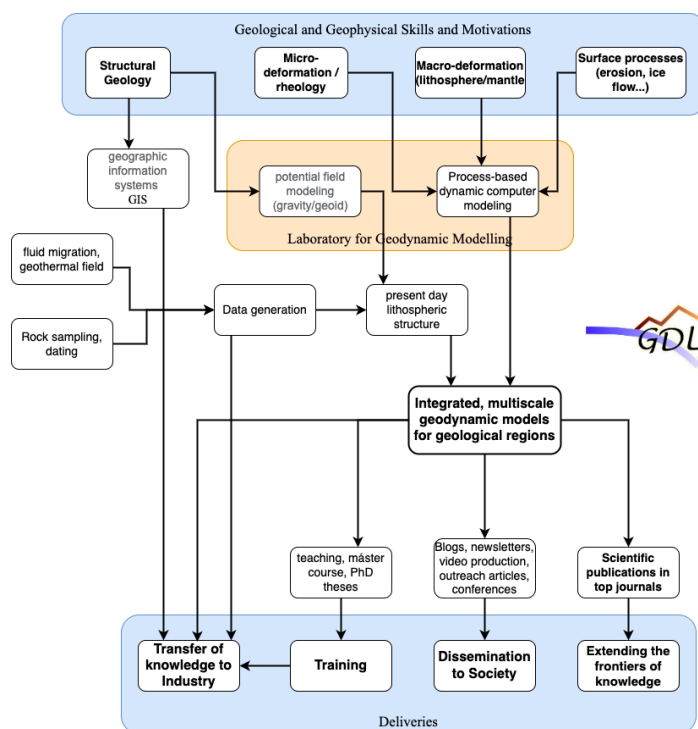


1. Previous results of the team in the theme of the project.

The capability of our team to tackle these scientific issues is demonstrated by our publication record on comparable geological settings and using numerical modelling techniques close to those proposed here. The [GDL group](#) (which includes all of the Working Group members in this project) has accumulated a wide experience in determining the present-day structure of the crust and upper mantle and in characterizing the mantle composition, temperature distribution and sublithospheric anomalies in other regions of the Alpine-Himalayan orogenic belt (projects ATIZA CGL2009-09662 and TopoAtlas CGL2006-05493), the Iberian Peninsula (MITE CGL2014-59516 and SUBITOP MSCA-ITN-2015-674899) and recently in Western-Central Mediterranean zone (GeoCAM PGC2018-095154-B-I00) Figure 5.

Our capability to produce balanced and restoration of a cross-section at crustal and lithospheric scale is reflected in several projects in collaboration with the industry (e.g., two projects with TOTAL in Iraqi-Kurdistan and Polish Carpathians, and REPSOL-YPF in Cuba). The interplay between tectonic deformation and erosion modelling along cross-sections has been the focus of previous projects of our group such as MITE (CGL2014-59516) and TopoAtlas (CGL2006-05493). Geodynamic modelling of subduction systems has been the



subject of TOPOMOD (MSCA-ITN-2010-264517) and SUBITOP (MSCA-ITN-2015-674899) funded by the European Commission, and from the Spanish Ministry (CGL2009-13103 and CGL2014-59516-P). Moreover, all these previous cited projects deal with the interaction between the signatures at surface and depth, quantifying the topographic response related to the mantle processes.

All these projects demonstrate that our team has all the knowledge and capability to develop and use all the methods and tools necessary to carry out this proposal. Most of the members of the group have been collaborating over the last 20 years.

Figure. Organization of the GDL group capabilities. See web site: <https://sites.google.com/site/ictjagdl/home>

2. Human, material and equipment resources available for the execution of the Project.

The PI's of this proposal are the Scientific Directors of the Laboratory of Geodynamic Modelling from Geo3BCN-CSIC. This Laboratory, established officially in 2016, offers the experience on several codes and on numerical modelling techniques. The institute is equipped with a cluster (EARTH) with 312 CPU and 2,5 TB of RAM and a workstation (MITE).

