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The relation between the physical properties and the collisional outcome of meteoritic matrix

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03.09.2012 /Planet Formation and Evolution 2012

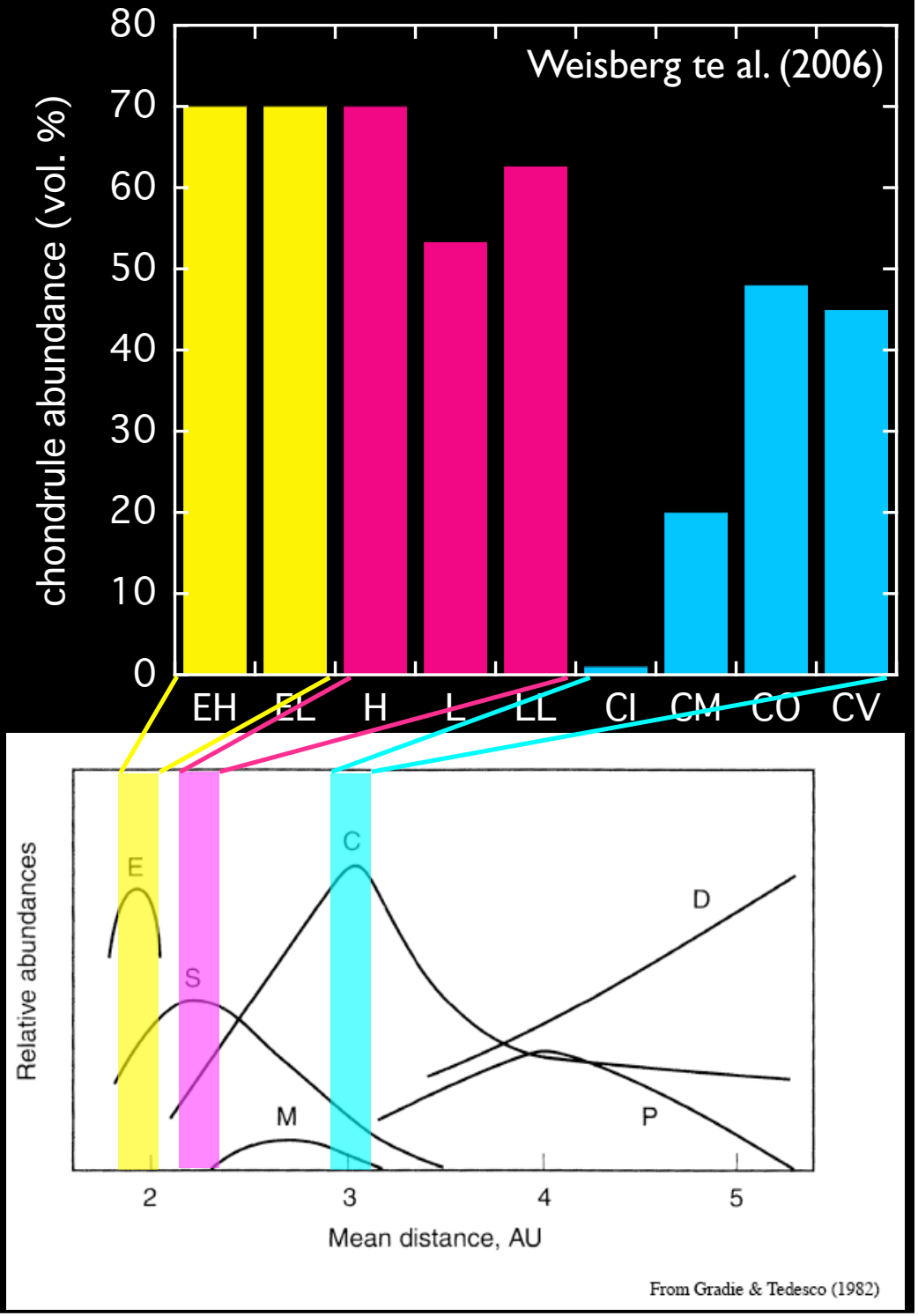
Introduction

Analyses of chondrites
- Chondrules - high temp.
- Matrix - low temp.

It is difficult to form in the same environment.

Observation of asteroids
- Heliocentric distribution of chondrite parent bodies
- Abundance of chondrule decrease inversely with distance

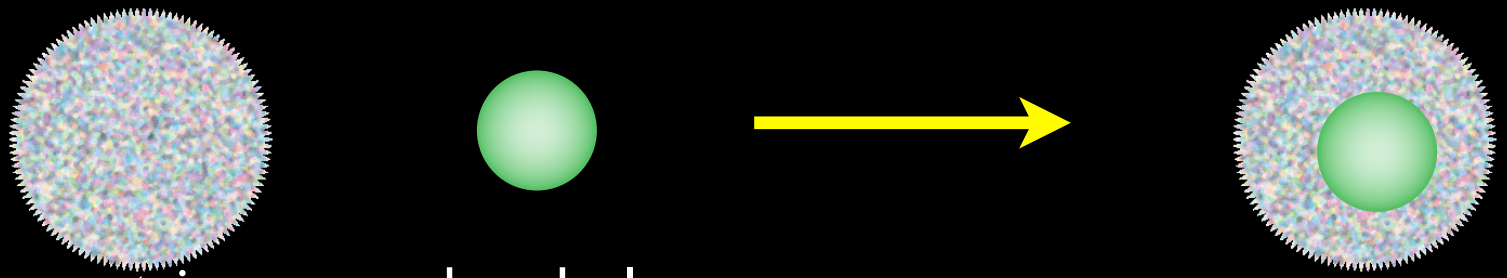
Chondrules were distributed inhomogeneously in the solar nebula.



