Analogue modelling: visit to experimental tectonics lab

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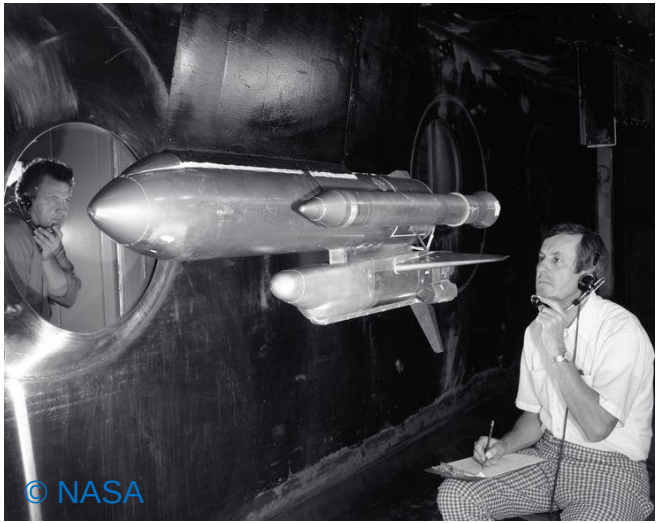
Analogue modelling

…is an experimental technique using analogue models



Henry M. Cadell

”EXPERIMENTAL RESEARCHES IN MOUNTAIN BUILDING”

(1889)

Scaling & Similarity

The following criteria are required to achieve similarity:

Geometric similarity – Shape as the prototype at a smaller scale

Kinematic similarity – Rates scale down consistently

Dynamic similarity – Forces scale down consistently

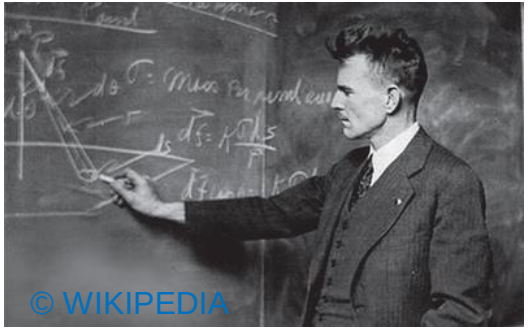
Dimensionless numbers (ratios) are kept constant, e.g.

Friction coefficient = shear strength / normal load

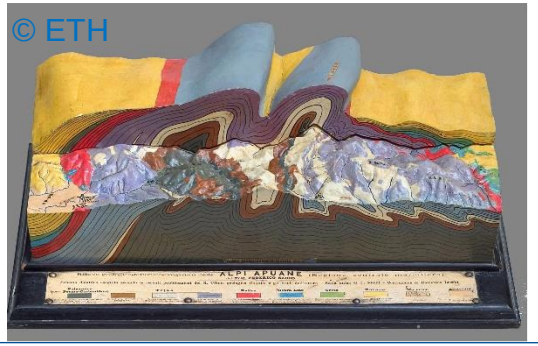
Froude number = inertia / gravitational force

Cauchy number = inertia / compressibility

Reynolds Number = inertia / viscous force

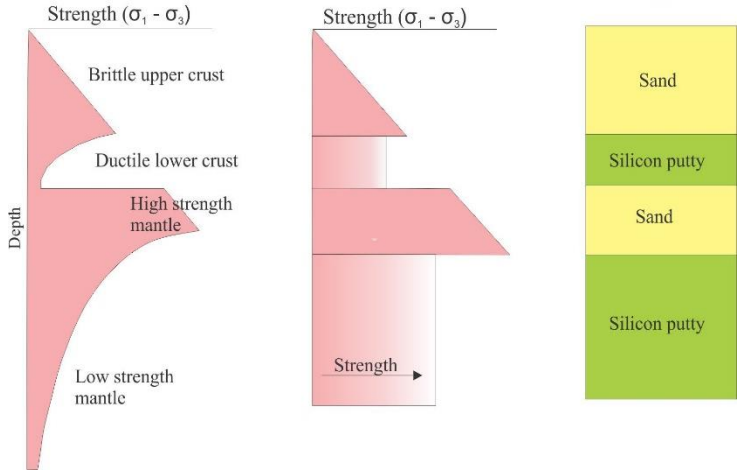


M. King Hubbert
"THEORY OF SCALE MODELS AS APPLIED TO THE STUDY OF GEOLOGIC STRUCTURES" (1937)



Rock analogue materials

Granular materials: brittle deformation – Coulomb friction (upper crust)
Viscous materials: ductile deformation – (non)Newtonian flow (lower crust and mantle)