During the last 15 years, several members of the present research team have been involved in projects using the RES (Red Española de Supercomputación) and PRACE (Partnership for Advanced Computing in Europe) resources. They offer world class computing and data management resources and services, including computing time in one of their supercomputers (Marenostrum). Recently, our group participated in the creation of an Associated Unit between BSC and CSIC, which will facilitate the collaboration between the researcher and the utilization of their infrastructures. Our institution CSIC also provides high performance computation facilities (e.g. Cluster Trueno).

The facilities of the Geosciences Barcelona institute (GEO3BCN-CSIC) have an optical and electron microscope laboratory that allows the development of microstructural and

petrographic studies of fault rocks and fracture-filling carbonates that will be dated by means of the U-Pb dating method. Also, the Department of Mineralogy, Petrology and Applied Geology of the University of Barcelona will facilitate access to the cathodoluminescence microscope and the ultrasound pulse velocity apparatus. The High-Resolution Mass Spectrometer (HR-ICP-MS) of the labGEOTOP, also in the GEO3BCN, will allow to develop elemental analyses in order to measure the content of uranium and lead of fracture-filling carbonates and select those promising for dating analyses

3. Training capacity

This proposal involves a large diversity of geophysical and geological data and modelling techniques that make it ideal for the training and formation of two doctoral students. Their research will focus on the state-of-the-art open scientific questions and geodynamic processes described above and linking them with regional data on the seismicity, volcanism, and changes in topography. Working in an interdisciplinary group the PhD students will integrate several techniques to gain a common objective. The students' training will consist of using and modifying numerical codes, as well as getting familiar with managing large available data sets from local to regional scale. As the numerical models have been developed (or are commonly used) by members of the research group, the students will have the necessary support from the same people who have developed the programs, thus ensuring quality training in a broad spectrum of geological, geophysical and numerical aspects. The PhD students will also benefit from the Laboratory for Geodynamic Modelling and the Master Course on Dynamics of the Lithosphere (both run by within our group) and from the Earth Sciences PhD Program by the University of Barcelona.

Theses completed or in progress within the research team (last 10 years)

In progress PhD Thesis:

1. Wentao Zhang (2019 - planned November 2023): "The Central Alpine Mediterranean Orogenic System: numerical modelling of the lithospheric structure". University of Barcelona. Advisors: I. Jiménez-Munt, M. Torné and AM Negrodo. 1 Publication: Zhang et al., 2022, JGR, doi: 10.1029/2022JB024800.
2. Estefanía Bravo Gutiérrez (2020 - planned 2024): "Tectònica i formació de conques sedimentaries en el Mediterrani central durant el Cenozoic", Universidad de Barcelona. Advisors: D. García-Castellanos and J. Vergés
3. Yuanhao Yu (2020-2024) Fabric evolution and seismic anisotropy of multiphase rocks, with applications to prediction of Earth's mantle flow. Advisors: Maria-Gema Llorens, Daniel García-Castellanos, Albert Griera
4. Baqin Hao. (2020-2024) "Dynamic behaviour of salt rocks: exploring the interplay between deformation, recrystallisation and trace element transport with full-field numerical simulation. Advisors: E. Gomez Rivas (UB), MG Llorens y A Griera
5. José Federico del Pozo Díaz (2020-planned 2024): Análisis integrado de la Cuenca de Antepaís Varisca (Carbonífero, NO de España), Universidad de Oviedo. Advisors: Óscar Antonio Merino Tomé and Jaume Vergés.