Introduction

Condition of solar system

- Chondrule formation: 2-3 Ma after CAI (Kurahashi et al. 2008)
- Size of dust aggregates: a few cm at 10000 year after CAI (Windmark et al. 2012)
- Relative velocity between mm-sized dust and cm-sized dust: 0.01-5 m/s (Weidling et al. 2009)



To investigate the collisional condition between chondrule and matrix, we measured

physical properties of large dust agglomerate

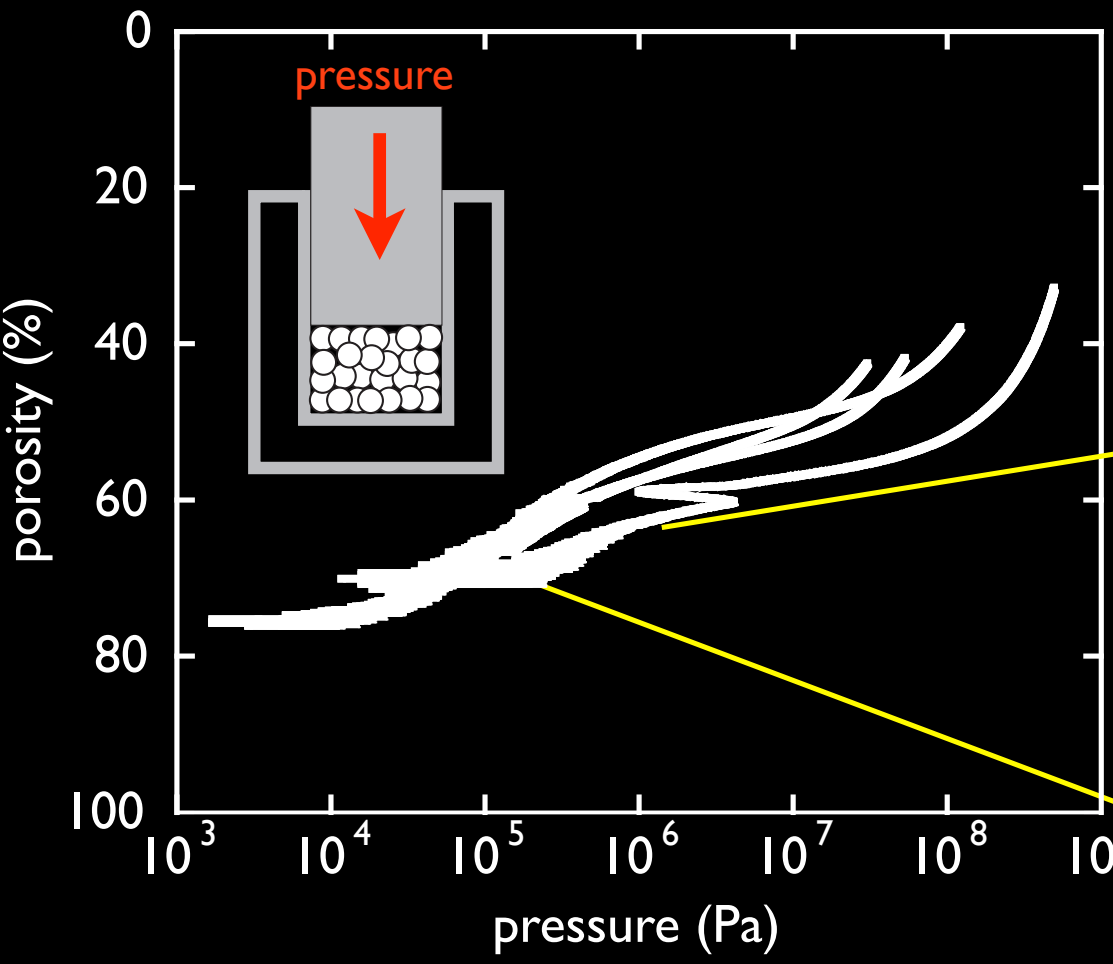
and

their collisional outcomes

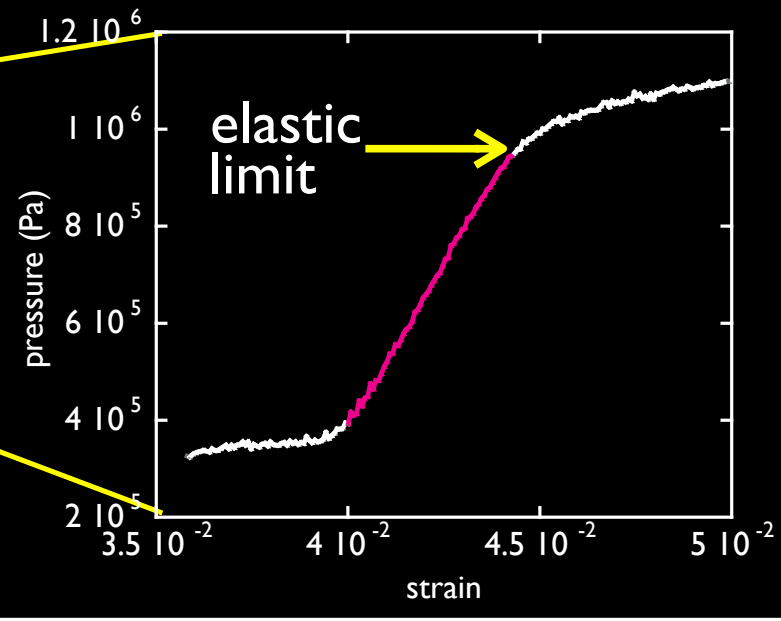
Experiment 1: Measurement for physical property of agglomerates

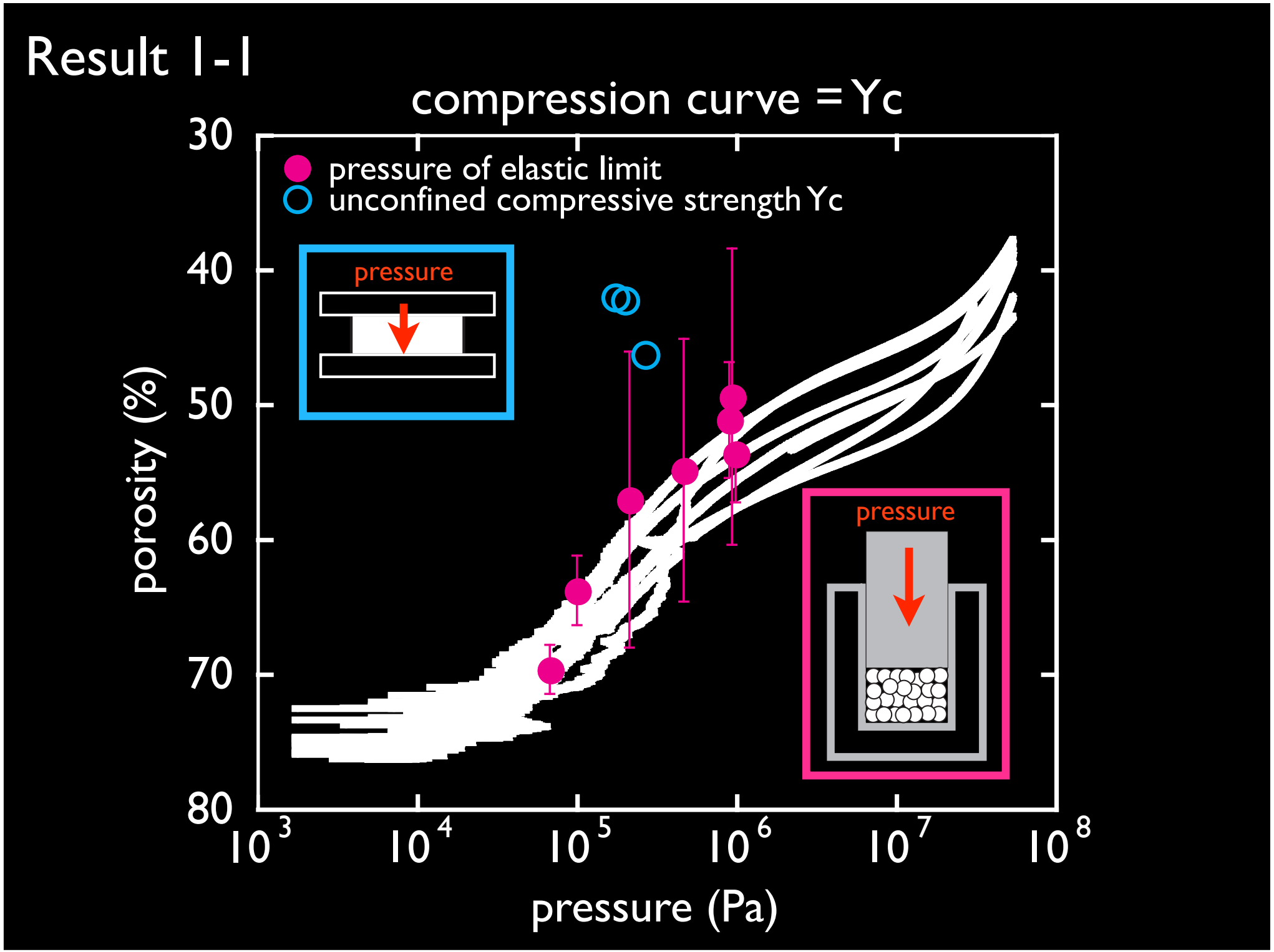
Sample: polydisperse silica particles, d = 0.8 ± 0.3 μm, ρ = 2200 kg/m^3

