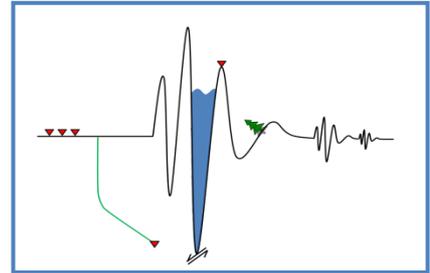


Proposal for an ILP task force

‘From Microseismicity to Large Earthquakes: Studies Related to Seismic Hazard Assessment, Carbon Sequestration and Sustainable Resource Management’
(currently funded as a Helmholtz-University Young Investigators Group -YIG)



The objectives to be addressed in this Young Investigators Group aim at investigating earthquakes over a very wide range of magnitudes extending from microseismicity with magnitudes as low as -2 to large damaging earthquakes, 9 orders of magnitude larger. Furthermore, Acoustic Emissions recorded during rock-deformation experiments in the laboratory will be considered. These studies will address fundamental scientific questions of earthquake physics at multiple scales as well as a number of previously-unaddressed scientific questions related to geologic sequestration of CO₂ and exploitation of sustainable hydrocarbon and geothermal energy resources. The analyses to be carried out for the entire range of scales will focus on the spatiotemporal evolution of hypocenters, the physics of faulting and the seismotectonic implications of the events, in order to develop quantitative models of the occurrence of seismicity in space and time.

Natural seismicity along the North Anatolian Fault Zone (NAFZ) in NW Turkey will be investigated. Unique data sets acquired prior to and after the M>7 Izmit and Düzce 1999 earthquakes will be analyzed and related to on-fault recordings from the Istanbul/Marmara region where a major earthquake with high socio-economic impact is expected in the near future. High-precision hypocenter location methods for array-deployments will be further developed to identify activity patches along the relevant NAFZ segments. These methods will then also be applied to downhole seismic recordings from the SAFOD observatory in the San Andreas Fault in central California. Using Fault-Zone Head Waves the rupture directivity along the eastern Istanbul-Marmara seismic gap will be determined. Analysis of seismic activity patterns, fault kinematics and spatio-temporal variations of the local stress tensor will be performed with unprecedented detail. This will allow us to characterize and investigate asperities along the NAFZ as a major plate-bounding transform fault over a time period that includes two M>7 earthquakes.

Induced microseismicity generated during fluid injection into reservoir rocks and sequestration of CO₂ will be investigated. Utilizing data from a number of projects in which the Stanford Rock Physics and Borehole Geophysics Project (SRB) is involved, will yield data sets with source-receiver distances as low as a few 100 m and allow to study events with magnitudes down to M= -2. These recordings permit us to trace injected CO₂ into depleted oil and gas reservoirs and saline aquifers where the feasibility

of geologic sequestration of CO₂ is being considered. The relation between fluid transport processes and induced seismicity will be addressed analyzing Acoustic Emission data generated during deformation of porous sandstones in the laboratory in collaboration with the Physics and Application of Seismic Emission (PHASE) consortium at FU Berlin.

The studies will be supplemented by analyzing state-of-the-art data sets of induced seismicity from industry-scale hydraulic fracturing experiments to refine existing theoretical models of man-made earthquakes. Newly developed hypocenter determination algorithms applied to data from both environments and analysis of source parameters will refine existing models relating earthquake occurrence to fluid-flow and tectonic loading processes. To compare the results obtained from both types of seismicity a systematic analysis of the rock failure processes focused on earthquake nucleation and migration in space and time in either environment will be performed allow addressing scaling-related objectives for earthquake processes covering the entire range from microseismicity to great earthquakes. With the data sets proposed to be examined in this Young Investigators Group, bridging the gap between surface-based seismological field observations, downhole seismic monitoring during reservoir stimulation and small-scale brittle failure induced during rock deformation experiments in the laboratory becomes a realistic task.

Keywords: Geophysics, Seismology, Seismic Hazard, Transform Faults, CO₂ sequestration, Physics of Faulting