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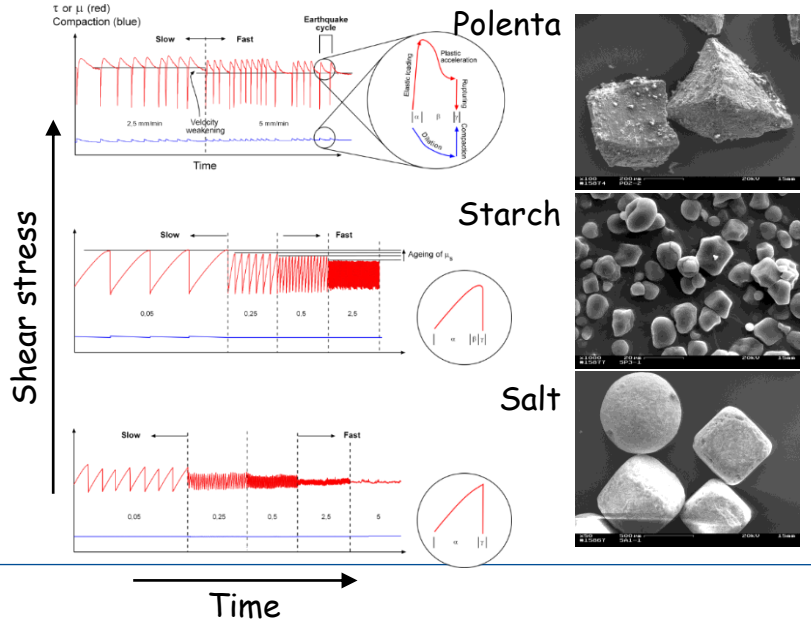
Rock analogue materials

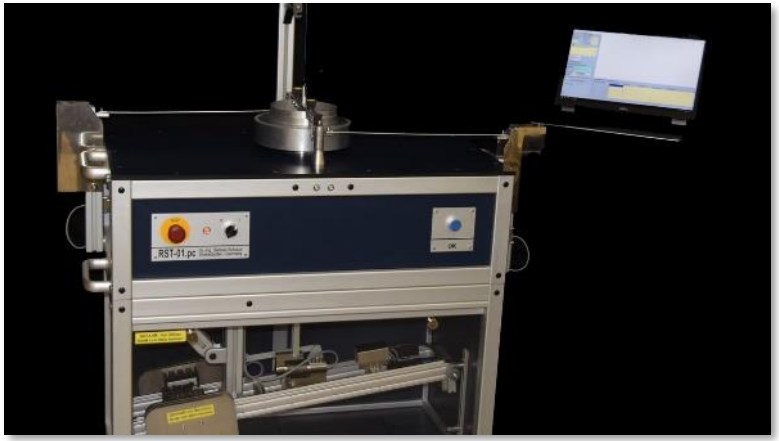
Granular materials: brittle deformation – Coulomb friction (upper crust)
Viscous materials: ductile deformation – (non)Newtonian flow (lower crust and mantle)

Stick-slip materials: rate-state friction
Viscoelastic materials: Maxwell relaxation



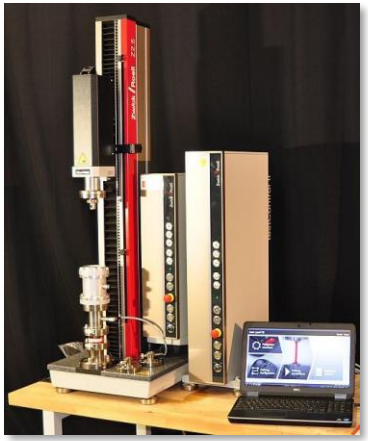
Rock analogue materials

Ring-shear tester
(friction coefficient & cohesion)