compression tests
loading rate: 0.01 mm/s
container size: ∅5, 10, 15, 20 mm



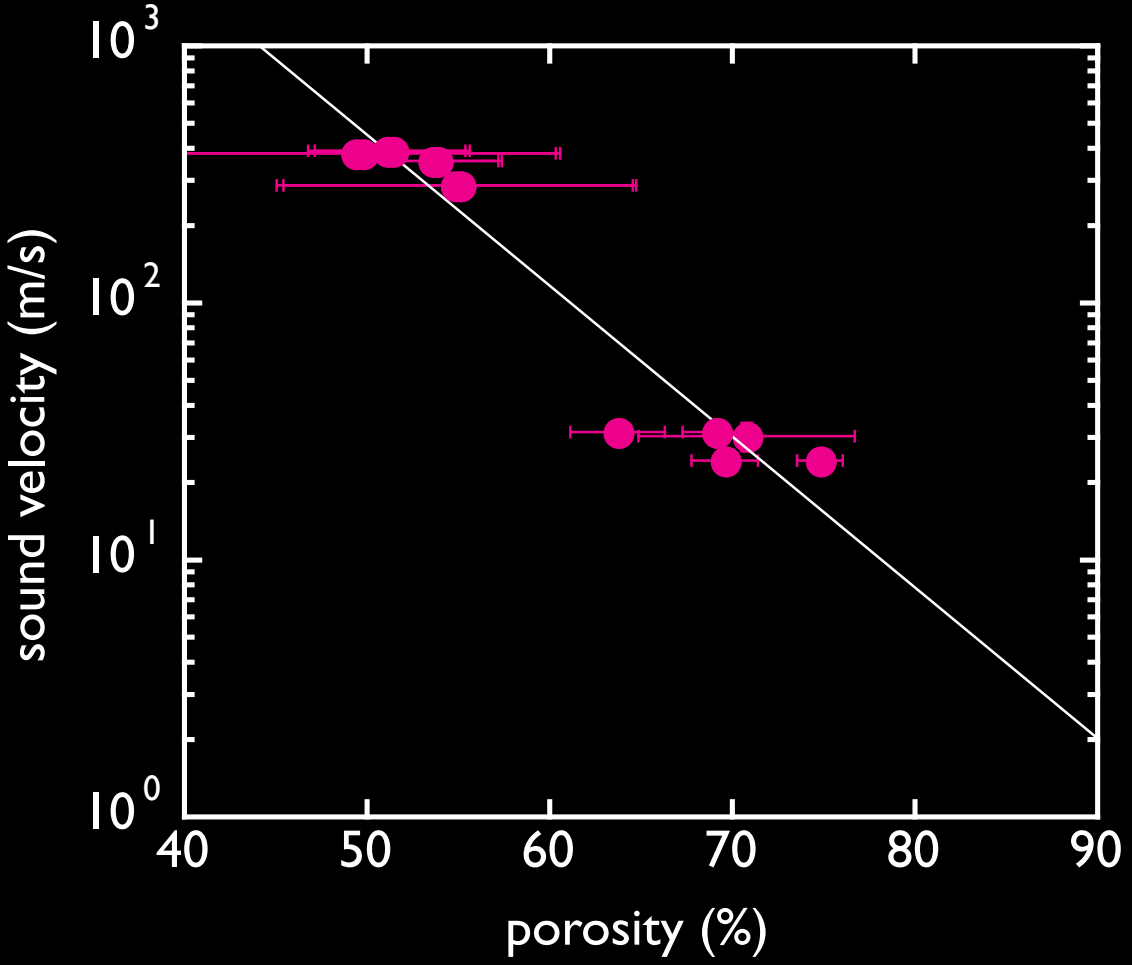
elastic limit
=
compressive strength Yc

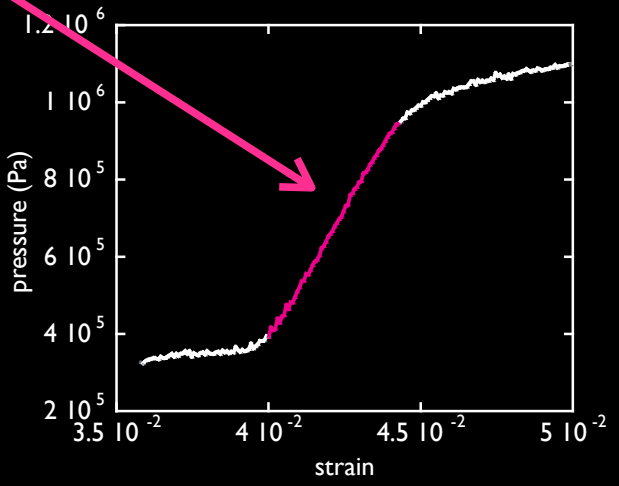



Result 1-1
compression curve = Yc
pressure of elastic limit
unconfined compressive strength Yc
pressure
pressure
porosity (%)
30
40
50
60
70
80
10 3
10 4
10 5
10 6
10 7
10 8
pressure (Pa)

Result 1-2 sound velocity

sound velocity C = (slope of the curve ⁄ ρ)$^{0.5}$





compression curve

obtained from the fitting line:

