Call for applications to a PhD fellowship

Institute Dom Luiz (IDL) at the University of Lisbon, is offering six (6) research fellowships (PhD Grants) in the areas of Geology, Geophysical and Geoinformation Sciences, and Sustainable Energy Systems, under the rules set up by FCT in its "Regulamento das Bolsas de Investigação" (RBI) and "Estatuto do Bolseiro de Investigação" (EBI).
The grants wil be financed by FCT, under the "Protocolo de Colaboração para Financiamento do Plano Plurianual de Bolsas de Investigação para Estudantes de Doutoramento" and IDL (UIDP/50019/2020).

1. Application
   Applications must be submited between June 19, 2023 at 00h and July 15, 2023 at 23h59 (Lisbon time).
   Applications and supporting documents (listed in the present call) must be submitted by e-mail to clee@ciencias.ulisboa.pt
   Each candidate can only submit one application. Multiple applications will imply the rejection of the candidate. False declarations or plagiarism is also a reason for the rejection of an applications, and may lead to further sanctions
2. Grants
   PhD grants are designed to support research activities by the candidate, leading to the attribution of a doctoral degree by a Portuguese University. These research activities must be part of the research program of IDL (UIP/50019/2020-Instituto Dom Luiz) and require registration in one of the following doctoral programs:
   - PhD in Geophysical and Geoinformation Sciences, Faculdade de Ciências da Universidade de Lisboa.
   - PhD in Geology, Faculdade de Ciências da Universidade de Lisboa.
   - PhD in Sustainable Energy Systems, Faculdade de Ciências da Universidade de Lisboa.

The research plan may be developed totally or partially in a national institution (with a national or mixed grant)
In the case of mixed grants, the total period of work abroad can not exceed 24 months.

3. Applicants
   The PhD grants may be given to candidates that are registered or are in conditions to be registered in one of the aforementioned PhD programs (section 2 of this call) and want to develop their PhD research in UIDP/50019/2020 - Instituto Dom Luiz, or in an associated institution.
4. Conditions for acceptance
   4.1 admission to the call
   Applicants may be:
   - Portuguese or European Union citizens
   - Citizens from other states
   - Refugees
   - Stateless persons

To apply to a PhD Grant, the applicant needs:

- A degree (Licenciate-BSc or MSc) in Geology, Geophysics, Geospacial Engineeering, Energy and Environment or related areas.
- Be a regular resident in Portugal at the date of the start of any research abroad, it the plan includes such research, this requirement applies both to national and foreign citizens.
- Not have been the recipient of a previous doctoral fellowship from FCT, of any duration.
- Not to be holder of a doctoral degree.

4.2 Other requirements
The following documents must be included in the application:

- ID (Citizen card, passport)
- Curriculum vitae;
- Certificates for the degrees, with the final mark and, if possible, individual marks in all courses, alternatively the candidate may submit a declaration of honour guaranteeing that he has concluded those degrees before the application deadline.
- Official recognition of degrees given by foreign institutions and of the conversion of marks to the Portuguese marking system, alternatively the candidate may submit a declaration of honour guaranteeing that he has obtained such recognition before the application deadline.

- Motivation letter;
- 2 letters of recommendation
- The application and all supporting documents, including the motivation and recommendation letters must be written in Portuguese or English.

Please note:
For a fair comparison of degrees from different countries, the recognition and mark conversion of foreign degrees is required. This can be done by any Portuguese University or by the Direção-Geral do Ensino Superior (DGES, only for automatic recognitions). Details can be found in http://www.dges.gov.pt.
Candidates must have completed is MSc or BSc (Licenciatura) degree before the application deadline. It the certificate is not yet available, they can be accepted against a statement of honor, but the documents must be submitted before the contract.

5. Research plan and supervision

Each candidate must select one or more of the proposed research plans (anexo I), in order of preference. Each plan includes a list of supervisors, a description of objectives and methods, and requirements. If two of the selected candidates have applied to the same plan, that plan is offered to the highest marked, with the other candidate being offered an alternative plan. It the latter candidate does not won't to accept the second plan he will be asked to quit the call and the next candidate in the ordered list will be called.

6. Evaluation

The evaluation will consider the academic path of the candidate, his/her capacity of pursuing innovative research and of contributing to IDL objectives.
Applications are marked in a scale 0-5 in the following criteria:

- A – Academic path, with a 40% weight:
  - A1 – degrees concluded, following FCT table 1 (60%)
  - A2 – Marks in the final year courses (40%) of the more relevant degree.
- B – Research experience in the context of the PhD plan (30%)
- C – Motivation and work qualities assessed by interview (30%)

The final mark will be computed as:

$$\text{Final mark} = (0.4 \times \boldsymbol{A}) + (0.3 \times \boldsymbol{B}) + (0.3 \times \mathbf{C})$$

In case of equal final marks, the order will be obtained by the partial marks in the following order: A, C, B.
Important:
Candidates with foreign degrees that do not present an official conversion of the marks, will be given the lowest mark in A1 (1, 1.5 or 2.5, depending on the degrees, following table 1). Contracts with foreign candidates will only be signed after the recognition and mark conversion.
Grants will not be given to candidates with a final mark below 3.

7. Bonification

NA

8. Evaluation

Panel:

- Pedro Miranda, Professor Catedrático, FCUL (coordenador do painel), efetivo
- Ana Azeredo, Professora Catedrática FCUL, efetivo
- Emanuel Dutra, Investigador Principal, IPMA, efetivo
- Maria Ana Baptista, Professora Coordenadora, ISEL, efetivo
- Rui Taborda, Professor Associado com Agregação, FCUL, efetivo
- Maria Cristina Cabral, Professora Auxiliar FCUL suplente
- João Catalão, Professor Associado com Agregação, FCUL, suplente

The members of the panel will accept the FCT rules for an independent and impartial evaluation, avoiding any conflicts of interest and guaranteeing the confidentiality of the process. The panel will fill an evaluation template for each candidate, with a clear description of the reasons for the different marks in each evaluation criterion. Each panel meeting will be closed with

minute signed by all members, listing the members and their affiliation, applications rejected with justification, methods of evaluation for specific cases not considered in this call, evaluation templates for each candidate, ordered list of all candidates, declaration of conflit of interest, panel composition in case of justified absence.

9. Dates, including complaints and appeal

After the publication of the provisional ordered list, the candidates can appeal within the next 10 working days, following articles 121º-ff from the "Código do Procedimento Administrativo".
A final decision will be issued after the analysis of the responses of the candidates. An appeal to that decision can be submitted in the next 30 working days, after notification. That appeal must be submitted to the direction of FCT.

10. Contracts

Before the contract, the following documents must be submitted:

a) Copies of ID, fiscal registration and social security;
b) Copies of certificates of the degrees;
c) Official recognition of the degrees, with mark conversion to the Portuguese system;
d) Work plan;
e) Registration in the PhD program;
f) Statement of acceptance by the supervisors, following the template given by FCT;
g) Statement of acceptance by IDL, supporting the work plan, following the template given by FCT;
h) Statement of the candidate guaranteeing the full time enrolment in the plan, following the template given by FCT;

The grant will always require:

- All conditions described in the present call
- A positive evaluation
- The absence of previous unjustified failures in other FCT contracts (direct or indirect);
- The financial capacity of FCT.

All required documents must be submitted up to 6 months after the offer of the Grant. Otherwise the grant will be cancelled.

11. Funding

Funding wil start after the submission of the signed contract, which must be done within 15 working days of its reception from FCT. The present grants will be supported by FCT under its State Budget and, when eligible, with funds from the European Social Fund, following the relevant law and rules.

12. Grant

Each grantee will receive a monthly subsidy (table in RBI).4
Other components may be defined in article 18 of RDI, and in its anexo ii.
All grantees will be offered an insurance for personal accidents associated with their research activity, paid by FCT.4
The grantees may obtain social security support by contracting that support within the conditions described by article 10 of RBI, with FCT support.

13. Payments

Payment will be made by bank transfer to the select account. The monthly subsidy is due in the first working day of each month. Payments pf registration and tuition fees are made by FCT directly to the host institution of the phD program.

14. Grant renewal

Grants renewals must be required annually, 60 working days before the renewing date, with the following documents:

a) Statements from the supervisor and from the host institution supporting the renewal;
b) Document concerning the full time dedication to the research;~
c) Certificate of registration in the PhD program;

15. Infornation and publicity

All activities directly or indirectly funded by the Grant, namely communications pubications, and thesis, are required to acknowledge the financial support of FCT and FSE through the Program Demografia, Qualificações e Inclusão (PDQI).
The documents need to include the symbols of FCT, MCTES, FSE and UE, abiding to the graphical rules of the supporting programs.
Research results supported with RBU are required to abide to open access rules set by FCT.
All grants supported by FSE may be audited by national and European systems, and grantees are required to offer their support to those actions, even after the conclusion of the Grant.

16. Non-discrimination and equal access policies

FCT promotes a non-discrimination and equal access policy, guaranteeing that candidates will not be affected positively or negatively by his/her ascendency, age, sex, sexual orientation, civil state, family situation, economic status, instruction, social origin, genetics, disability, chronic disease, nationality, ethnical origin or race, territory of origin, mother language, religion, politic or ideologic convictions or syndicate affiliation.

17 Law

This call is ruled by the present document, by FCT RBI, Regulamento nº 950/2019, publicado na II Série do DR de 16 de dezembro de 2019, by EBI (Law 40/2004, de 18 de agosto, in its present form), and by National and European Law.