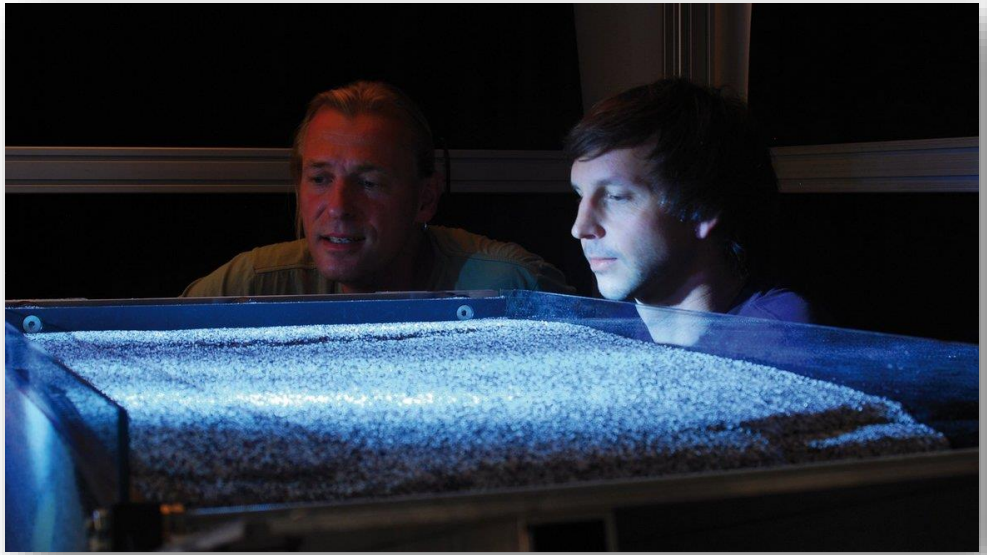
Rheometer
(viscosity)

Axial tester
(Elasticity)