50 % - 460 m/s
75 % - 15 m/s
90 % - 2 m/s

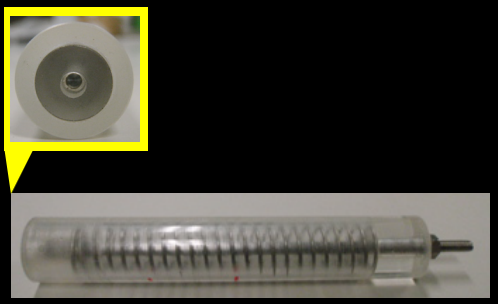
Experiment 2. Collisional experiment: matrix analog vs chondrule analog

Target: polydisperse silica particles, d = 0.8 ± 0.3 μm, ρ = 2200 kg/m^3
Projectile: glass bead, d = 1, 3, and 4.7 mm, ρ = 2500 kg/m^3

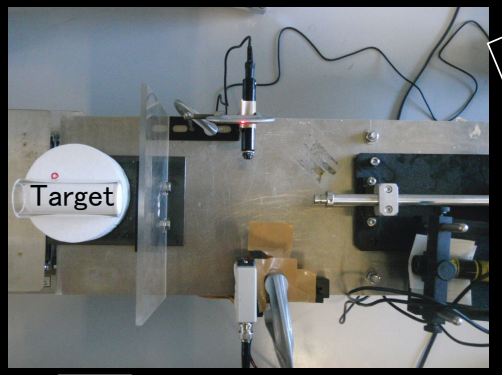
velocity (m/s)	projectile (mm)	target (cm)	target porosity (%)	accelerator
0.2 - 2	1, 4.7	3 x 3	90, 75, 50	drop tube
2 - 5	3	3 x 7.5	75, 50	spring gun
30 - 300	3	3 x 7.5	75, 50	light-gas gun

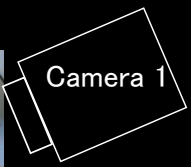
Beitz et al. (2011)

drop tube



spring gun





Camera 2

light-gas gun

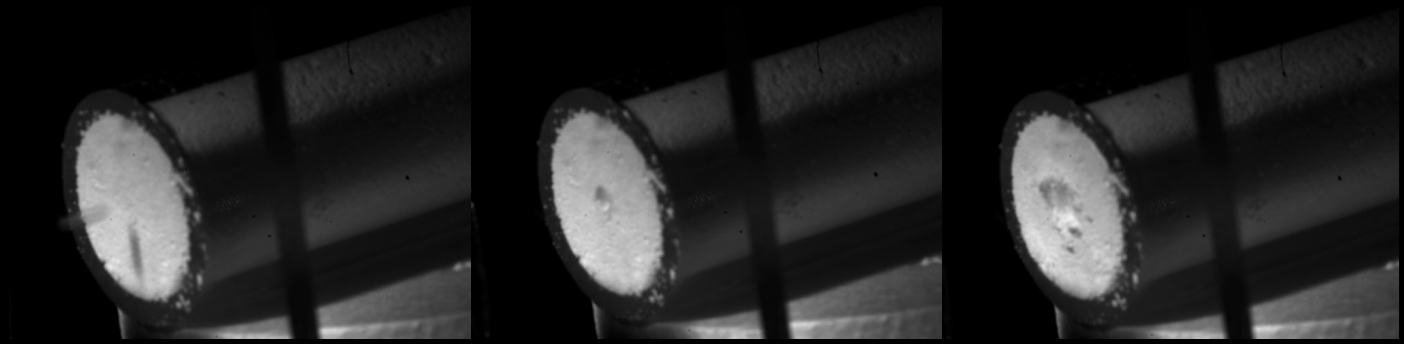
Result 2-1: Image sequence of the collisional outcomes