IDL 2023 - XXX

PhD in Geology – Geochemistry

Petrological evolution of the exhumed lower crust – mantle boundary in Northern Morocco: a geochemical and thermochronological approach

Supervision

Telmo Bento dos Santos (IDL), Jean-Michel Lafon (UFPA)

Part of the work will also be performed at Toulouse (France) and Belém (Brazil)

Abstract

The exhumation of lower crustal rocks along major shear zones is common [e.g.: 1], yet a highly debated subject. Less common is the exhumation of upper mantle rocks along such structural discontinuities. However, this is the case of the Southern Rif Shear Zone (SRSZ), an important shear zone that separates two major geodynamic domains in Northern Morocco: a) The Rif, to the North, mostly composed of Miocenic sedimentary units; and b) the Western Meseta, to the South, mostly composed of Paleozoic metasedimentary units, correlated with the Iberian Variscan Belt [2]. Associated to the SRSZ, and exhumed by its activity, is a large high-grade metamorphic belt composed of abundant granulite and amphibolite facies rocks and an exotic sequence of igneous mafic and ultramafic rocks, representative of the upper mantle [3].

Several lines of evidence suggest that this shear zone is coeval and correlated to the tectonic events that formed the Betic Cordillera in Spain [2]. Although the SRSZ's activity exposed those rocks making them very accessible for study and they are well preserved, comparative petrological, geochemical and isotopic studies on this lower crust – mantle boundary segment are still to be performed, inhibiting the full characterization of this important testament of the infra-crustal conditions of the pre-Alpine geodynamics and the description of the activity and exhumation along the SRSZ. This project will, therefore, be developed in two main axes and objectives: 1) the characterization of the petrological and geochemical evolution of the exposed lower crust – mantle boundary igneous and metamorphic rocks; and 2) the definition of the P-T-t evolution of the studied rocks within the exhumation process and the overall geodynamics of the Variscan and Alpine events.

Workplan

In order to achieve Main Objective 1, it will be required to:

a) Perform field work and sampling in the region of Moulay Yacoub (Northern Morocco) with detailed geological mapping and structural and stratigraphic analysis of significant sections;

b) Obtain information on the petrographic, petrological, lithogeochemical and isotopic nature of the rocks associated to the SRSZ;

c) Perform geochemical analysis and modelling of the physical-chemical conditions during the formation and evolution by fractional crystallization of the different igneous rocks and metamorphic evolution of all other lithotypes [as in 4];

d) Integrate the obtained data in order to understand the petrological evolution and interaction between deep lithospheric reservoirs.

In order to achieve Main Objective 2, it will be required to use the data obtained in the previous tasks and to:

e) Perform comprehensive micro- and macrostructural analyses, allowing the depiction and characterization of the deformation events that affected the region and their relationships to the activity of the SRSZ;

f) Qualitatively and quantitatively characterize the relationship between deformation and metamorphism (mineral assemblages, chemistry and geothermobarometry) during the main stages of the Variscan and Alpine events;

g) Obtain geochronological data of the rocks associated to the SRSZ using robust isotopic systems (U-Pb, Sm-Nd, Rb-Sr and Ar-Ar) and thermochronological integration in order to determine the duration of the tectonometamorphic events and the exhumation rates related to the SRSZ's activity [as in 1; 5];

h) Build petrological and geochemical models for the exhumation activity of the SRSZ, to constrain the Alpine geodynamic evolution of Northern Morocco and to compare it to the Iberian analogue of the Betic Cordillera.

Additionally, this PhD will lead to an increased knowledge regarding: a) the structure, geometry, functioning and evolution of shear zones; b) the interaction of different geochemical reservoirs (e.g.: heat and mass transfer along the lower crust/mantle boundary) during orogenic events; and c) the understanding of heat and fluid transfer along shear zones, which is paramount to accurately depict the water flow pattern in the region's thermal spas.

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IDL 2023 - XXX

PhD in Geology/Internal Geodynamics

The geodynamics of the Azores Triple Junction

Supervision

Stéphanie Dumont(IDL/FCUL), Ricardo Ramalho (Cardiff University), Rui Quartau (IDL/IH)

Part of the proposed work will be done at Cardiff and UCL (UK)

Summary

The Azores Triple Junction is a highly complex tectonic structure that marks the boundary between the North-American, the Eurasian and the Nubian tectonic plates, and which attracted the attention of geodynamicists for decades. Thought to be the result of the interaction between a mantle plume with the Mid-Atlantic Ridge (MAR), the evolution and mechanisms behind the dynamics of this transient boundary are far from being understood, with several key questions remaining controversial. One of the most prominent questions refers to the complex tectonic-magmatic interactions and their role in creating some of the most striking morphotectonic structures of the area, namely the alternation of deep basins and high volcanic edifices along the ultra-slow spreading ridge of the Terceira Rift. Other key questions to be answered concern the activation/deactivation/re-activation of local rift systems and possible rift jumps, as well as the link between the Terceira Rift, the MAR, and the Gloria Fault, in the context of the overall transtensional forces acting in the region, and the possible influence of an impinging mantle plume.

The proposed project aims to revisit and address several of these questions and investigate the evolution of the Azores Triple Junction in its wider geodynamic context, and with an emphasis on the Terceira Rift. The project will employ a combination of seafloor morpho-tectonic mapping, analysis of fault population, and numerical and/or analogue modelling. Crucially the project will compile and make use of recently amassed high-resolution marine geophysical datasets from several sources, to produce a detailed and up to date structural map of the region. Analyses of tectonic structures will be performed and could be combined with seismic data recently analysed as part of the project UPFLOW (in collaboration with A. Ferreira, UCL, PI of this project) to formulate a better image of the strain distribution and stress field in the area. Finally, the project will then explore the mechanisms behind the origins, evolution, and geodynamic implications of the Azores Triple Junction through a combination of analogue and/or numerical modelling, potentially addressing key problems such as oblique rifting, rift localization and jumps, and plume-rift interactions. It is expected that the project will result in a new, modern perspective on the Azores Triple Junction, with implications in terms of global geodynamics and hazards within the context of the NE Atlantic.

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Land Use Changes and Atmosphere Feedbacks in an Evolving Climate

Supervision

Rita M Cardoso[1], Elena García Bustamante[2], Carlos C. DaCamara[1]

[1]IDL - Instituto Dom Luiz, Faculdade de Ciências da Universidade de Lisboa, Lisbon, Portugal
[2]CIEMAT - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (ciemat.es), Madrid, Spain

Location: The proposed work will be performed at IDL and at CIEMAT, Spain

Summary

Demands for regional-to-local climate information have increased in recent years [1]. However, local-to-regional scales are currently beyond the capabilities of earth system models (ESMs) [2], and these limitations are greatly amplified in areas of difficult geomorphology, where regional-to-local thermal and mechanical circulations are forced by surface heterogeneities [3,4,5,6,7]. As in the ESM community, the establishment of ensembles of regional climate simulations at continental scale has been pursued to reduce/assess uncertainty in regional climate simulations [8]. Still, there remains a lack of clear understanding of changes in regional phenomena and drivers of variability (IPCC AR5, [9]). Through soil moisture and vegetation exchanges, land-atmosphere coupling contributes significantly to the evolution of extreme events [10,11,12,13]. At regional scales, land cover may enhance surface heterogeneity, which can lead to the development of mesoscale circulations that may intensify/suppress convection and feedback to large-scale circulations [14]. For several variables, land use/land cover changes (LUC) have an impact of similar magnitude but of the opposite sign to that of increased greenhouse gases and warmer oceans [12]. Yet, the heterogeneity of land use representation in current land surface schemes (LSM) leads to contradicting results even under idealised experiments [15,16]. The large inconsistencies in the LUC impacts highlight the need for common LUC across a large ensemble of models [17]. Additionally, most of the current LSMs lack any representation of regional groundwater relevant to soil drainage, moisture, and vegetation changes [18]. It is thus, imperative to further investigate land atmospheric feedbacks, especially within the framework of risk assessment and future warming scenarios. Yet, significant methodological inconsistencies remain in the analysis of surface-atmosphere coupling [19,20]. The project entails the analysis of regional climate simulations using evolving land use maps and different representations of groundwater to assess the impact of LUC and water table in past, present, and future climates. This effort will be linked to the Flagship Pilot Study LUCAS (Land Use & Climate Across Scales). The project will focus on land-atmosphere coupling associated with extreme events (floods, heatwaves, droughts, wildfires) and the influence of LUC on their enhancement/mitigation. The analysis will focus on the partitioning of available energy in latent and sensible heat fluxes, moisture fluxes and the influence of soil desiccation/planetary boundary layer (PBL) growth feedback on the severity of the extreme events. The project will seek to answer the following questions:

Q1 To what extent RCMs incorporating more sophisticated parameterization schemes and new components improve the description of the water cycle? How is this related to land-atmosphere coupling in different regions?
Q2 How large is the contribution of LUC and/or soil thermo-hydrodynamics signal in relation to the effect of other changes in the present climate?
Q3 How strongly do LUC and soil thermo-hydrodynamics contribute to detected potential future climate trends?
Q4 What is the potential of LUC to mitigate/enhance extreme events?

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INSTITUTO DOM LUIZ

Ciências ULisboa Faculdade de Ciências da Universidade de Lisboa

FCT Fundação para a Ciência e a Tecnologia

IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Holocene Portuguese continental shelf paleoenvironmental evolution: characterization of the global and regional controlling factors

Supervision

Pedro Silva (FCUL/ISEL/IDL), Teresa Drago (IPMA/IDL), Cristina Roque (EMEPC/IDL)

Part of the proposed work will be done at IPMA Tavira field station

Summary

Continental shelves sedimentary record preserves a detailed and unique archive of environmental changes involving complex interaction among climate, oceanographic regime, sea level and sediment input from continental sources (Gao & Collins 2014; Lobo & Ridente, 2014). Changes in rainfall and hydrology, storm energy and frequency, global climate changes may leave their signature in shelf sedimentary record and morphology. Continental shelf sediments usually present a high deposition rate and proximity to sedimentary sources and thus are very sensitive to even minor environmental changes. They, therefore, can be used to distinguish between regional and global effects, and possibly to assist in differentiating between human-induced and natural environmental changes (Asioli *et al*. 2001).

