NATIONAL UNIVERSITY OF SAN JUAN
Faculty of Exact, Physical, and Natural Sciences
Geology Graduate Program

Postgraduate Course

Earthquake Geology and Seismic Landscape

From Active Fault Identification to Seismic Hazard Characterization. Application of the ESI-2007 Scale for Earthquake Analysis

Prof. Alessandro Maria MICHETTI

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This 40-hour theoretical-practical course will be held at UNSJ facilities from September 22 to 26, 2025. It includes a field trip on the final day, to visit the epicentral area of the January 18, 2021, Mw 6.5, earthquake occurred ~ 45 km southwest of San Juan

Presentation – Justification

The course aims to increase awareness that the Andean region, including Argentina, is subject to high levels of seismic risk, due to both ground motion and ground rupture hazards. In fact, in numerous Latin America countries and beyond a significant portion of earthquake risk stems from coseismic geological occurrences, such as surface faulting, tsunamis, landslides, and liquefaction. Based on recent studies on earthquake environmental effects (EEE), and following the results of the INQUA Project on the ESI 07 intensity scale, Argentina must enhance its identification and characterization of seismogenic sources and related geological hazards. This course's main objective is to train young specialists in this area. Italy has made significant progress in this task in the past decades, in particular after the 1980 Irpinia earthquake and the national effort for the siting of nuclear power plants terminated in 1986. Today Italy has arguably the best seismic catalogue in the world, in terms of quality and quantity of information. ITHACA, the Italian database of capable faults, constantly updated, includes more than 3000 structures. The EEE catalogue is presently under significant expansion due to the Geoscience IR project based at ISPRA – Italy Geological Survey. The instructor has been actively involved in this process, also as President of the INQUA TERPRO (Terrestrial Processes, Deposits and History) Commission.

The course seeks to raise knowledge among postgraduate students in geosciences about seismic landscape characterization and earthquake risk mitigation in tectonically active regions like Argentina's Andean Precordillera. In particular, how to better identify and characterize seismic threats in the San Juan province and surrounding areas.

Theoretical Framework

NW Argentina, particularly the Precordillera and Sierras Pampeanas (San Juan province), is the most seismically active region in the country due to the interaction between the flat slab of the Nazca Plate and the South American continent. San Juan and Mendoza provinces hold a privileged position to lead studies in seismic risk reduction, starting with the identification of natural seismic hazards. This field, known as "Earthquake Geology," has emerged in the past 40 years, developed by geologists, geomorphologists, and Quaternary scientists, and it focuses on identifying active tectonic structures and their earthquake-generating potential.

Course Information

- **Title:** From Active Fault Identification to Seismic Hazard Characterization. Application of the ESI-2007 Scale for Earthquake Analysis
- **Instructor:** Alessandro Maria Michetti
- **Collaborators:** Dr. Laura Perucca (UNSJ), Dr. Martín Rothis
- **Format:** In-person
- **Dates:** September 22-26, 2025
- **Objectives:** To transmit principles and methodologies in Earthquake Geology and Seismic Landscape analysis, aimed at quantifying seismic hazards, also taking advantage from the Environmental Seismic Intensity scale (ESI-07)
- **Teaching Methodology:** Theoretical (PowerPoint presentations) and practical (field trip to the epicentral area of the 2021 San Juan earthquake).
- **Evaluation:** A true/false written test on the fourth day of the course. For its ease of application and correction, and in turn for allowing many aspects transmitted to be easily covered and explored, participants will have to complete a written test of the true-false type at the end of the theoretical course, in the afternoon of the 4th day, prior to the field trip.
- **Minimum Contents**: Earthquakes and Seismicity, Source Parameters, Magnitude and Intensity, Active Tectonics and Seismic Landscape analysis, Seismic history and seismogenic characterization, Earthquake environmental effects, Siting of critical facilities, Paleoseismology and geochronology of deformations, and Practical field work:
- **Program**:
- 1. Earthquakes and Seismicity: Assessing of the size and location of an earthquake; Wave and type of waves; Tectonic earthquakes; Volcano-tectonic earthquakes; Induced earthquakes;
- 2. Source parameters: Location (hypocenter, epicenter); Magnitude (Ml, Ms, mb); seismic moment Mo and moment magnitude Mw; Macroseismic Intensity (MCS Mercalli, Cancani, Sieberg; Modified Mercalli; EMS-98; ESI-2007); historical seismic catalogues; Focal mechanism and style of faulting: Fault:

normal, reverse, strike-slip, oblique; Active fault; Capable fault; Geological fault vs. slope instability; tectonic fault creep;