high

velocity

low

intrusion

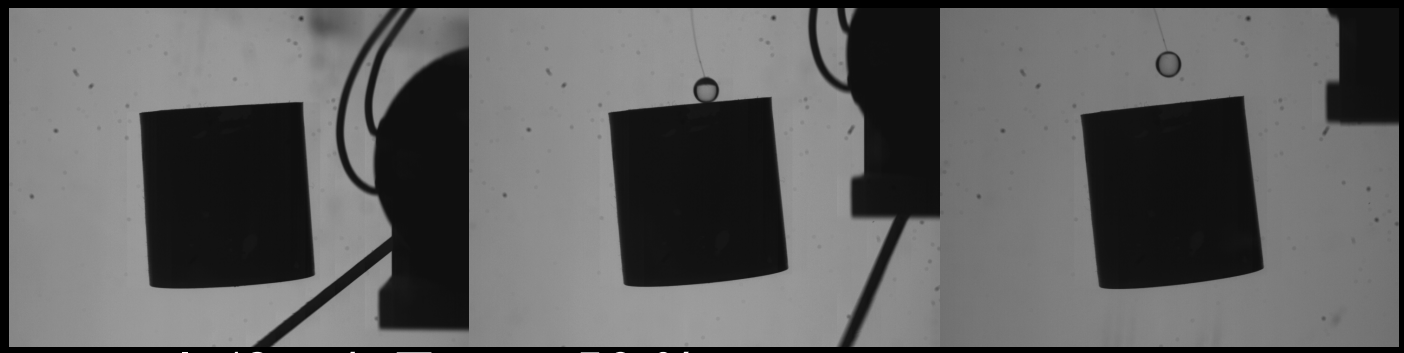


v_{imp} = 40 m/s, Target: 74 % porosity

sticking

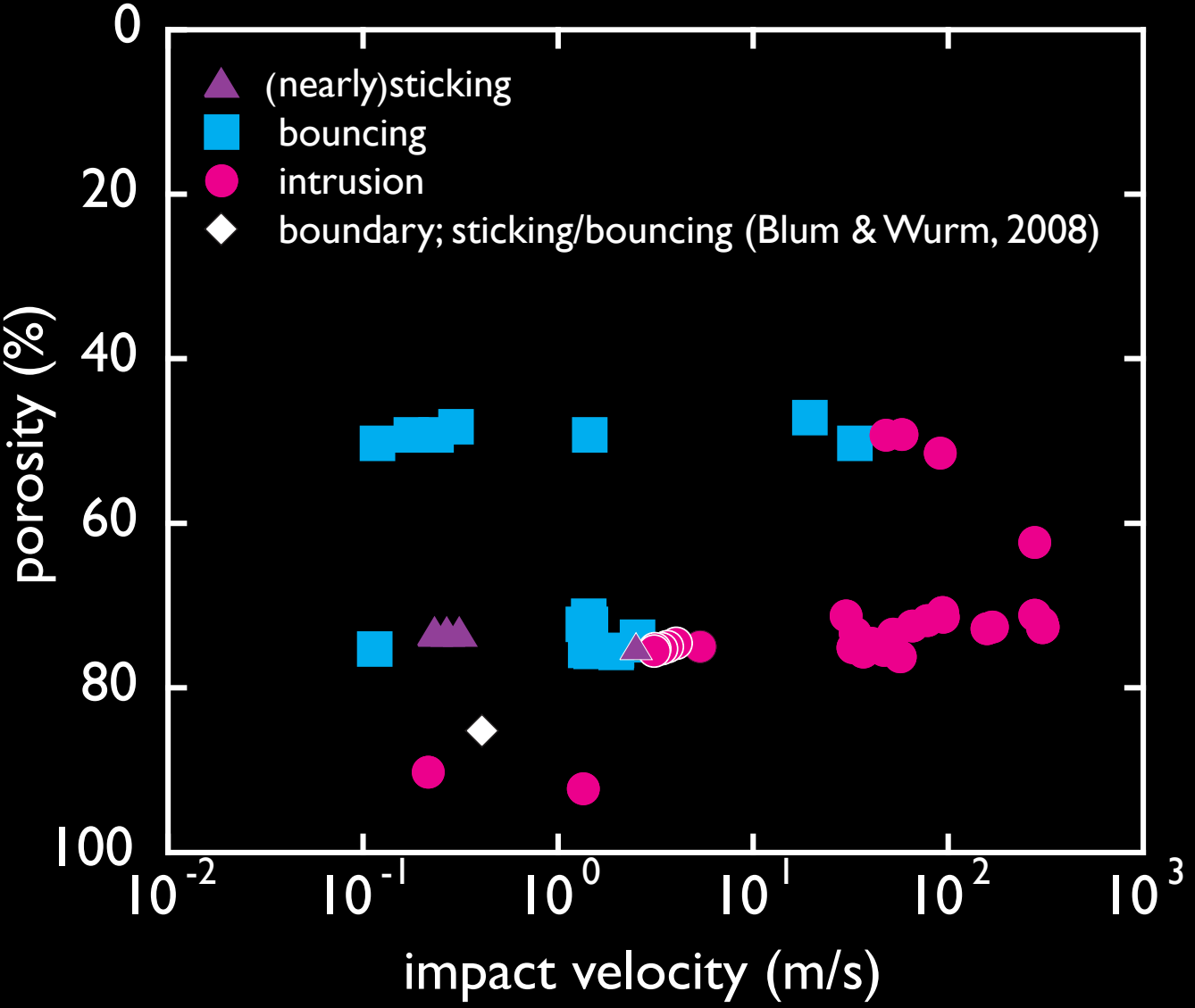
v_{imp} = 2.5 m/s, Target: 75 % porosity

bouncing



v_{imp} = 1.42 m/s, Target: 50 % porosity

Result 2-2:

