

Curriculum Vitae

Leonardo DEL SOLE, Ph.D.

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EDUCATION

November 2017 – May 2021

Doctoral degree in Earth, Life and Environmental Sciences, Univ. of Bologna, Italy. Final exam evaluation: "Excellent". Thesis: *Fracture Networks Development, Fluid Flow, and Diagenetic Processes in Sandstones and Carbonate Rocks*, DOI: [10.6092/unibo/amsdottorato/9678](https://doi.org/10.6092/unibo/amsdottorato/9678). Supervisor Prof M. Antonellini.

October 2015 – October 2017

Second cycle-master's degree in Field and Natural Resources Geology, Univ. of Roma Tre, Italy, graduated cum laude. Thesis: *Tectonic evolution of the Rennick Fault (North Victoria Land, Antarctica) through the analysis of fault-related fractures of analogues: the case of the Val Roveto Fault (Central Apennines, Italy)*. Advisors Prof F. Salvini, Dr P. Cianfarra.

September 2012 – July 2015

First cycle-bachelor's degree in Geological Sciences, Univ. of Bologna, Italy, graduated cum laude. Thesis: *Description of fluid flow and deformation sequence in the Monte Venere Formation (Northern Apennines, Italy)*. Supervisor Prof M. Antonellini.

PROFESSIONAL EXPERIENCE / INTERNSHIPS

September 2021 – present

Postdoctoral Researcher at the School of Science and Technology – Geology Division, Univ. of Camerino and Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy. Project: *Seismic vs aseismic slip in carbonate-hosted upper-crustal faults*. Advisors Prof S. Mazzoli, Prof E. Tondi.

April 2021

Technical collaborator. Collaboration in the monitoring of water points (spring, well, piezometer, watercourse) located in the project area related to the quadrupling of the railway line Fortezza – Verona. Responsibilities: Collection of physical (flow rate, water table depth) and water quality (pH, ORP, conductivity, dissolved oxygen, temp.) parameters of water points along the *Valle Isarco* (South Tyrol, Italy).

April 2019 – July 2019

Internship at the Univ. of Montpellier - Geosciences Montpellier, France. Project: *Diagenesis of deformation bands in porous sandstones*. Achieved during the PhD. Advisors Prof R. Soliva, Dr G. Ballas.

Curricular internship (75 hrs) at the GeoQuTe Lab at the Univ. of Roma Tre, Italy. It focused on the analysis of structural data collected in North Victoria Land (Antarctica), with focus on the inversion of fault kinematic data (Monte Carlo method; Daisy3 software) with the aim to infer the paleo-stress field responsible for the observed deformation. Achieved during the M.S (A.A. 2016-17). Supervisor Prof F. Salvini.

Curricular internship (96 hrs) at the Institute of Marine Sciences - National Research Council, ISMAR-CNR, Bologna, Italy. It focused on the analysis and interpretation of magnetic susceptibility data (core sample) and seismic reflection profiles (SeisPrho). Achieved during the B.S (A.A. 2014-15). Supervisors Dr A. Polonia, Dr L. Gasperini.

RESEARCH INTERESTS

My general topics of interest include Structural Geology & Tectonics:

- **Fault zone analysis:** Strain localisation, fabric development, and deformation mechanisms in brittle shear systems; Fracture networks characterization; Petrophysical properties and Fault zone hydrogeology.
- **Rock mechanics:** Rock geomechanical properties; Mechanics of faulting and earthquakes
- **Fluid / fault interaction and Structural diagenesis**

Recently, my work has been focused on the interaction between deformation, fluid flow, and diagenesis in porous sandstone and carbonate rocks by means of a multidisciplinary approach (fieldwork, analytical methods, modeling), involving structural geology, fracture and fault mechanics, geochemistry, and sedimentary petrology.

PUBLICATIONS

In preparation:

Del Sole, L., Mazzoli, S., Carafa, M.M.C., Giuli, G., Invernizzi, C., Tondi, E. Interseismic locking vs. aseismic slip of carbonate-hosted normal faults: Insights from the northern Apennines, Italy. (author list not finalized; to be submitted within 2022).

Napoleoni, S., **Del Sole, L., Antonellini, M.** From outcrop-mapped structural and diagenetic heterogeneities to a 3D numerical flow model: a workflow for a sandstone aquifer. (title, author list and order not finalized; to be submitted within 2022).