The major environmental traits of the last deglaciation of Portuguese continental shelf based on studies integrated sedimentary, morphological and radiocarbon data were only published in the eighties (Dias, 1985). Since then, studies focusing on specific aspects on sedimentology and geochemical data (Araújo et al., 2015; Mil-Homens et al., 2017) or micropaleontology (Mendes at al., 2020; Martins et al., 2012; Rosa et al., 2011) allowed to increase and detail specific aspects of the environmental changes' knowledge regarding the last 20ky. However, there is a lack of an integrative work, to highlight the patterns of the Holocene sedimentation, emphasising the sedimentary expression of climatic processes and forcings derived from the relation between the last deglaciation and the regional components.

Objectives

This proposal aims to build a paleoenvironmental model for the Portuguese continental shelf based on the detailed and multidisciplinary study of sediment cores from two different areas: the northern continental shelf, offshore Douro and the southern west part of Algarve continental shelf. In this model, identification of the global and regional forcing factors contributing to continental shelf paleoenvironmental evolution during the Holocene will be included.
More specifically, this PhD proposal intends to i) identify and characterize sedimentary units associated with different environmental settings; (ii) compare the defined sedimentary units at different locations; (iii) identify the global and regional forcing factors responsible for the sedimentary record; (iv) establish the sedimentary sources.

Methodology

The methodology includes the study of six cores of the northern and southern continental shelf, collected at depths between 80 and 120m, to perform a whole set of multidisciplinary analyses, that includes the use of several new IPMA equipment, such as X-Ray and Computed Tomography (CT), Multi Sensor Corer Logger (MSCL), X-Ray Fluorescence Core Scanner (XRF) and Micro-Raman confocal microscope which allow to analyse the results in further detail and make a comparison to previous work. This data analysis will be completed with a high resolution of grain size, calcium

carbonate and organic matter contents. The implemented multi-proxy approach will contribute to furthering the current understanding of the sediment sources (by identifying the sediment mineralogical composition) and depositional and post depositional conditions. When adequate, analyses of elemental and isotopic C and N (Total organic carbon (% Corg), total nitrogen (%N), δ13C and δ15N) will be performed to derive the source of organic matter and to help establish the marine and terrestrial influence. Environmental magnetic analyses along cores will be conducted at the laboratory of Paleomagnetism of IDL, in order to understand physical properties of the main magnetic carriers (type of magnetic phases, granulometric state and their concentration), which are sensitive to physical processes responsible for sedimentation such as climate changes, transport/deposition and pollution (Evans and Heller, 2003; Liu et al, 2012; Silva et al, 2020).

With this project the student will gain valuable skills in various areas of the Earth Sciences and will benefit from a very considerable data series (obtained during Envi-Changes (FCT project) and ASTARTE FP7- European project) beyond the instrumental facilities of IDL (Lisbon) and IPMA (Lisbon and Tavira).

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Evolutionary history of the crocodylomorphs from the Neogene of Portugal

Supervision

Pedro Mocho (Instituto Dom Luiz e Departamento de Geologia, Faculdade de Ciências, Universidade de Lisboa, Lisboa Portugal), Francisco Ortega (Universidad Nacional de Educación a Distancia UNED, Madrid, Spain)

Summary

The sedimentary deposits from the Cenozoic of Portugal, particularly from the Miocene of the Lower Tagus Basin are rich in vertebrate fossil macro remains. This siliciclastic sequence was deposited in a set of marine-to-continental environments, and, at least, seven sedimentary cycles have been established (Antunes & Pais 1993; three following Cachão & Silva 2000). Around Lisbon, the Miocene sequence reach almost 300 meters and is characterized by numerous fossiliferous assemblages with vertebrate fossils, including fishes, turtles, crocodiles, and mammals. (Bergounioux et al. 1953; Antunes 1961, 1984; Antunes & Ginsburg 1983).

Crocodylomorpha was a diverse group of vertebrates during the Mesozoic, but nowadays, it is represented only approximately by 23 species (depending on authors) of the three lineages of Eusuchia (crocodiloids, alligatoroids, and gavialoids) that make up the Crocodylia crown-group. The members of Crocodylia living today are adapted to subtropical and tropical freshwater and saltwater environments, and are semiaquatic ambush predators and piscivores (e.g. Rio & Mannion 2021). Several crocodylomorph remains have been discovered in Miocene rocks of the Lower Tagus Basin and they were briefly described by Zbyszewski (1949), and Antunes (1961, 1987, 1994). These remains include two nearly complete skulls, several incomplete cranial and tooth remains and an appreciable set of axial and appendicular elements, currently deposited on the Museu Nacional de História Natural e da Ciência (Lisboa, Portugal) and Museu Geológico (Lisboa, Portugal). Antunes (1961) established a new species of the genus *Tomistoma*, *Tomistoma lusitanica*, which is recorded from the Burdigalian to Tortonian. In this study, the presence of another species of *Tomistoma*, *Tomistoma* aff. *calarinatus,* is tentatively considered. Since then, no other study was performed to describe the material in detail and to test its taxonomical validity, and to understand the evolutionary history of Portuguese Neogene crocodiles, particularly the taxon *Tomistoma lusitanica*. The phylogenetic position of the genus *Tomistoma* and their European members within Crocodylia have been debated, as there is a clear disagreement between the morphological phylogenetic proposals (classifying it as a member of the Crocodyloidea) and the molecular phylogenetic proposals (assigning it to the Gavialoidea) (e.g. Brochu 1997; Lee and Yates, 2018; Rio & Mannion 2021). Recently, Rio & Mannion (2021) recovered '*Tomistoma*' *lusitanica* within a Gavialoidea clade of late Oligocene–Miocene western European (*Gavialosuchus eggenburgensis*) and North American (*Thecachampsa*) taxa. This discussion is important for interpreting the evolutionary history of modern crocodiles and increases our knowledge of the extinct forms of the group may contribute to a better understanding of the evolution of Crocodylia.

The following PhD project aims to describe the crocodylomorph fossil record of the Neogene of Portugal, especially focused on the one recovered from the Miocene deposits of the Lower Tagus Basin, to characterize the crocodylomorph diversity in this region during this time. Two main lines of research with associated objectives (O) and hypothesis (H) have been established:

O1: Proposal of a new systematic approach for the crocodylomorph remains recovered in the Neogene of Portugal to assess the diversity of the clade and their stratigraphic and environmental distribution. **H1.** The Miocene crocodylomorphs are represent by more than one taxon: an estuarine and longirostral form related to Gavialoidea (‘*Tomistoma*’ *lusitanica*) and a less abundant and more robust form belonging to Crocodyloidea.

02. Description of the holotype and referred material to ‘*Tomistoma*’ *lusitanica* and test the validity of the taxon, provide a new diagnosis, and propose a new phylogenetic approach using the more recent datasets of morphological data. **H2.** ‘*Tomistoma*’ *lusitanica* is a valid crocodilian species fully adapted to an estuarine environment, which is phylogenetically placed within Gavialoidea as an early branching form and closely related to the North American genus *Thecachampsa*.

Methodology: This project incorporates traditional and new methodologies and techniques. The first part of these study is based on the morphological characterization of new and previously known specimens (e.g. description, identification of the character states, collection of numerical data). If necessary, the amendment of existing diagnoses and the formulation of new ones for new taxa will be proposed. The morphological variation will be described and justified in terms of individual, ontogenetic and sexual variability. Several characters will be encoded and included in phylogenetic analyses (some focused on resolving the relationships within problematic clades). A new data set of morphological characters will be established based on previous studies (e.g. Rio & Mannion 2021) and phylogenetic trees will be generated using Parsimony and Bayesian analyses (Goloboff et al. 2008; Ronquist et al. 2012). Computerized Tomography (CT) scan will be used to study internal structures to analyze the neurobiology of sensory systems of ‘*Tomistoma*’ *lusitanica*.

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INSTITUTO DOM LUIZ

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

The role of large-scale patterns in extreme weather events in a changing climate

Supervision

Pedro M. M. Soares (IDL-FCUL), David Barriopedro (Univ. Complutense, Madrid)

Part of the proposed work will be done at Univ. Complutense, Madrid.

Objectives

- To develop a new methodology for the identification of large-scale patterns (atmospheric blockings) at the global scale using machine learning methods. Subsequently, extend the methodology to extreme weather events and associate it with the configuration of large-scale patterns.
- To contribute to the understanding of these links in a changing climate, through paleoclimate modelling covering different past periods, as well as through different climate change scenarios until the end of the present century.

Motivation & Summary

The mid-latitudes climate in the northern hemisphere is regulated by a series of perturbations with a zonal westerly flow. This flow can sometimes be disturbed by intense large-scale atmospheric perturbations, often leading to large quasi-stationary high pressure anticyclonic systems known as atmospheric blockings [1,2]. These atmospheric perturbations are related with complex dynamics often have associated extreme weather events that can sometimes be catastrophic [1-3]. Recently, the impacts of atmospheric blockings have been catalogued, varying geographically depending on the region that is blocked, with important impacts on extreme temperatures [4] and anomalous precipitation patterns due to changes in the trajectories of low-pressure systems (cyclones) [3,5]. However, the analysis of these events and consequent link to extreme episodes through numerical models is difficult to perform, being under-represented in medium-term weather forecasts and in climate models [6,7]. In recent years, an important effort has been made to improve the understanding of the dynamics and other characteristics of blockings, as well as to assess the changes in frequency and amplitude that atmospheric blockings will undergo in a changing climate, and what this implies for the occurrence of extreme events [1].