Monitoring

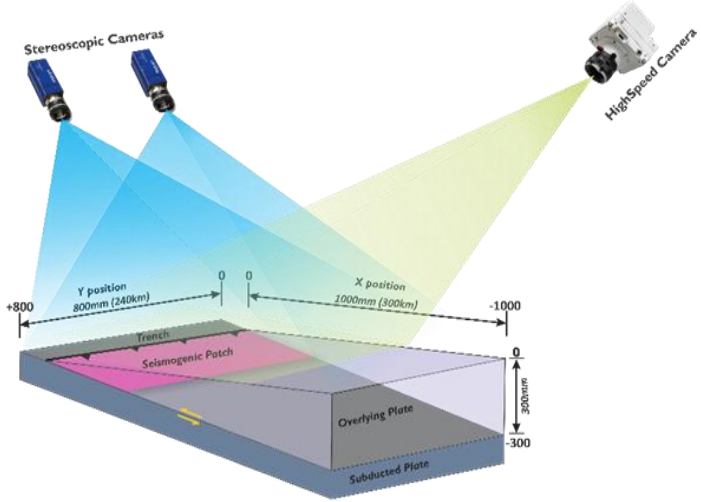
with all senses…



Laboratory geodesy

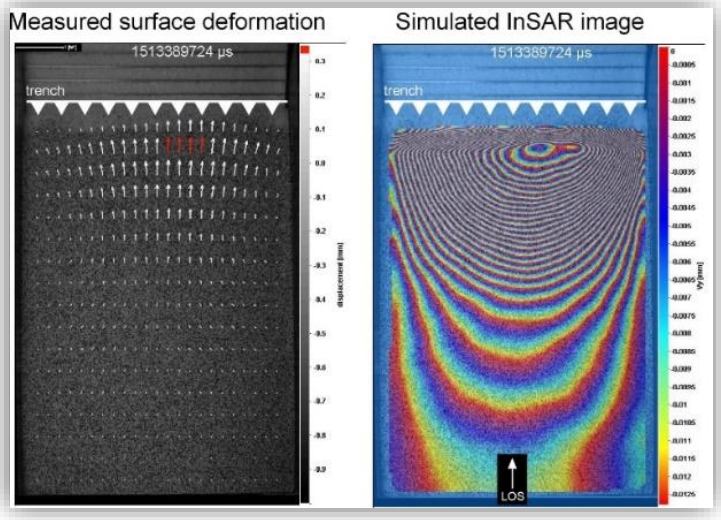
Optical cameras

<20 px/mm <kHz



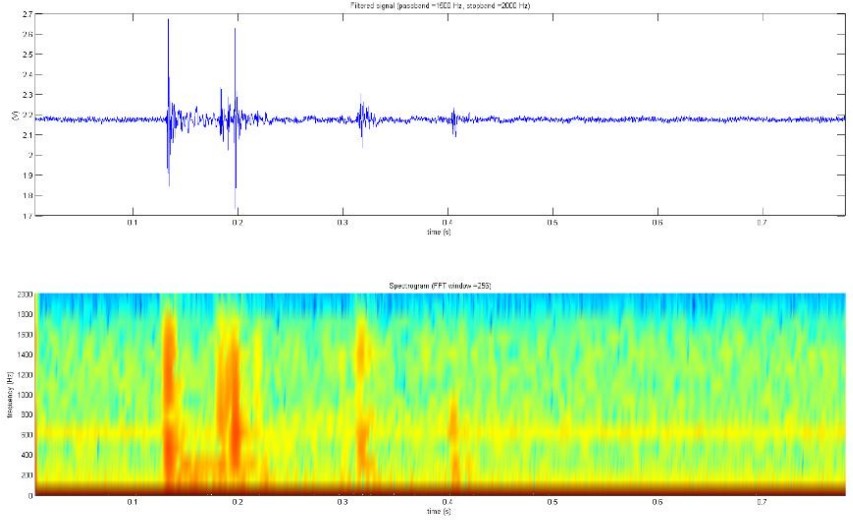
Digital Image Correlation (DIC, PIC, SfM)