Published (Peer reviewed journal articles):

Del Sole, L., Antonellini, M., Soliva, R., Ballas, G., Balsamo, F., Viola, G. (2020). Structural control on fluid flow and shallow diagenesis: insights from calcite cementation along deformation bands in porous sandstones, *Solid Earth*, 11(6), 2169-2195, <https://doi.org/10.5194/se-11-2169-2020>.

Del Sole, L., Antonellini, M., Calafato, A. (2020). Characterization of sub-seismic resolution structural diagenetic heterogeneities in porous sandstones: Combining Ground-Penetrating Radar profiles with geomechanical and petrophysical *in situ* measurements (Northern Apennines, Italy). *Marine and Petroleum Geology*, 117, 104375. <https://doi.org/10.1016/j.marpetgeo.2020.104375>.

Antonellini, M., **Del Sole, L., Mollema, P. N. (2020).** Chert nodules in pelagic limestones as paleo-stress indicators: a 3D geomechanical analysis. *Journal of Structural Geology*, 132, 103979. <https://doi.org/10.1016/j.jsg.2020.103979>.

Del Sole, L., Antonellini, M. (2019). Microstructural, petrophysical, and mechanical properties of compactive shear bands associated to calcite cement concretions in arkose sandstone. *Journal of Structural Geology*, 126, 51-68. <https://doi.org/10.1016/j.jsg.2019.05.007>.

Antonellini, M., Mollema, P. N., **Del Sole, L. (2018).** Reply to Comment by Trinchero et al. on "Application of analytical diffusion models to outcrop observations: Implications for mass transport by fluid flow through fractures". *Water Resources Research*, 54(11), 9706-9707. <https://doi.org/10.1029/2018WR023312>.

Antonellini, M., Mollema, P. N., **Del Sole, L. (2017).** Application of analytical diffusion models to outcrop observations: Implications for mass transport by fluid flow through fractures. *Water Resources Research*, 53(7), 5545-5566. <https://doi.org/10.1002/2016WR019864>.

OTHER CONTRIBUTIONS

Del Sole, L., Antonellini, M. 2020. Compactive shear bands. In: Mukherjee, S. (Ed) Atlas of Structural Geology. 2nd Edition. Elsevier, pp. 115–118. ISBN: 978-0-12-816802-8. <https://doi.org/10.1016/B978-0-12-816802-8.09995-9>.

CONFERENCE ABSTRACTS (*oral presentation)

Del Sole, L., Mazzoli, S., Carafa, M.M.C., Giuli, G., Invernizzi, C., Tondi, E. (2022, Dec). Interseismic locking vs. aseismic slip of carbonate-hosted normal faults: Insights from the northern Apennines, Italy. AGU Fall Meeting 2022, Dec. 12-16, Chicago IL, USA. [under evaluation]

Napoleoni, S., **Del Sole, L., Antonellini, M. (2022, Sept).** From outcrop-mapped structural and diagenetic heterogeneities to a 3D numerical flow model: a workflow for a sandstone aquifer (abs.) SGI-SIMP Congress "Geosciences for a sustainable future", Sept. 19-21, 2022, Torino, Italy.

Del Sole, L., Calafato, A., Antonellini, M. (2020, May). Combining Ground-Penetrating Radar profiles with geomechanical and petrophysical *in situ* measurements to characterize sub-seismic resolution structural and diagenetic heterogeneities in porous sandstones (Northern Apennines, Italy). In *EGU General Assembly Conference Abstracts – GRA*. ID: EGU2020-3118.

Del Sole, L., Antonellini, M. (2019, April). Strengthening effect of compactive shear bands and associated carbonate nodules in arkose sandstone: a natural analog of composite multilayer. In *EGU General Assembly Conference Abstracts – GRA*. ID: EGU2019-6134.

Del Sole, L. *, Antonellini, M. (2018, Sept). Calcite-cement precipitation mediated by cataclastic shear bands in arkosic sand: petrophysical and mechanical considerations (abs.): SGI-SIMP Congress "Geosciences for the environment, natural hazards and cultural heritage", Sept. 12-14, 2018, Catania, Italy. (p. 165).

AWARDS and BURSARIES

2020 "Stephen E. Laubach Structural Diagenesis Research Award" (\$4,000.00) awarded from the Geological Society of America (GSA). <https://community.geosociety.org/sedimentarygeologydiv/awards/laubach>.

