

ICTP DIPLOMA PROGRAMME IN EARTH SYSTEM PHYSICS 2015-16

SYLLABUS

MECHANICS OF EARTHQUAKES AND TECTONOPHYSICS

[12 lectures: 18 hours] - A. Aoudia

Fundamental mechanical principles of earthquakes and faulting from four related perspectives: rheology, seismology, geodesy and tectonics; Physical processes that control the rheology of faults, including friction and fracture, how these rheological processes are manifested in faulting and earthquakes; Earthquake cycle and rheology of the lithosphere, postseismic deformation and transients; mechanics of faulting vs. mechanics of earthquakes; Continental and oceanic examples of faulting and earthquakes.

Brittle deformation

Stress tensor; Mohr circles; states of stress; strain

Stress and strain

Griffith theory and fracture mechanics: Theoretical Fracture Strength, Stress concentration; Fracture Strength in Presence of Atomically Sharp Crack, Thermodynamic basis for fracture, Crack Extension Force, Crack Resistance, Stress Intensity Factor and Critical Stress Intensity Factor

Crack models: elastic, Dugdale and small-scale yielding models

Macroscopic failure criteria: faulting, fracture, friction

Macroscopic strength

Fracture energies

Pore fluid effects on fracture

Brittle-plastic transition

Friction and earthquakes

Theoretical concepts: adhesion theory, elastic contact theory, other frictional interactions

Experimental observations of friction

Physics of faults: Stick-slip and stable sliding rate and state variable friction laws, frictional stability regimes, dynamics of stick-slip

Earthquake Mechanics

The dynamic energy balance

Dynamic shear crack propagation

Earthquake ruptures (field, seismology, geodesy, laboratory)

Scaling relations

Aseismic slip

Slow earthquakes, Creep events, Tsunamogenic earthquakes

Slow precursors to “normal” earthquakes

Earthquakes with a distinct nucleation phase

Afterslip and transient postseismic deformation

Normal (fast) earthquakes

Viscoelasticity

Simple shear flow

Newton's law of viscosity

Newtonian fluids

Plasticity and yield stress

Creep curve
Stress relaxation and creep experiments
Elastic (solid-like) response
Viscous (liquid-like) response
Network formulation of viscoelasticity: Maxwell, Voigt-Kelvin, Standard-linear solid, ...
Creep and relaxation functions
Generalized Maxwell model
Relaxation spectrum
Generalized Voigt-Kelvin model
Boltzmann's principle
Dynamic (Oscillatory) Testing
Complex and Dynamic Viscosity

Active deformation

Tools and techniques: GPS, DInSAR, Seismology, direct observations
Tectonic geodesy and GPS seismology
Velocity field
Models of active deformation: distributed vs. localized
Kinematics and dynamics of the deformation
Strength and rheology of the lithosphere
Mechanics of the earthquake cycle inclusive of transient deformation
Case studies

Recommended texts

Mechanics of Earthquakes and Faulting
by Christopher Scholz (2nd Edition- Cambridge)

Earthquake and Volcano Deformation
Paul Segall

Deformation of Earth Materials
By Shun-Ichiro Karato (Cambridge)