During the last decade, several groups have been applying machine learning methods with the aim of improving the study of various areas of science. In the context of this work, relevant studies highlight the importance of using these methodologies for the study of extreme atmospheric events in a changing climate [8], and for the substantial improvement of medium-term forecasting systems [9]. Recently, these methods have been reviewed in [10], where several different machine learning approaches are presented to evaluate their performance when tackling on real case scenarios of extreme events such as heavy precipitation, heat waves, droughts, and various cyclonic systems from extra-tropical to tropical. Regarding atmospheric blockings, [11] used a machine learning algorithm to identify these patterns using known blocking indices, showing great potential in this approach.

In this context, the present PhD proposal aims at integrating advanced data science techniques, namely machine learning, to improve the already known methods for identifying atmospheric blockings (globally) and extreme events

(focused on Europe). Subsequently, an in-depth analysis will be performed between the observed relationship between blockings and extreme events with a historical framework (approximately since the beginning of the 20th century), in relation to paleoclimates (relative to the last millennium, the last glacial maximum and the last interglacial Eemian period) and in relation to different climate change scenarios for the 21st century.

Methodology

To use and train the machine learning methods, a reproduction of the most recent atmospheric blocking catalogues will be made, using high spatial resolution sub-daily reanalysis data. The intention is to later use the same data and extend the analysis to a longer period using machine learning methods. Afterwards, the already extensive bibliography of identification of several extreme events will be used to associate them with blocking catalogues. Finally, these relations obtained in the historical period will be compared with other two periods, through a set of simulations of coupled climate models, specifically for the past with the "Paleoclimate Modelling Intercomparison Project phase 4" (PMIP4) and for the future based on the "Coupled Model Intercomparison Project phase 6" (CMIP6).

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Probabilistic PV and load forecasting for enhanced energy management in Renewable Energy Communities

Supervision

Miguel Centeno Brito (IDL), Rodrigo Amaro e Silva (Mines Paris, France)

Part of the proposed work will be done at Mines Paris.

Summary

The expected exponential growth of photovoltaics (PV) will demand an ever more efficient integration of an energy source which is characterized by an intrinsic variability at different spatial and temporal scales. In this sense, the legal framework for Renewable Energy Communities (REC) aims to bolster the development of local self-consumption of renewable energy sources and its interaction with prosumer collectives and complementary technologies (e.g, batteries and electric vehicles), all leveraged by local energy management (EM) strategies [1].

Thus, this PhD project aims at building a support framework for the operation of RECs, mainly consisting of PV and batteries for collective self-consumption, relying on EM strategies driven by load and PV forecasts. Traditionally, deterministic forecasts prevail in industrial applications since these are easier to understand and evaluate [2]. However, this PhD project aims to understand how probabilistic forecasts – which provide an awareness of uncertainty, likelihood, and risk – can be integrated and enhance the management of batteries. By modelling the integration of such forecasts in a given energy management strategy, it will be possible to evaluate the techno-economic value of different forecasts [3] and understand if *a priori* statistical performance metrics can be used as proxy indicators.

Both forecast variables have well-known strong dependencies with meteorological conditions (e.g., solar irradiance, air temperature), making it of great importance to properly understand and take advantage of the different information layers present in Earth Observation data [4]. Namely, in-situ measurements, satellite data, and numerical weather prediction models may be explored.

In summary, this work aims to adopt a holistic approach towards RECs, EM, and probabilistic forecasting, for which the literature is abundant as individual research topics, but scarce when combined.

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

3D crustal and mantle structure of the East mid-Atlantic region using active seismic data recorded by the UPFLOW OBS array

Supervision

Marta Neres (IPMA, IDL), Susana Custódio (FCUL, IDL) and Ana Ferreira (UCL)

Part of the work plan will be carried out at the University College London

Summary

The classical description of the structure of the oceanic crust is the layered Penrose model proposed in 1972. This model is supported by observations of fast-spreading ridges, in which the melt supply generates a regular, fully igneous crust. However, in slow-spreading ridges the melt supply is weaker and tectonic extension may play a major role, originating exhumation of deep crustal and upper mantle sections and promoting mantle serpentinization.

In this project, the PhD candidate will work with recent (2022) data from passive and active seismic surveys conducted on the region between the Tore-Madeira Rise and the Canaries. This region of the East Atlantic Ocean is still not well understood with respect to the original seafloor spreading and oceanic accretion processes. In addition, it was later affected by significant magmatic activity, as testified by a large number of volcanic islands and seamounts, and the causes for this magmatic activity are still unknown.

The aim of the project is to build a 3D seismic velocity model of the crust and upper mantle structure of the East mid-Atlantic region around Madeira and the Canary islands. The Pn tomography method (e.g., Buehler and Shearer, 2010) will be used along with regional seismic tomography to map 3-D crustal and upper mantle variations in seismic wave speed and in anisotropy. The resulting model will be compared and integrated with results from active seismic profiles. This approach will cover the resolution gap that exists between active experiments (in which only the crustal structure can be studied with high vertical resolution, but limited to the surveyed profile) and passive experiments (that are mostly prone to large scale studies of the mantle structure).

The project's results will allow evaluating the roles of the mantle upward flow, tectonics and original crustal structure on the past and present deformation of the oceanic crust. This has potential implications for the understanding of magmatic accretion, mantle exhumation and serpentinization, volcanism and seismic hazard.

The UPFLOW experiment (upflow-eu.github.io/) consisted of a passive seismic survey in which 49 OBSs (ocean-bottom seismometers) were left on the seafloor for more than one year (July 2021 to September 2022) for collecting seismic data in a ~1,000×2,000 km^2 area covering the Azores-Madeira-Canaries region. The UPFLOW OBSs recorded a large variety of signals, from earthquakes, Earth's normal modes, whale vocalisations, and many other seismic sources and noise.

The LISA-ATLANTIS active seismic survey was conducted in June and July 2022 on the Madeira-Canaries region and comprised the acquisition of two seismic reflection and refraction lines of 450 km and 220 km length. Fortunately, the seismic shots of the LISA-ATLANTIS active experiment were recorded by the UPFLOW OBSs deployed on the

nearby seafloor, up to several hundreds of km of distance. These recordings comprise seismic waves that were generated at each sea surface source point and travelled through the water column, crust and mantle layers until each OBS. Thus, they contain information that can be used to investigate the crustal and mantle structure of the travelled path. Since the seismic source was moving and the OBSs were deployed on a large array, these data will allow constraining the structure with a large azimuthal coverage. In particular, Pn waves (P waves bottoming in the uppermost mantle) will be used due to their excellent sensitivity to both crustal and upper mantle structure.

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IDL 2023 - XXX

PhD in Marine Sciences

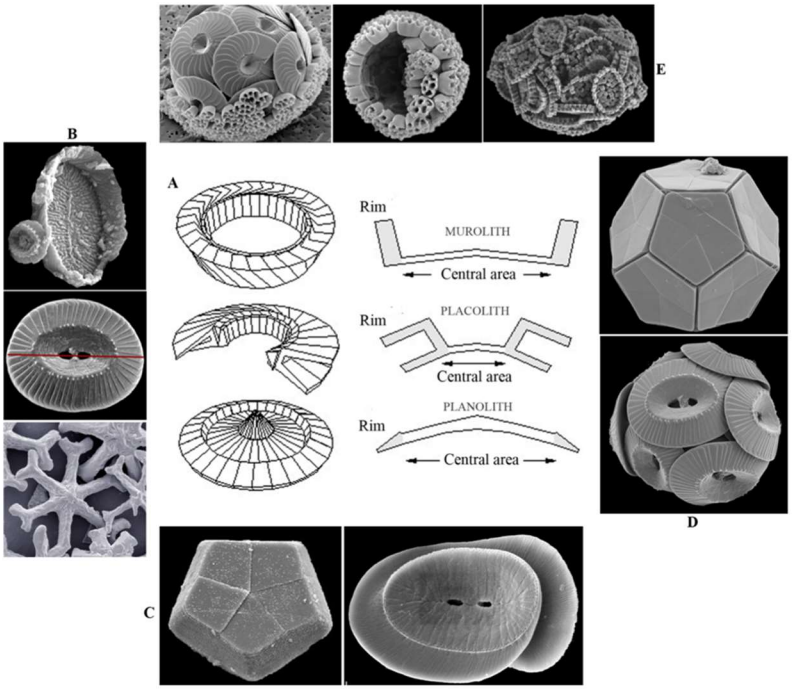
Title West Iberia Marine Primary Productivity in a Global Warming Scenario - WestPhyto-Glows

Supervision

Mário Cachão (IDL & FCUL), Gonçalo Prista (IDL)