"MARCO POLO Program" Student Support scholarship (€3,450.00) from the Alma Mater Studiorum – University of Bologna for abroad research period (Geosciences Montpellier, France, April–July 2019).

TEACHING EXPERIENCE

Teaching assistant for practicals for BSc students - Field Camp (University of Camerino) 2021

Teaching assistant for practicals for MSc students - Field Camp (University of Camerino) 2022

PROFESSIONAL ACTIVITY

Reviewer for: *Journal of Structural Geology* (2021); *Journal of Petroleum Science and Engineering* (2019).

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

European Geoscience Union (EGU) 2019 – present

Società Geologica Italiana (SGI) 2019 – present

ADVANCED COURSES

[1] Training REDI - REducing risks of Natural Disasters - co-organized by UNICAM, INGV, INFN and GSSI, at the Univ. of Camerino, Italy, 26-30 Sept 2022 [lectures + practicals] [2] Online short course "Introduction to fluid inclusion studies in sedimentary basins" held by Dr M Gasparrini (Univ Milan, Italy), 23-25 Feb 2022 [12hrs lecture] [3] Workshop "3D Photogrammetry and virtual outcrop models of geological structures" organized by Soc Geol Ita, co-held by Prof S Tavani (Univ of Naples Federico II - CNR), Dr A Corradetti (Univ of Trieste), Dr M Mercuri (Sapienza Univ of Rome) at the Sapienza, Italy, 31 Jan – 2 Feb 2022 [16hrs practice + lecture] [4] Summer School "The role of the geoscientist in the energy transition" co-organized by UNICAM (Italy), UPPA (France), Sapienza (Italy), and RE&E, at the Univ. of Camerino, Italy, 20-24 Sept 2021 [34hrs lecture] [5] Online short course on "Seal bypass structures using 3D and 4D seismic data" held by Prof D. Iacopini (Univ. of Naples Federico II, Italy), 14-16 May 2020 [12hrs lecture] [6] Online short course on "The structure and growth of fault zones" held by Dr G. Camanni (Univ. of Naples Federico II, Italy), 11-13 May 2020 [12hrs lecture] [7] Short Course on "Selling Science to politicians and publics - communicating technical science to non-technical audiences" held by Prof I. Stewart (Plymouth Univ, UK) at the Univ of Bologna, Italy, 25 Feb 2019 [6hrs lecture] [8] Short Course on "Thermometry,

chronometry, barometry and fluid geochemistry in sedimentary basins" held by Dr M. Gasparri (IFPEN, France) at the Univ. of Rome Tre, Italy, 17-21 Sept 2018 [27hrs lecture] **[9]** "Statistics: theory and application (R software)" held by Dr A. Boattini, Dr A. Lucchetti (UniBo, Italy), 25-29 June 2018 [30hrs lecture and exercise + final exam] **[10]** Volcanology PhD field course: Campi Flegrei and Vesuvio (Italy)" held by Dr F. Lucchi (UniBo, Italy), 9-11 May 2018 [3 days field-trip] **[11]** Short course "Subduction: Dynamics and Tectonics" held by Prof L. Royden (MIT, US), January 19-20, 2017, Univ of Roma Tre, Italy [16hrs lecture] **[12]** VIII Volcanology School - AIV, 7-12 Dec 2015, Bolsena, Italy [15hrs lecture, 20hrs fieldwork].

TECHNICAL SKILLS

Computational knowledge O.S.: MacOS, Windows.

Business Software: Microsoft Office package, LaTeX (basic knowledge), etc.

Graphic and SFM Software: Inkscape, Adobe Illustrator; Agisoft Metashape, Cloud Compare.

Scientific Software: QGIS, Stereonet, Daisy3, OpenPlot, ImageJ/Fiji, R; basic knowledge: MATLAB, MODFLOW/ModelMuse.

CERTIFICATES

UAS Remote Pilot Open Category - A1+A3. Issued by the European Union Aviation Safety Agency (EASA) and the Direction de l'Aviation Civile (DAC) – Grand Duché de Luxembourg [Issued Aug 2022 – Expire Aug 2027].

OTHER INFORMATION

Languages: Italian (native tongue), English (proficient user), Spanish (excellent knowledge).

International Driving Permit: A2; A; B

Camerino, September 2022

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