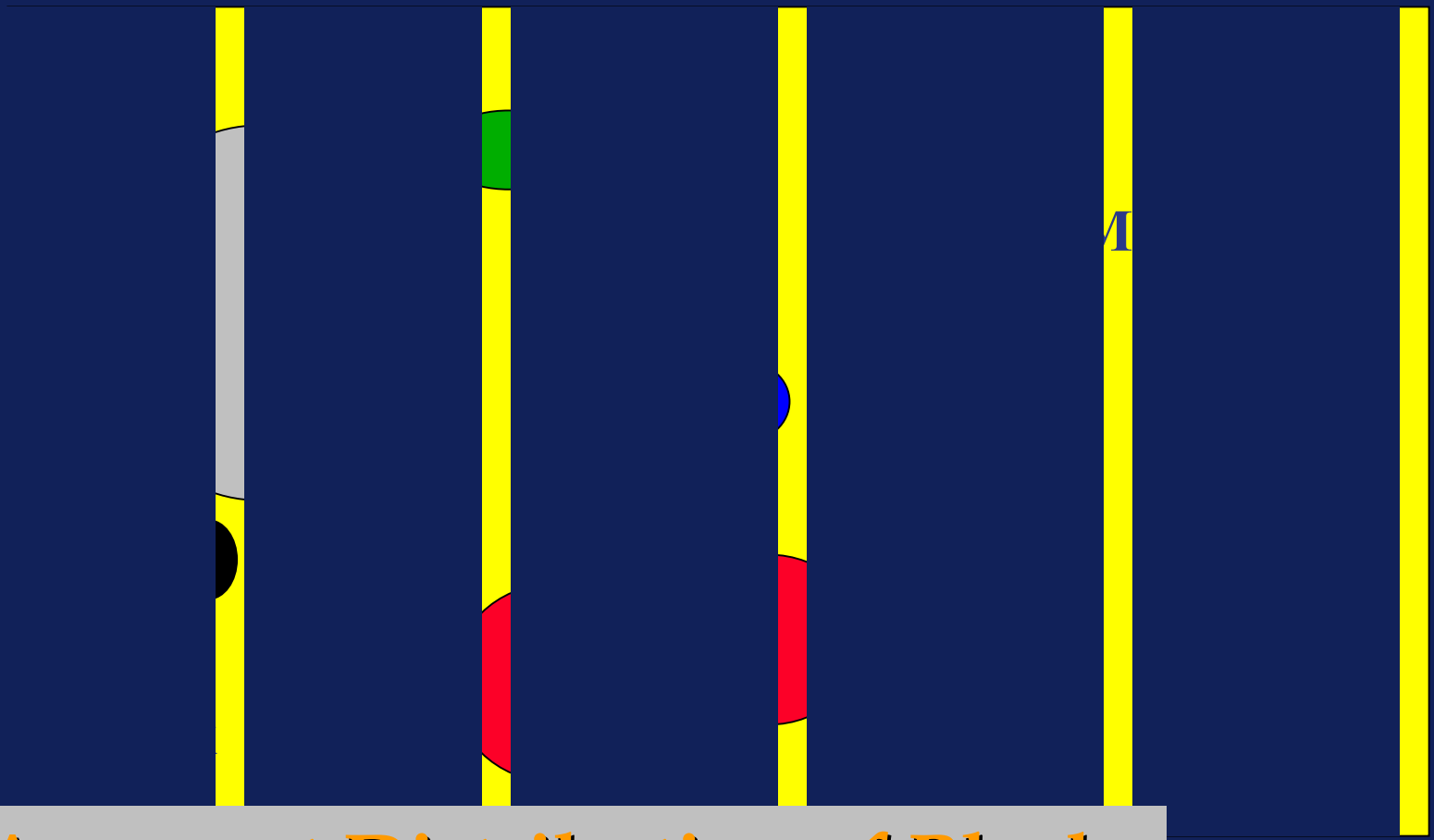
BIG CONCLUSION 1:
Remember this picture!!!



Actual Distribution of Blocks

Medley, 2000

BIG CONCLUSION 2:
Remember this picture as well!!!



Apparent Distribution of Blocks

Willis, 2000