µm 3D displacements at high spatial and temporal resolution

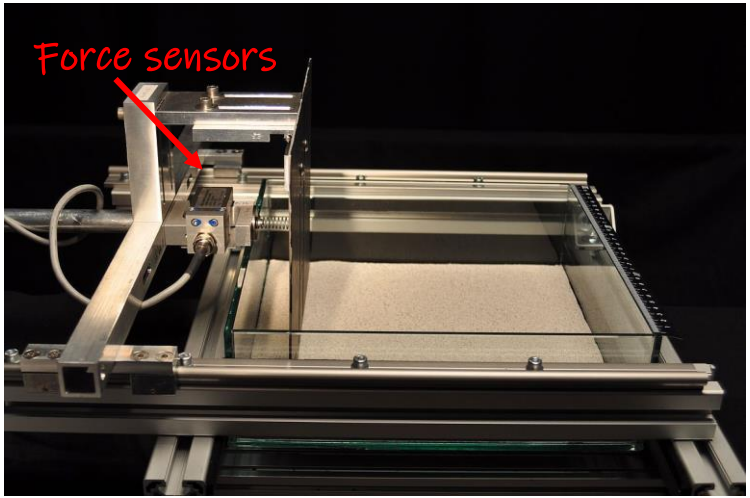


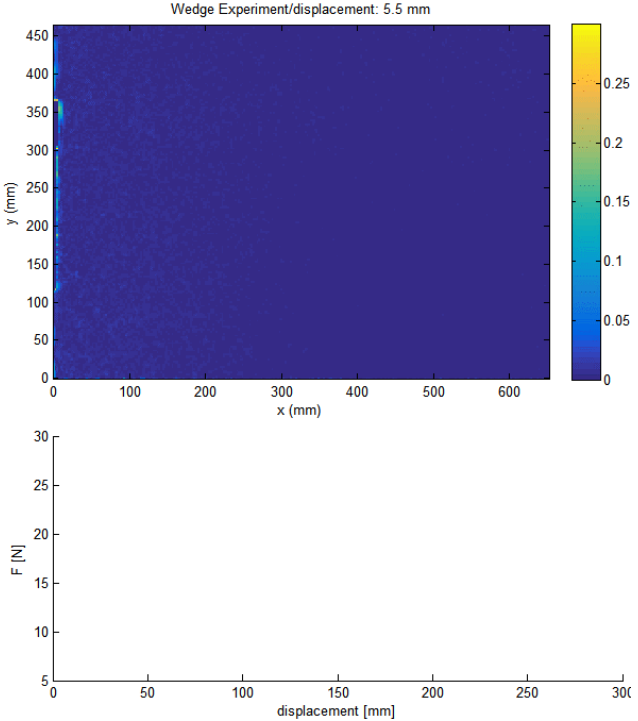
MEMS accelerometers

0 Hz (static) to kHz

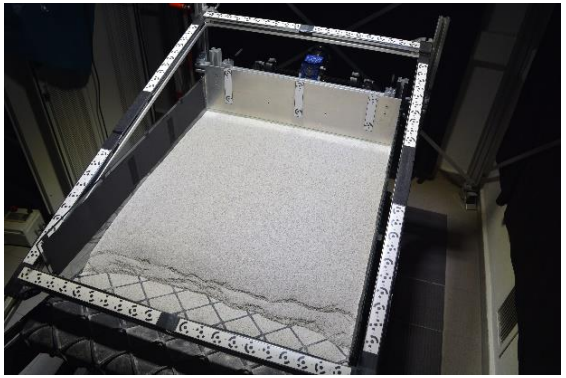


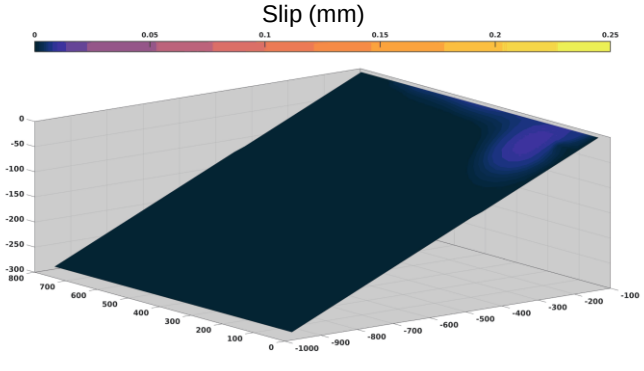
Stress vs. strain

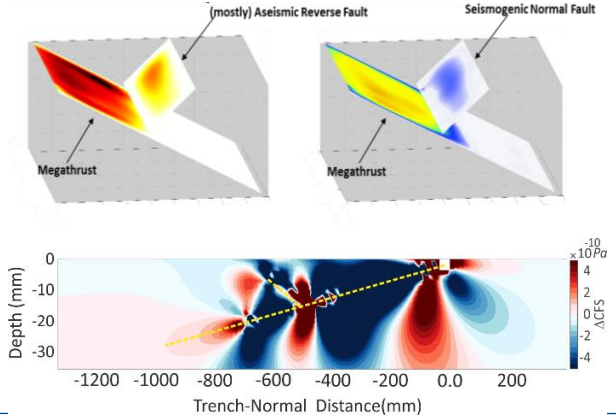




Subduction zone megathrust earthquakes

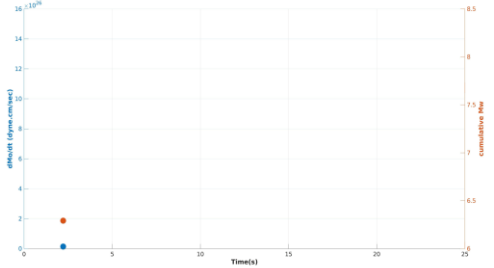






Source parameters

blue = moment rate red = cum. Mw



Volcano flank collapse