Summary

Upwelling regions play an important role on productive fisheries and carbon sequestrations for sufficiently long periods to act as carbon sink (Hutchings et al.,1995). The effects of future climate change on upwelling systems are of high ecological, social, and economic importance, but predicting the response of marine ecosystems to it is difficult due to the complexity of these ecosystems (Mote & Mantua, 2002). One of the best tools we have is looking into the past and study the ecosystems response to climate events, as stated by McCarroll (2015), "study the past, if you would divine the future".
There are different methodologies to study marine primary productivity in the geological record. Different proxies have different advantages and limitations. They depend on favorable preservation conditions, are subjected to sediment and oceanographic dynamics, have different residence time (see Paytan, 2009). In addition, these proxies may reveal other limitations, like demonstrated by Steiner et al. (2017) for Barium, which can leave undetected periods of increased productivity, or the decomposition of most of the organic matter during early stages of diagenesis, with only <0.5% of the original gross production reaching the sediment (Burdige, 2007).
Microfossil assemblages has long been used to access primary productivity in paleoceanography, both foraminifera (see Paytan, 2009) and coccolithophores (see Baumann et al., 1999). However, the biology knowledge of fossil species is limited and as stated by Paytan (2009), it is not clear to what extent the plankton assemblage reflects primary production, export production, or food availability.
With these limitations in mind and looking into developing a method for primary productivity studies in the Cenozoic, Prista et al. (2020) used morphometry of coccolithophore *Coccolithus pelagicus* s.l. to extract the variability in coastal primary productivity. This species was chosen for 3 main reasons: 1) it first appeared in the early Paleocene; 2) it still exists today, and we have a good biological knowledge of it; 3) it thrives in upwelling regions.
Sheward et al. (2014, 2017) and Daniels et al. (2014) showed how *C. p. braarudii* changes sizes as response to nutrient availability, which created the opportunity to use morphometry to extract primary productivity information.
Prista et al. (2020) methodology opens the door to increase our knowledge on past upwelling systems and, more importantly, for studies of upwelling variability under climate change and climatic events of the Cenozoic. This tool, Integrated Multivariate Morphon Analysis (IMMA), can be used to study different sets of crucial Cenozoic intervals and events to understand the possible impact of current future projections on marine primary productivity of upwelling regions.
Although current knowledge gives robustness to IMMA methodology, it is important to determine the morphometric relation between *C. p. braarudii* and the upwelling index, which would allow for the development of a new primary productivity index that can be used in the current upwelling systems and the geological record. To achieve this goal, it is necessary to collect samples in the west coast of Portugal and perform morphometry of *C. p. braarudii* coccoliths, which would be compared to the upwelling index.
This PhD project will consist on 4 samples collection per year on board fishing vessels, preparation of smear slides for morphometry of *C. p. braarudii*, and finally developing an upwelling index based on morphometry of *C. p. braarudii*.
This study is expected to largely contribute to studies on the effects of climate change on upwelling systems, which has major ecological and social importance for the near future.



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IDL 2023 - 01

PhD in Geology

Revisiting the dolomite problem: geochemical and mineralogical controls of dolomitization processes in sedimentary and metasomatic environments

Supervision

Mário A. Gonçalves (FCUL/IDL), José Mirão (UÉvora/HERCULES Lab)

HERCULES Lab will provide complementary access to experimental facilities.

Introduction

The formation of primary dolomite instead of the dolomitization of calcium carbonates is still a major conundrum for understanding Earth processes, especially regarding the global sedimentary Mg budget as revealed by the lack of significant sedimentary dolomites in the geological record in the last 30-40 million years. This gave rise to the well-known “dolomite problem”, but to this day experiments have systematically failed to precipitate dolomite at ambient conditions, unless some very specific conditions are met which seldom exist in nature.[1,2] The unsuccessful attempts to crystallise dolomite is often attributed to kinetic factors, while for calcites, there is a limited incorporation of Mg in their structure, depending on Mg activity.[1] However, there is also ample geological evidence that dolomites result from late replacement mechanisms whose details are debatable, including the now much accepted coupled dissolution precipitation mechanism with porosity generation.[3,4,5] As a matter of fact, the molar volume of the reaction that substitutes calcite by dolomite is negative. Thus, dolomites are important in characterising the porosity in carbonate reservoirs, with implications for the evolution of sedimentary basins including their suitability as hosts for hydrothermal ore deposits generated by basin-scale hydrodynamics and fluid flow, as well as for petroleum reservoirs.

Objectives

The project aims at unravelling the mechanisms of dolomite formation in different settings by choosing two distinct environments with known dolomitization processes: the Lusitanian Basin (LB), a thick (circa 5 km) Mesozoic sedimentary sequence developed after the first stages of the opening of the Atlantic, and Paleozoic dolomitized marbles associated with metavolcanic rocks in the Ossa Morena Zone (OMZ).

Description

It has been demonstrated that dolomitic rocks in the LB have a rather complex history with frequent dedolomitization reactions, posing other challenges like the fate of Mg[6,7] (Figure 1). For this purpose, selected dolomitization fronts will be sampled according to their suspected origin as being either diagenetic (stratigraphically controlled), associated to faults (discordant to primary sedimentary structures), or metasomatic (as some cases of the Paleozoic dolomites). Each of these environments will be studied in detail, addressing their mineralogy and microscopically characterising the mineral structures and interfaces. This is combined with a careful and detailed characterisation of the chemical signatures, especially in trace elements, and stable isotopes. This approach is expected to pinpoint differences between the leading processes and elucidate the dolomite formation mechanisms in each environment. The project will use state-of-the-art techniques including electron microscopy (Env-SEM with EDS and Electron Microprobe),

Cathodoluminescence microscopy, μ-x-ray diffraction, LA-ICP-MS, μ-FTIR, and Mass Spectrometry. Most of the supporting equipment is available in the partner institutions, but additional techniques to be used will be secured through current ongoing collaborations on foreign institutions (WWU, Münster, Germany), including the submission of proposals to synchrotron time (SLS, Switzerland) to deepen the studied problem.

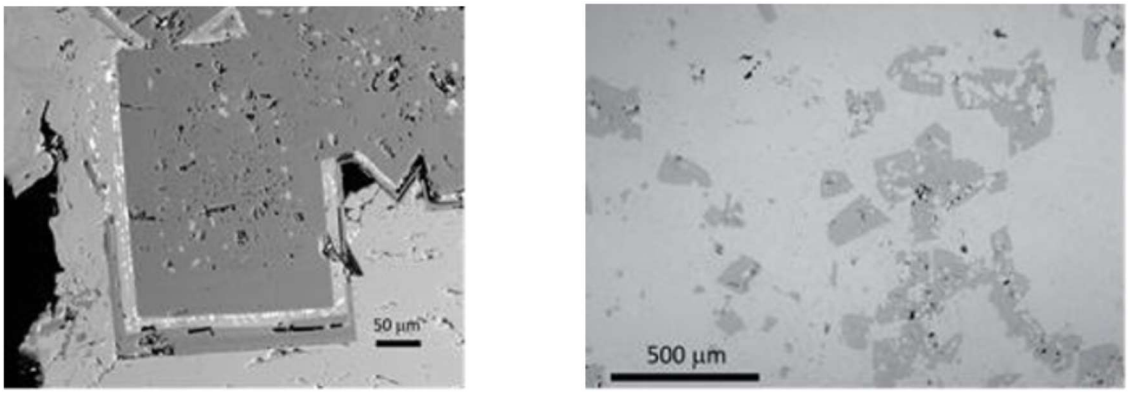

Figure 1. **Left**: Backscattered electron (BSE) image of dolomite crystals (dark grey) with a recrystallized rim and a porous core with calcite relicts. Late calcite partially replacing dolomite along cleavage plans, leaving a trail of iron (hydr)oxides **Right**: BSE image of partially replaced dolomite crystals (dark grey) by calcite (dedolomitization). Image from [7].

Requisites

Degree in Earth Sciences (Geology/Geophysics) or Chemistry; good background in Mineralogy/Structural Chemistry.

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Drought monitoring applications of GRACE satellite data

Supervision

Maria C. Neves (UAlg, IDL), Maria do Rosário Carvalho (FCUL, IDL)

Part of the proposed work may be done at a partner institution.

Motivation and Summary

The effects of climate change have become increasingly evident in recent years, leading to acute deficits in precipitation and water availability in many parts of the world. Droughts have become more frequent and severe, posing a significant challenge to water resource management. Understanding the linkages between climate variability, particularly droughts, and all water storage components is critical for effective water resource management.

Groundwater plays a vital role in the hydrological cycle but is often overlooked because it is invisible. The depletion of aquifers due to overexploitation and improper management can have severe consequences, including water shortage, land subsidence, reduced water quality, and ecosystem degradation (Wu et al., 2020). To manage groundwater resources effectively, it is essential to have accurate and timely information on the groundwater levels and soil humidity. The scenarios of climate change with projected reduction or change in precipitation patterns, and environmental temperature rise, increase the risks associated with groundwater exploitation. These risks are greater in coastal aquifers, where the intrusion of seawater and salinization of aquifer water is a major concern in all European countries with extensive coastlines, such as Portugal and Spain.

In recent years, satellite-based remote sensing has emerged as a valuable tool for monitoring groundwater resources at regional and global scales. The Gravity Recovery and Climate Experiment (GRACE) and its follow-on mission, GRACE Follow-On (GRACE-FO), are two satellite missions that provide total water storage (TWS) anomalies, which are a good indicator of large-scale groundwater quantitative status. By measuring changes in the gravity field, these satellites can detect changes in TWS, which include changes in groundwater, surface water, soil moisture, and snow and ice.

GRACE satellite data has been used to show evidence of groundwater depletion in aquifers all over the world (Rodel et al., 2018) and NASA currently generates weak groundwater and soil moisture drought indicators based on GRACE as part of the United States drought monitoring program (Thomas et al., 2021). In Europe, the Copernicus Global Drought Observatory also uses GRACE total water storage (TWS) anomalies as a proxy for groundwater drought. The use of GRACE satellite data for water resource management, particularly for groundwater systems in the Iberia Peninsula, looks promising (Neves et al., 2020), but its suitability to monitor drought requires further research including its downscaling (Vishwakarma et al., 2021). **The primary goal of this thesis is to employ GRACE data to monitor groundwater drought in the Iberian region.** Related research questions this study will address are how the GRACE-based groundwater drought compares with other drought indicators and how will climate change affect groundwater storage in distressed aquifers in the coming years. This might involve selecting the appropriate aquifers

to study, collecting, and analyzing historical data on groundwater storage and climate variables, and running simulations using climate model projections.