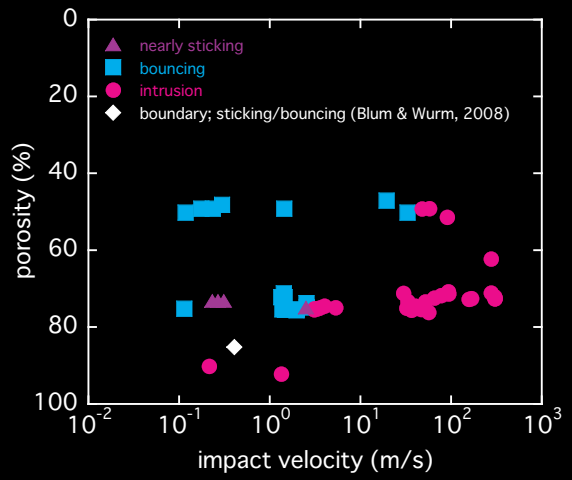


※nearly sticking

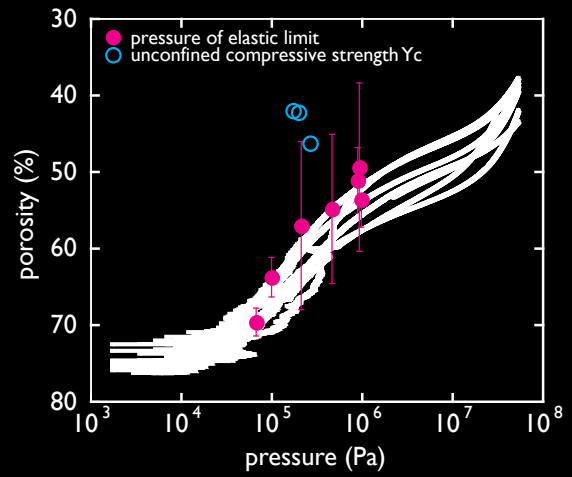
For the experiment with drop tube: the displacement of the projectile could not be confirmed more than 120 ms after collision.

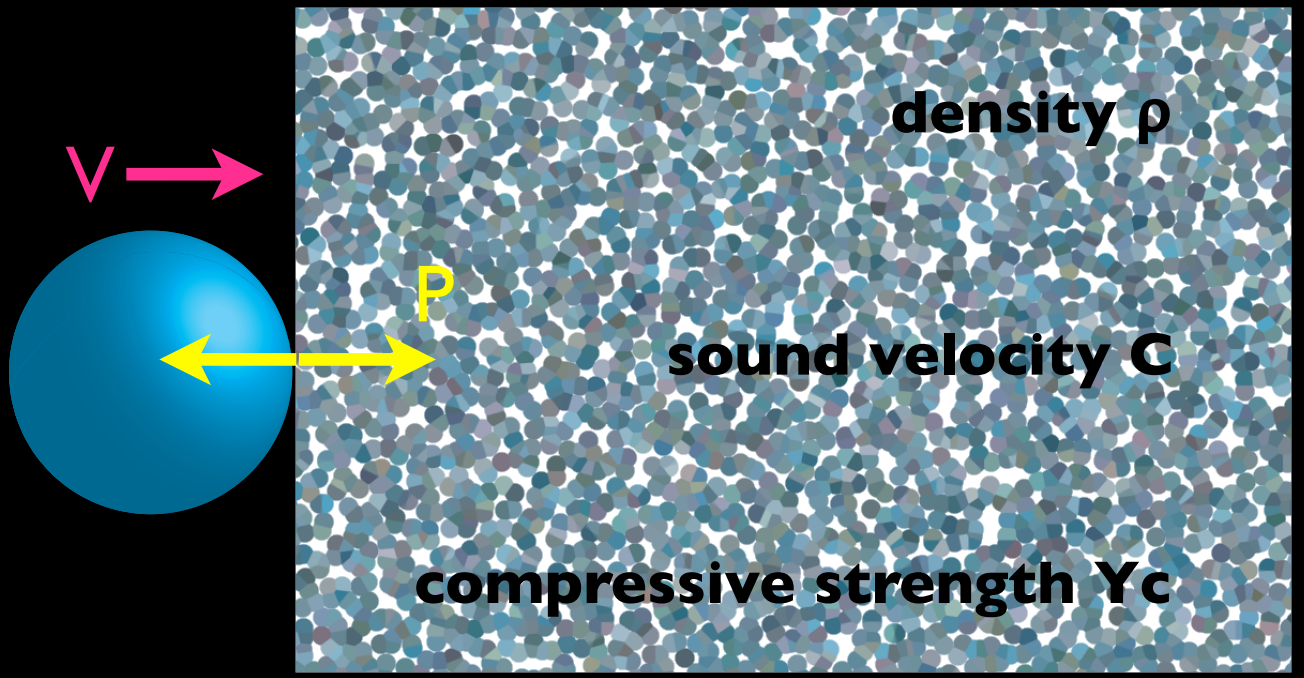
For the experiment with spring gun: the projectile fell down after collison-sticking due to gravity. / the intrusion depth is smaller than the projectile diameter.