Completed PhD Thesis:

1. Sara Rodríguez Molina (2016-2022): "Inter-eruptive volcanic deformation: Three Sisters (Cascades cordillera USA) as study case". Universidad Complutense de Madrid. Advisors: A. M. Negrodo and M. Charco Romero. 1 Publication: Rodríguez-Molina et al., 2012, Frontiers in Earth Science, doi: 10.3389/feart.2020.577588.
2. Hanneke Heida (2018-2022): "Isostatic vertical motions during the Messinian salt giant or marginal vertical motions". Contract from SALTGIANT ETN (2018). University of Barcelona. Advisors: D. Garcia-Castellanos and I. Jiménez-Munt. 5 Publications: 1) Gvirtzman et al., 2022, 10.1038/s43247-022-00540-4, 2) Maillard et al., 2022, 10.1016/j.tecto.2022.229295, 3) Raad et al., 2022, 10.1111/bre.12702, 4) Heida et al., 2021, 10.1111/bre.12610, 5) Andreetto et al., 2021, 10.1016/j.earscirev.2021.103577.
3. Kittiphon Boonma (2017-2021): "Slab tearing, vertical tectonic motions, and the Miocene marine gateways across the Gibraltar Arc". Funded with the European ITN Project SUBITOP. University of Barcelona. Advisors: D. Garcia-Castellanos and I. Jiménez-Munt.

- 2 Publications: 1) Boonma et al., 2019, *Scientific Reports*, 10.1038/s41598-019-54374-w, 2) De Felipe et al., 2022, *Front. Earth Sci*, doi: 10.3389/feart.2022.828005.
4. Angel Valverde (2016-2021): “Numerical modeling of continental collision and intraplate deformation. Application to the Cenozoic geodynamic evolution of North Iberia”. University of Barcelona. Advisors: D. Garcia-Castellanos and I. Jiménez-Munt.
 5. Ajay Kumar (2017-2020): “Thermal and chemical imaging of the upper mantle anomalies: application to Western Mediterranean”, University of Barcelona, Advisors: M. Fernández and J. Vergés. 4 Publications: 1) Jiménez-Munt et al., 2019, 10.1029/2019JB018445, 2) Boonma et al., 2019, 10.1038/s41598-019-54374-w, 3) Kumar et al., 2020, 10.1029/2019GC008777, 4) Kumar et al., 2021, 10.1029/2020JB021388
 6. Mireia Peral (2015-2020): “Dynamics of subduction systems with opposite polarity in adjacent segments: application to the Westernmost Mediterranean”. Universitat de Barcelona. Advisors: M. Fernández and S. Zlotnik. 4 Publications: 1) Peral et al., 2028, doi:10.1029/2017TC004896, 2) Peral et al., 2018, DOI: 10.1344/GeologicaActa2018.16.1.6, 3) Peral et al., 2020, doi: 10.1029/2020GC009035, 4) Peral et al., 2022, doi:10.1016/j.tecto.2022.229309.
 7. David Cruset Segura (2015-2019): “Sequential fluid migration along a fold and thrust belt: SE Pyrenees from Late Cretaceous to Oligocene”, University of Barcelona, Advisors: J. Vergés and Anna Travé. 6 Publications: 1) Cruset et al., 2016, 10.1016/j.jog.2016.05.004, 2) Cruset et al., 2018, 10.1016/j.gloplacha.2017.11.001, 3) Nardini et al., 2019, 10.3390/min9020117, 4) Muñoz-López et al., 2020, 10.1155/2020/8815729, 5) Muñoz-López et al., 2020, 10.5194/se-2020-65, 6) Cruset et al., 2020, 10.1016/j.dib.2020.105896.
 8. Chiara Amadori (April 2018). “3D architecture and evolution of the Po Plain – Northern Adriatic Basin since the Messinian salinity crisis through Pliocene-Pleistocene time”. Univ. Pavia, Co-advisor: D. Garcia-Castellanos. 1 Publication: Amadori et al., 2018, *Basin Research*. doi:10.1111/bre.12302
 9. Mar Moragas (2011-2016): “Multidisciplinary reservoir characterization of mixed sedimentary sequences integrating field examples and numerical modelling. La Popa Basin, High Atlas Basin, and North Iberian basins”. Universitat de Barcelona. Advisor: J. Vergés and E. Playà. 7 Publications: 1) Orti et al., 2014, *Sediment. Geol.* 10.1016/j.sedgeo.2014.06.004. 2) Martín-Martín et al., 2017, 10.1002/2016TC004300. 3) Moragas et al., 2018, 10.1111/bre.12223. 4) Saura et al., 2014, 10.1144/jgs2013-079. 5) Moragas et al., 2017, 10.1016/j.marpetgeo.2017.10.001. 6) Moragas et al., 2013, 10.1111/gfl.12017. 7) Verges et al., 2017, 10.1016/B978-0-12-809417-4.00027-6.