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IDL 2023 - XXX

PhD in Geology

Title

Paleoenvironmental reconstruction of the Morocco Atlantic coast since the late Pleistocene

Supervision

Maria da Conceição Freitas (IDL, FCUL)

Supervisor 2 (Affiliation)

Part of the proposed work will be done at … (if applicable).

In the context of climate change, the consequences of sea-level rise are of undeniable importance and is still needed to bring together analyses at a greater range of timescales, from seconds to millennia or even longer (Shennan et al., 2015). Paleoenvironmental reconstructions are essential to understand how the environment has changed and to disentangle global and local factors forcing its evolution, to characterize coastal responses to forcing factors over centennial to millennial time scales. Such knowledge is essential for planning appropriate adaptation options to minimize the impacts of sea-level change, and in particularly sea level rise (García-Artola, 2018) at the land-ocean interface. Among the different depositional environments, transitional systems as estuaries and lagoons are privileged locals to study the sea level changes as they meet continental and marine influences. The study of their sedimentary record can be a useful tool to understand their response, particularly since the last deglaciation.

The Morocco Atlantic coast is more than 2000 km long and little is known about its evolution during the Holocene and the relation with the sea-level variations.

The present proposal aims to build a paleoenvironmental regional model for the estuaries located in the Atlantic Morocco coast north of Oualidia, based on the detailed and multidisciplinary study of the lagoonal/estuarine sedimentary infill obtained in several cores. The results acquired will be compared with the ones already published for the European Atlantic coast.

The study of the cores will include sedimentological (grain size, calcium carbonate and organic matter contents) analysis and geochemical (elemental, isotopic) proxies and the use of the possible techniques to acquire high resolution data. This multi-proxy approach will contribute to the knowledge of the sediment sources (by identifying the sediment mineralogical composition) and depositional and post depositional conditions. When adequate, analyses of elemental and isotopic C and N (Total organic carbon (% Corg), total nitrogen (%N), δ13CVPDB and δ15NAIR) will be performed to derive the source of organic matter and help to establish the marine and terrestrial influence.

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Advancing Satellite-based Surface Temperature Estimates combining Optical and Infrared Observations

Supervision

Isabel Trigo (IPMA), Glynn Hulley (NASA Jet Propulsion Laboratory), Carlos da Camara (IDL)

Part of the proposed work will be done at the NASA Jet Propulsion Laboratory (Pasadena, CA, USA).

Summary

Land Surface Temperature (LST) is an important climatological variable, determining surface emitted radiation. Furthermore, LST has been demonstrated to provide key information on land surface processes as it is intrinsically linked to the partition of available energy into surface sensible and latent heat fluxes. Remote sensing observations in the thermal infrared (IR) have been extensively used to derive LST over large areas and on a regular basis. Nevertheless, despite the long experience in exploring such observations, which are being provided by multiple instruments and platforms, there is still a long list of unresolved issues that pose strong limitations to the use LST datasets, e.g., in climate studies. One such example is related to LST retrievals in the presence of high dust concentrations in the atmosphere, when uncertainties in radiative transfer models are high. Indeed, large aerosol loads significantly impact atmospheric transmissivity in the IR, which, to our knowledge, leads to large errors in all currently available LST operational products. This PhD project targets a deeper understanding of radiative transfer modelling within the thermal infrared domain, aiming to improve the inversion of top-atmosphere observations to derive reliable LST values under moderate-to-high dust aerosol concentrations. For this purpose, this PhD project will address the following objectives:

1. Understanding the full impact of aerosols on LST and emissivity retrievals, taking into account radiative transfer models, satellite and in situ observations. Previous work addressing this issue have considered radiative transfer (RT) simulations over a limited set of atmospheric conditions, while mostly disregarding uncertainties in RT models (Jiménez-Muñoz & Sobrino, 2006). Here we will make use of a multi-model approach (MODTRAN, RTTOV using different aerosol schemes), together with in situ observations collected, e.g., in ARM sites and KIT-LSA SAF stations, together with atmospheric profiles from reanalysis (ERA5 and CAMS) to perform a comprehensive assessment of the impact of dust aerosols on current LST operational products, and to quantify the uncertainties of various schemes/models.
2. Development of an appropriate database for the calibration and verification of LST algorithms, including information on aerosol profiles and simulations of top-of-atmosphere (TOA) observations in thermal window bands. High quality reference data are a pre-requisite to develop either semi-empirical, or purely data-driven LST algorithms. These datasets usually rely on RT simulations to ensure that a sufficiently wide range of atmospheric and surface conditions, as well as observation geometries are represented (Ermida & Trigo, 2022). The student will develop a comprehensive database, considering profiles (including, temperature, humidity, ozone, and dust aerosol, and surface temperatures and emissivities) representing realistic, but wide range of conditions. TOA observations will then be simulated for each profile using state-of-the-art RT models and configurations. The derived ensemble of simulations, together with the preliminary assessment made in 1., will allow the estimation of uncertainty in TOA observations associated with each profile.

3. Improve the atmospheric correction in LST algorithms to appropriately consider aerosol effects. This objective primarily will focus the improvement of operational products provided by the EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA-SAF) and the NASA Jet Propulsion Laboratory (JPL). LSA-SAF LST products are based on the Generalized Split-window algorithm (Trigo et al., 2021), that uses the dual-channel information of the IR atmospheric window and prescribed emissivity values to estimate LST. The NASA JPL LST products are based on the Temperature-Emissivity Separation (TES) algorithm combined with a Water Vapor Scaling (WVS) atmospheric correction method (Hulley et al., 2014), that uses multi-channel information to perform simultaneous retrievals of emissivity and LST. The student will explore methodologies to correct the effect of dust aerosols for each of these products using the reference database of RT simulations developed as part of objective 2 (see previous point), including an assessment of the accuracy of the WVS method to correct for the effects of dust aerosols.
4. Maximize satellite observations in the optical and infrared domain to derive accurate LST datasets. The accuracy of LST retrievals under high dust aerosol loads is highly dependent on the correct identification of the aerosol concentration. Although a few aerosol products are available for some platforms, remotely sensed dust aerosol concentrations are not widely available, and they generally have high uncertainties (Descheemaecker et al., 2019). The student will explore methodologies to estimate dust aerosol concentrations, combining visible and IR channels. The work will focus on the new capabilities of the most recent sensors, such as the Flexible Combined Imager aboard the Meteosat Third Generation satellite (MTG), and the Ocean and Land Colour Instrument (OLCI) and the Sea and Land Surface Temperature Radiometer (SLSTR) onboard Sentinel-3.

This PhD will be mostly conducted at the Instituto Portugues do Mar e da Atmosfera (IPMA), which is the leading entity for the EUMETSAT LSA-SAF, under the supervision of Dr Isabel Trigo and Dr Carlos da Camara. Part of LST algorithm development (improving TES) will be conducted at the NASA JPL under the supervision of Dr Glynn Hulley.

We will also count with the collaboration of other teams working on radiative transfer modelling, in particularly, the group led by Dr Jerome Vidot (Météo-France), which work on the development of RTTOV within the framework of the NWP SAF.

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IDL 2023 - XXX

PhD in Geology

Role of crustal extension in the breakup and assembly of supercontinents: The northern Gondwana margin and Pangaea geodynamics revisited in the Ossa Morena Zone (Portugal)

Supervision

Ícaro Dias da Silva (IDL-FCUL), Aitor Cambeses (Universidad de Granada - IBERSIMS), João Casal Duarte (IDL-FCUL)

Part of the proposed work will be done at University of Granada (UGr), in the IBERSIMS and UGr laboratories.

Summary

Orogeny is a fundamental step in the Supercontinent Cycle, the backbone of modern plate tectonics [1]. While modern orogens can be directly observed, their internal structure is generally not readily accessible. Old eroded orogens are, therefore, windows that allow studying lithospheric processes that are unreachable in their active counterparts. Among the different types of orogens, collisional orogens often involve a combination of different lithospheric mechanisms that can lead simultaneously to uplift and crustal thickening, as well as to subsidence and crustal thinning [2, 3].

The Variscan orogen is a Devonian-Carboniferous collisional orogen that extends from Eastern Europe to Morocco [4]. It was formed by the collision of two mega-continents, Gondwana and Laurussia, to form Pangea, the last supercontinent on Earth [1]. At the core of Pangea, the Iberian Massif [5, 6] is a unique natural laboratory to study deep-to-surface geodynamic processes, providing fundamental constraints on how collisional orogens evolved over the Earth's history [7]. Notwithstanding, a comprehensive understanding of the evolution of the Variscan orogen is still lacking. Currently, several models are under debate, differing in (i) the timing of ocean closure [5, 8]; (ii) the polarity of the subduction and position of the magmatic arc [4, 5, 8], and (iii) the closing of one or multiple oceanic basins [8, 9]. Defining orogenic processes from shallow to deep crustal levels can provide better constraints that will help validating different conceptual models. These models can be tested using geodynamic analogue and numerical models, which in turn can then be applied to gain insights into the geometry and dynamics of collisional orogens worldwide. Localized within the Iberian Massif, the Ossa Morena Zone is a key tectonic unit to investigate these fundamental questions [5, 6, 8, 9, 10, 11].