- 3. Active tectonics: Morphology of active faults: normal, reverse, strike-slip, oblique; Kinematics and average displacement rate from morphology; Geology of active faults: Evaluation of stress fields (Microtectonics), Chronology of deformations/tectonic phases, Kinematics and displacement rate, Fault segmentation;
- 4. ESI 07 scale, Earthquake Environmental Effects; case histories;
- 5. Siting of critical facilities; IAEA SSG-9; scales of investigation; completeness of the database; ground motion hazard and ground rupture hazard; 5. Complementary methods to active fault characterization: Seismic reflection; InSAR; Detailed LIDAR surveys; Shallow reflection seismic; GPR; Electrical tomography; Radon gas measurements (transects); GNSS or GPS;
- 6. Seismic history and seismogenic characterization: Seismicity windows: Instrumental, Historical and/or Archaeoseismology, Pre-Historical; Seismic history of faults or segments; Seismogenic characterization; Relationships: Magnitude vs. rupture length, Magnitude vs. coseismic displacement, Magnitude vs. rupture area; the value of a naturalistic approach; the conceptual framework of Seismic Landscapes
- 7. Paleoseismology: Geological record of past earthquakes and tsunamis (objects to be studied); (Paleo-) Liquefaction of soils; Paleoseismic methods: Trenches, test pits, cores; Excavation and interpretation of paleoseismic trenches; magnitude of events and their periodicity (seismic history); Seismic Cycle; spatial and temporal clustering of earthquakes;
- 8. Geochronology of deformations: Relative dating: Syntectonic sedimentation, Relative movement rates; Absolute dating: Radiocarbon, Uranium series, amino acid racemization, TL, OSL, Cosmonuclides;
- 9. Practical fieldwork: includes a one-day field trip to the epicentral area of the 2021 San Juan earthquake, in order to put into practice what was presented during the theoretical course. This fieldwork is scheduled for the fifth and last day of the course, with departure at 8 a.m. and return at 7 p.m.
- **Development and Evaluation Schedule**
- The theoretical part of the course will be held from Monday to Thursday, between 8 a.m. and 12 p.m. and 2 p.m. and 6 p.m. The field trip (practical component) will take place on Friday, September 30, between 8 a.m. and 7 p.m.
- **Duration and Workload**
- Minimum of 40 hours, over five (5) continuous days, with hours from 8 a.m. to 12 p.m. and 2 p.m. to 6 p.m., but it can be adjusted to suit the participants or local customs; or period or season of the year.

- **Quota (minimum and maximum number of participants). Selection method if the quota is exceeded**
- Minimum number of participants: 5; the maximum number of participants will be defined by the capacity of the means of transport (university or not) that can be used to carry out the field activity; selection will be made on a "first come, first served" basis.
- **Admission Requirements**
- Directed to students and professionals in the geosciences (geologists, geological engineers, geophysicists, geophysical engineers, seismologists, geomorphologists, geographers, earthquake-resistant engineers, civil engineers, etc.). Preference will be given to students enrolled in the postgraduate course in geological sciences at UNSJ.
- **Resources Needed (classroom, PC, etc.)**
- For the theoretical component:

  - Room with the capacity of desks or tables for the number of participants reached. With blinds and/or dark curtains that allow audiovisual projection

  - Projection projector (video-beam)

  - Acrylic marker board and/or flipchart

  - Acrylic markers and whiteboard eraser

  - PC/laptop with PowerPoint program

  - Laser pointer and batteries
- For the practical component:

  - Appropriate vehicle with capacity for registered participants

  - Megaphone

  - Snacks and sandwiches
- **Bibliography**

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