 10. Jan Globig (2011-2016): “The lithospheric structure of Africa: Mapping crustal and lithospheric thickness using geoid and elevation constraints together with a thermal analysis”. Universitat de Barcelona. Advisor: M. Fernández and M. Torné. 1 Publication: Globig, J. et al., *J. Geophys. Res. Solid Earth*, 121, doi:10.1002/2016JB012972, 2016.
 11. Alberto Carballo (2010-2015): “Geophysical and petrological characterization of the lithospheric mantle in Iberia and North Africa”. University of Barcelona. Advisor: M. Fernández and I. Jiménez-Munt. 4 Publications: 1) Carballo, A. et al. *Gondwana Research*, 27, 1430-1445, doi: 10.1016/j.gr.2013.12.012, 2015. 2) Pedreira, et al., *Lithos*, 230, 46-68, doi: 10.1016/j.lithos.2015.04.018, 2015. 3) Carballo, A. et al., *Tectonophysics*, 663, 399-418, doi:10.1016/j.tecto.2015.07.009, 2015. 4) Bosch et al., 2016, *Comptes Rendus – Geoscience*, 348, doi: 10.1016/j.crte.2015.08.005.
 12. Lavinia Tunini (2010-2015): “The Central Asia collision zone: numerical modelling of the lithospheric structure and the present-day kinematics”. University of Barcelona. Advisor: I. Jiménez-Munt and M. Fernández. 3 Publications: 1) Tunini, L. et al. *Geophys. J. Int.*, 200, 596-614, 2015. 3 publicaciones: 2) Tunini, L. et al., *Tectonics*, 35, doi:10.1002/2016TC004161, 2016. 3) Tunini, L. et al., *J. Geophys. Res. Solid Earth*, 122, doi: 10.1002/2017JB014487, 2017.
 13. Juan Rodríguez González (2008- 2013): “Numerical modeling of subduction processes in 2D and 3D. Influence of the characteristics of the overriding and subducting plates and interaction with the mantle flow”. University Complutense of Madrid. Advisors: A. Negredo (UCM) and M. Billen (University of California Davis). 4 Publications: 1) Pavón-Carrasco et al., 2011, *J. Archaeol. Sci.*, doi: 10.1016/j.jas.2010.09.021. 2) Rodríguez-González et al., 2012, *Geoch. Geophys. Geosys.*, doi: 10.1029/2011GC003859. 3) Rodríguez-González et al., 2014, *Terra Nova*. doi: 10.1111/ter.12095. 4) Rodríguez-González et al., 2014, *Earth Planet. Sci. Lett.* doi: 10.1016/j.epsl.2014.06.013

Scientific or professional development of graduate doctors.

Hanneke Heida has a Postdoc contract in Geosciences Barcelona. Kittiphon Boonma is contract as research specialist in the Geoinformatics Center by the Asian Institute of Technology in Thailand. Ajay Kumar is a PostDoc in the GFZ in Postdam-Germany. Mireia Peral is doing research in collaboration with our group and contracted as lecture by the University of Barcelona. Jan Globig is working in the GFZ from Postdam-Germany as a projects and international affairs management. Mar Moragas has been contracted by the Worldwide CGG geosciences company located in North Wales and since 2022 she has a fellow research position at the University of Bergen. Alberto Carballo and Angel Valverde are contracted in private companies both of them dealing with big data. Dr. Chiara Amadori is currently postdoc researcher at University of Pavia. Lavinia Tunini has been a PostDoc contract at the Département de Géosciences from the Ecole Normale Supérieure de Paris and two years ago she got a research fellow position on the National Institute of Oceanography and Applied Geophysics (OGS) in Trieste-Italy. Juan Rodríguez is teaching in a school.