# ICTP DIPLOMA PROGRAMME IN EARTH SYSTEM PHYSICS

## MECHANICS OF EARTHQUAKES AND TECTONOPHYSICS (ESP-MET)
## [13 lectures: 18 hours]

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 viscoleasticity: Maxwell, Voigt-Kelvin, Standard-linear solid, …
Creep and relaxation functions
Generalized Maxwell model
Relaxation spectrum
Generalized Voigt-Kelvin model
Boltzman's princicple
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)