This project aims at contributing to the knowledge of the evolution of collisional orogens, by studying a key-section of the Ossa Morena Zone. To achieve this goal, well-tested and state-of-the-art methodologies will be used, which include geological mapping, geochemistry, geochronology, stratigraphy, igneous and metamorphic petrology, microtectonics, analogue and numerical modeling. Given the accessibility to shallow to deep crustal orogenic levels, the segment of the Iberian Massif corresponding to the transition of the Évora Massif to the Elvas-Alter do Chão sector of the Ossa Morena Zone is a unique location to address the following questions:

- What type of orogen was the Variscan Belt? Are there any comparable ancient or modern orogens?
- When did the Devonian continental subduction and obduction of allochthonous nappes, including ophiolites, end? Why was it followed by an orogenic-scale High Temperature-Low Pressure tectono-metamorphic overprint in the early Carboniferous?

- What do the Devonian-Carboniferous synorogenic marine basins tell us about the palaeogeography and the geodynamics of the lithosphere at that stage?

To answer these questions the following tasks are proposed:

- Develop original geological maps and cross sections, defining and characterising the tectono-metamorphic units for each orogenic stage. This consists of field-based research work, under the supervision of Ícaro Dias da Silva;

- Discriminate magmatic ages and geodynamic settings to fingerprint sedimentary provenances and depositional ages, through petrology, geochemistry, and geochronology of pre- and synorogenic igneous and metasedimentary units. This will consist of laboratory work at FCUL and UGr, supervised by Aitor Cambeses.

- Conceive, develop, and test conceptual models of the Variscan Orogen with analogical and 4D numerical models, integrating the new dataset and available literature. This will be done in collaboration with the IDL geodynamic modelling group, supervised by João Casal Duarte.

The research works will be partially funded by IDL and by ongoing research projects where the supervisors are participant. Erasmus + exchange scholarships will be aimed to fund the scientific stays at UGr.

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Ciências ULisboa Faculdade de Ciências da Universidade de Lisboa

FCT Fundação para a Ciência e a Tecnologia

IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Title

Crustal structure of the Azores-Madeira-Canary Islands region from ambient noise ellipticity data and autocorrelation analysis

Supervision

Graça Silveira (IDL-FCUL/ISEL, PT, https://www.isel.pt/docentes/maria-da-graca-medeiros-silveira), Ana Ferreira (UCL, UK, https://www.ucl.ac.uk/earth-sciences/people/academic/prof-ana-ferreira)

Part of the proposed work will be done at the University College London (UCL) with the co-supervisor Ana Ferreira. A short-term visit to Dr Martin Schimmel, a senior researcher at CSIC - Geociencias Barcelona (Geo3Bcn), is also planned.

Objective

This project aims to build new 3D images of the isotropic seismic crustal structure of the Azores-Madeira-Canary-Islands region from the joint analysis of ellipticity data and autocorrelations using ambient seismic noise. The project is part of the European Research Council project **UPFLOW** - **UP**ward mantle **FLOW** from novel seismic observations, led by Prof. Ana Ferreira.

Summary

The Azores, Madeira and the Canary Islands are volcanic archipelagos located in the Eastern Central Atlantic (ECA), rooted in a lithosphere ranging in age from newly created at the Mid Atlantic Ridge to 180 Ma at the north-west African Atlantic margin. The most recent improvements in seismic imaging and computational power allowed us to progress in understanding the geodynamic mechanisms that sustain the observed vulcanism at a broad scale in this region (see Civiero et al., 2023 for a review). Highly resolved 3D models of the seismic structure need a seismic network roughly evenly distributed, which, considering the irregular distribution of the ECA archipelagos, requires the coupling of land stations with ocean-bottom-seismometers (OBSs). Thus, a detailed picture of the geodynamic processes from the crust to the Mantle Transition Zone (MTZ) beneath the Azores-Madeira-Canary region remains to be done.

The ongoing project UPFLOW has successfully acquired high-quality broadband seismic data in a dense array, from July 2021 to September 2022, with unprecedented geographical coverage in this region. This dataset, combined with data from the existing land stations, offers a unique opportunity to map the crust and the underlying uppermost mantle.

In this project, the PhD student will build new 3D images of the isotropic seismic crustal structure of the Azores-Madeira-Canary region from the joint analysis of ambient noise ellipticity data (Berbellini et al., 2019) and autocorrelation functions (Romero and Schimmel, 2018). The new model will be integrated with results from previous studies for the three archipelagos, namely Azores, Madeira, and Canaries (e.g. Dias et al., 2007, 2020; Ferreira et al., 2020; Martinez-Arevalo et al., 2013; Matos et al., 2015, Schlaphorst et al., 2021, Silveira et al., 2006, 2010).

The PhD student will collaborate actively with the UPFLOW team (https://upflow-eu.github.io). Collaboration with Dr Martin Schimmel (CSIC - Geociencias Barcelona Geo3BcnI) is also planned. He will also benefit from the acquired knowledge along previous and current projects in the same area as SIGHT – Seismic and Geochemical constraints on the Madeira Hotspot system led by Graça Silveira, and GEMMA – Improving Geodynamic Models in Macaronesia by reconciling geodetic, geophysical, and geological data where both supervisors participate as team members.

Work plan

This PhD project will have a run time of 4 years. The project is divided into the following steps. 1) Literature review and learning of required tools and methods. 2) Collecting and organising the necessary data from UPFLOW, IPMA and temporary networks. 3) Carrying out single station autocorrelations computation to obtain the shallow subsurface reflection response to map the crust-mantle boundary and other inner crustal discontinuities. 4) Retrieving the Rayleigh wave ellipticity from the ambient vibrations of the Earth. 5) Joint inversion of the autocorrelation functions and ellipticity data to obtain shear-wave velocity models beneath each station for the entire region. 6) Combining results and integrating them into existing studies from the surrounding archipelagos, namely Azores, Madeira and Canaries.

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INSTITUTO DOM LUIZ

Ciências ULisboa Faculdade de Ciências da Universidade de Lisboa

FCT Fundação para a Ciência e a Tecnologia

IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Lithospheric characterisation of the Iberian Pyrite Belt in Portuguese terrain through Magnetotelluric data.

Supervision

Advisor: Dr. Francisco José Martínez Moreno (Complutense University of Madrid)
Co-Advisor: Dr. Luís Manuel Henriques Marques Matias (IDL-FCUL)
Dr. Lourdes González Castillo (University of Granada-UGR, Spain)

Summary

The Iberian Pyrite Belt (IPB), located in the southern Portuguese zone of the Iberian Massif, is one of the best exposed sections of the Variscan orogenic belt in western Europe. The IPB forms an arc-shaped belt ~250 km long and ~60 km wide, consisting of several series of tectonically controlled asymmetric basins that reflect the progression of heterogeneous continental thinning, triggered by left-lateral transpressional convergence with the Iberian Terrane. The IPB Volcanic Sedimentary Complex (VSC) hosts one of the largest concentrations of massive sulphide deposits on a global scale including world known massive deposits such as Rio Tinto (Spain) and Neves-Corvo (Portugal). There are several hypotheses about the origin of massive sulphides in the IPB, but many aspects remain poorly understood, especially those related to deep lithospheric structure and the real extension of the IPB. Interest in the search for minerals deposits has led to many geophysical surveys being carried out in the area over the years. However, most of them are limited to the first hundred metres in local areas or have low spatial resolution, therefore not allowing a complete and global image of the IBP extension. The complete characterisation of the IPB is essential to decipher the geometry at depth of many tectonic structures that control the spatial distribution of many massive sulphide ore systems.

Objectives

The PhD thesis focuses on 3D resistivity/conductivity modelling of the IPB using the Magnetotelluric method (MT) from the first hundred meters to a depth of 50 km (Simpson and Bahr, 2005). The MT method measures simultaneously the natural magnetic and electric fields in orthogonal directions through the time variations of the magnetic field. The oscillating magnetic fields induce oscillating electric fields in the conducting earth, and both can be measured at the earth's surface in a wide frequency range. After the processing and inversion of the data, the resistivity distribution at depth is obtained. The massive sulphide ores have a high resistivity contrast compared to the host rocks, allowing us to identify and characterize them. The 3D model will be supported by other geophysical methods to constrain the forward modelling such as gravity and seismic data. The software FFMT will be used for the data processing. FFMT was developed at the University of Frankfurt Main (Castro et al., 2020) and it is stablished at the University of Granada, under the supervision of González-Castillo.

The model is based on processing previous and acquisition of new MT data. Data acquisition will be carried out with the equipment from the Instituto Dom Luiz (IDL-FCUL, ADU-07) and data processing will be performed at the University of Granada and Complutense University of Madrid. This PhD project involves research stays at both Universities. Model description and analysis will be based on the MT model and previous geological theories.

This PhD is supported by the FCT project PyBe-Iberian Pyrite Belt lithospheric characterization with Magnetotelluric (EXPL/CTA-GEF/0183/2021).

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IDL 2023 - XXX

PhD in Geology (Geodynamics)

3D numerical geodynamic modelling of continental collision

Supervision

Filipe M. Rosas (IDL, FCUL, University of Lisbon), Nicolas Riel (Institute of Geosciences, Johannes Gutenberg-University, Mainz, Germany) and Jaime Almeida (IDL, Universidade da Beira Interior – UBI)

Summary

Despite a number of classical contributions (e.g., Tapponier et al., 1982) and some recent modelling approaches (e.g., Toussaint et al., 2004; Copley and McKenzie, 2007; Burov et al., 2008; Faccenda and Gerya, 2009; Li and Gerya, 2009; Li et al., 2010, 2011, 2013; Duretz et al., 2012; Gray and Pysklywec, 2012; Schellart et al., 2019; Sizova et al., 2012), the fundamental processes of orogenic continental collision are still not fully understood. Namely, a 3D comprehensive understanding of the driving forces at the scale of the whole mantle is still lacking.