Model: Conversion of impact velocity into impact pressure

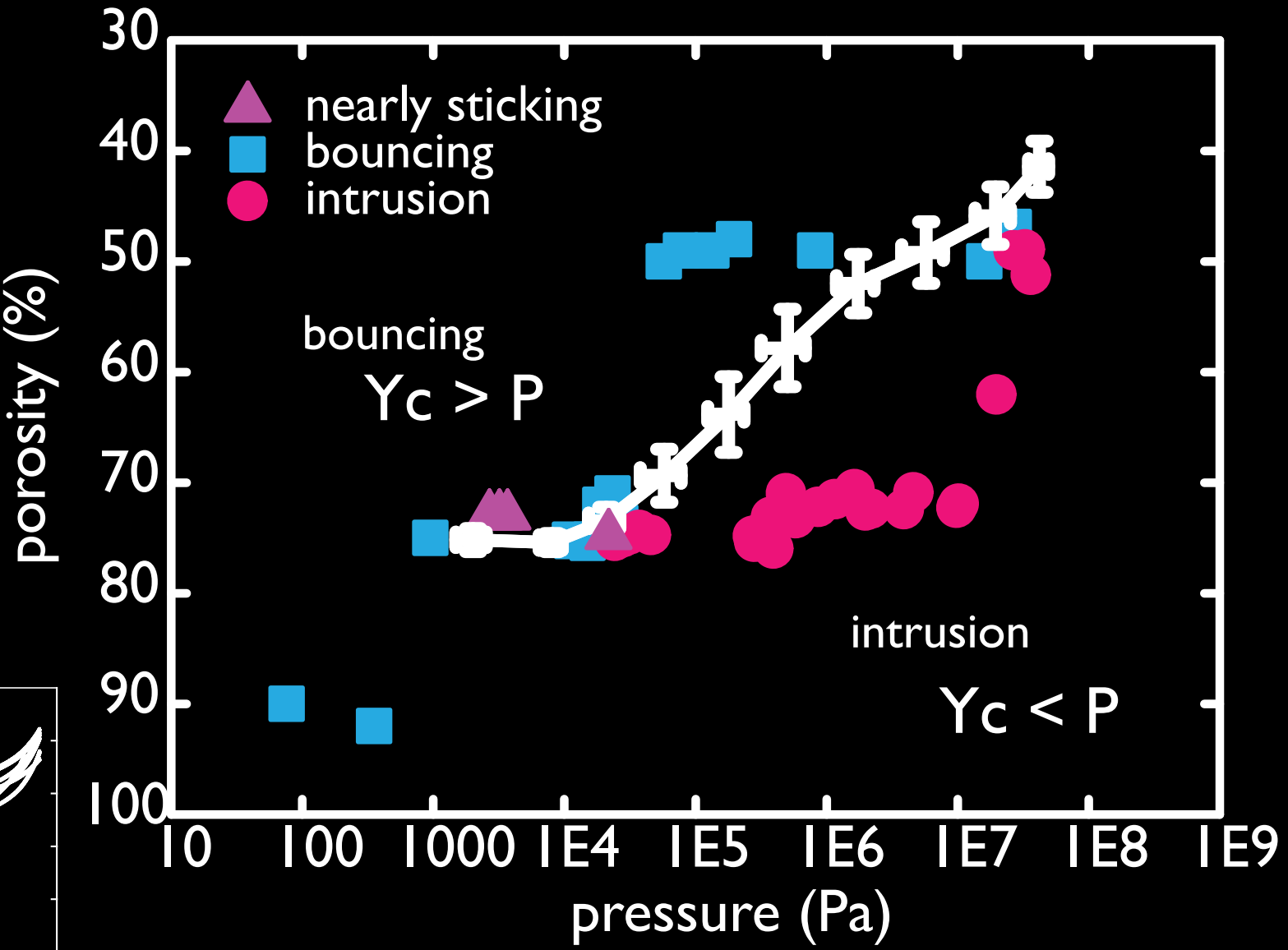


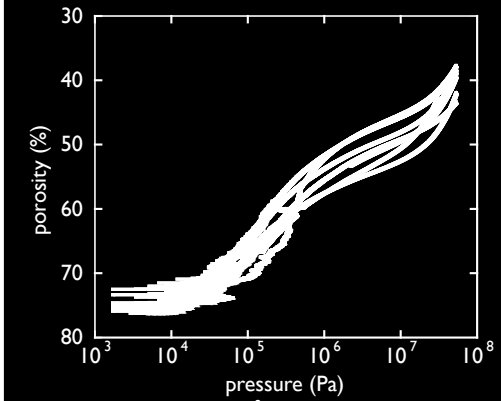
impact pressure: $P = \rho C v$





Result3: The relation between collisional outcomes and the target strength

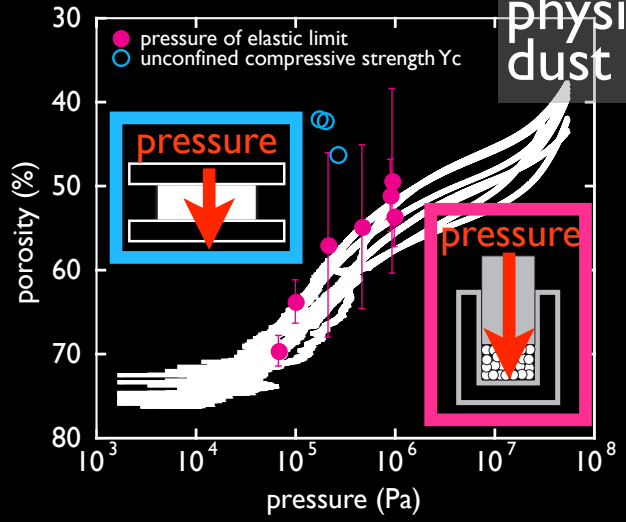




compresion curves

Summary

Measurements for physical properties of dust



Collision experiments