As such, in the present PhD proposal the candidate will engage on conceiving and carrying out state-of-the-art 3D numerical geodynamic models of continental collision. The modelling strategy will focus on unravelling the main geodynamic conditions that govern continental collision, sustained continental subduction and mountain building, both in general, as well as taking the Himalayan case as a benchmark comparative example. Comparison with Andean type orogens, and implications for the understating of continental Caledonian and Variscan orogenic systems, will also be further explored.

All models will be carried out using the state-of-the-art LaMEM code (Kaus et al., 2016, https://bitbucket.org/bkaus/lamem), which allows for unmatched computational efficiency in modelling 3D geodynamic settings (e.g., Almeida et al, 2022a,b; Riel et al., 2023) while taking into account complex visco-elasto-plastic rheologies, the effects of phase change and the development of topography. Three main breakthrough approaches will thus be attempted concerning the geodynamic numerical modelling of orogenic continental collision:

- A long term 3D numerical modelling approach, enabling a full understanding of the main governing geodynamic constraints, manly the full scope of the feed-back effect imposed by whole (upper and lower) mantle flow on the main driving forces during both oceanic and continental subduction evolutionary stages.
- Including the lower mantle in all simulations, allowing for realistic phase changes at the 660 km upper-lower mantle boundary, and for the consideration of its geodynamic implications in continental collision and mountain building.
- The use of sophisticated, thermal and strain-rate dependent, rheologies in all models, including the role of phase changes. As a mixed international grant proposal, this will allow the candidate to benefit from training with the top world class team of geodynamic modellers at Mainz Johannes Gutenberg-University, under the co-supervision of Dr. Nicolas Riel and with access to both the IDL cluster and the top-notch Mainz cluster to run the models.

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IDL 2023 - XXX

PhD in Geophysics and Geoinformation Sciences

Rainy season variability over Southwest Africa and its associated drivers

Supervision

Daniela Lima (IDL-FCUL), Alexandre Ramos (Karlsruhe Institute of Technology), Andreas Fink (Karlsruhe Institute of Technology)

Part of the proposed work will be done at Karlsruhe Institute of Technology.

Summary

Most of sub-Saharan countries are profoundly dependent on agriculture, as it serves as a major economic and food-source for populations that usually suffer from diseases and malnutrition [1,2]. Thus, the role played by the rainy season across these parts of Africa is extremely important for such rain-fed agriculture [3,4]. Southwest African countries are salient examples regarding this problem, as climate-change scenarios project widespread warming and reduced total surface freshwater availability in southwest Africa [5,6,7]. The region is characterized by arid to semi-arid climates [8], with most of the rainfalls occurring from October to March [9]. Rainfall gradients are large, varying from very little annual rainfalls near the coast, to copious precipitations over the continental plateaus [9]. Thus, delayed onset, early withdrawal or multi-day breaks in the rainy season can result in agricultural losses with severe socioeconomic consequences [2,3], as these regions suffer from limited economic and governmental capability to deal with climate-change-related events [5,10,11,12]. Over southern Africa, during the rainy season, regional-scale features such as Limpopo or Zambezi low-level jets (LLJs) are responsible for advecting thousands of tons of water vapor from Indian Ocean towards the interior plateaus of southern Africa [13]. At the synoptic-scale, the Angola Low (AL) and the Mozambique Channel Trough (MCT) represents a part of a band of tropical low-pressure systems converting the advected humidity in rainfall over central-western Southern Africa [14]. Both AL, MCT and the LLJs are responsible for precipitation variability over the region. This effect is captured in models, depending on their resolutions [13,14]. Thus, it is of greatest importance to understand the role played by such features over SW Africa, on the inter and intra-seasonal timescale. It is of our interest to identify inter and intra-seasonal rainfall patterns during these periods by inspecting the existence of rainy season delays or interruptions within the season. [15] developed methodologies to identify the beginning and the end of the rainy seasons over East Africa, where inter and intra-seasonality is largely influenced by regional features, such as LLJs, local low-tropospheric easterly winds or large-scale features, such as the Madden-Julien Oscillation [16,17,18].

The most important point of this PhD proposal is to investigate, in detail, the evolution (from the past to the future) of the rainy season inter and intra-seasonal variability across SW African region, as well as its main drivers. Thus, this proposal consists of 3 main objectives:

1) Understand inter and intra-seasonality of rainy-season rainfalls over south-west Africa. This topic aims to analyse inter and intra-seasonality changes in precipitation during the rainy season over south-west Africa, in countries like Angola, Namibia and Botswana. We intend to document and improve the understanding of delayed onsets, early withdrawals and breaks, by using global reanalysis products (e.g.: ERA5, MERRA2, JRA55…) and ground-based data (e.g.: from local weather stations or satellite products) for recent decades;

2) Quantify possible drivers of rainfall variability. Here, we propose to associate inter and intra-seasonal rainy season variability with (a) large-scale features, such as tropical-extratropical interactions, El-Niño Southern Oscillation (ENSO), Subtropical Indian Ocean Dipole (SIOD), tropical waves like Madden–Julian oscillation and equatorial Rossby waves; (b) synoptic features (e.g.: tropical lows - AL, MCT...) and (c) regional-scale systems and fluxes occurring over the region (e.g.: low-level jets, mesoscale convection…), by modelling it using global reanalysis and models, as well as ground-based data. Idealised simulations are expected to be performed to link rainfall variability with such possible drivers;
3) Comprehend the way global warming is affecting rainfall variability across the region. This last objective targets inter and intra-seasonal rainy season variability modelling, according to future climate projections using brand-new CMIP6-forced WRF simulations for CORDEX Africa's domain. With this analysis, we expect to understand if rainfall patterns and behaviours, between seasons and throughout each season, are changing.

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IDL 2023 - XXX

PhD in Igneous Petrology and Geochemistry

Contamination history and magma diversification of a synorogenic layered intrusion: implications for ore forming systems

Supervision

Ana Jesus (Instituto Dom Luiz), Mathieu Benoit (Géosciences Environment Toulouse- CNRS)

Summary

The relevance of synorogenic mafic/ultramafic magmatism in the genesis of oxide and particularly sulfide magmatic ore deposits has been rising with a large number of discoveries worldwide (e.g. (Mao et al., 2008; Piña, 2019). The Beja Layered Gabbroic Sequence (LGS) intruded the southern border of the Ossa Morena Zone (Portugal) during the Variscan Orogeny at ca 350 Ma. LGS dimension (~262 km^2) and nature makes it an exceptional study-case within its category or the Variscan orogen. Research in the western compartment of LGS has placed significant constraints to its petrogenesis and Fe-Ti-V oxide and Ni-Cu-Co-PGE sulfide ore-forming systems (Jesus et al., 2020; Jesus et al., 2014; Jesus et al., 2003). The magmatic evolution and ore-forming potential of most of this vast intrusion (ca. 70%) remains however, elusive as well as its relationship with coeval mesocratic magmatism formed during the HT-LP event (Jesus et al., 2007). SEMACRET is a Horizon Europe project (www.semacret.eu) that is applying the "Mineral Systems Approach" (McCuaig et al., 2010) to 5 reference sites including LGS, to improve genetic models and exploration methods in orthomagmatic deposits. Applying this knowledge-driven exploration to orthomagmatic systems is render difficult by overlapping geochemical signals from different processes during magma and ore formation and requires detailed petrological knowledge. This PhD project will therefore deliver large-scale geochemical mapping of LGS Eastern compartment with three main aims:

i) The mineralogy and degree of differentiation of gabbroic facies will determine the fertility of the magmas for sulfide mineralization and delimit evolved ferrogabbro domains favourable for oxide mineralization.

ii) The spatial and temporal distribution of crustal contamination, combined with other methods (e.g. geophysics, overabundance of cumulates, anomalously low blocking temperatures in HT minerals) will enable identifying domains with higher potential to have segregated early sulfide melts. The age and geochemistry of local country-rocks (Cambrian marbles, Proterozoic amphibolites) will provide precise constraints to modelling crustal contamination.

iii) Although LGS sulfide occurrences and olivine chemistry suggest that the main magmatic stage was unfavourable for magmatic sulfides (Barnes et al., 2023; Jesus et al., 2020), one intriguing, higher-grade sulfide generation may be related with a late rejuvenation of the magmatic system. Indeed, previous studies suggested that lower crustal underplating of LGS mafic magmas generated Deep Crustal Hot Zones by reworking of lower to mid crustal rocks, leading to magma diversification and multiple generations of evolved rocks (Jesus et al., 2016). This hypothesis will be further tested by constraining the spatial and temporal distribution of the various pulses of late mesocratic suites.

The integration in HEU Project SEMACRET enables formative interactions with a multidisciplinary, international research team. Crucially, it will provide hands-on-training in state-of-the-art analysis with TIMS and ICP-MS including all chemical procedures in a clean lab environment. The student will spend circa 3 months per year at GET with co-

supervisor, expert isotope geochemist and igneous petrologist Dr Mathieu Benoit that will further support data modelling and interpretation (Benoit et al., 1996; Python et al., 2020). This training represents a competitive advantage for building up highly differentiated skills that can improve the student's employability in reference geochemical labs and a crucial knowledge transfer to Portugal.

Main Tasks

The student is expected to accompany on-going field work and sampling which will be mostly undertaken by other members of SEMACRET team. Geophysical campaigns (airborne EM, ground IP) scheduled for 2023 will be processed by other consortium partners but scientific exchange is highly encouraged as geophysical data will enable unravelling the architecture of the intrusion and place first-order constraints geochemical / petrological models.

Sample preparation (thin sections, whole rock geochemistry and mineral separation for U/Pb geochronology), petrography (transmitted and reflected light) and mineral chemistry analysis (Electron Probe Micro Analysers; JEOL JXA-8200 and EDS spectrometer) will be carried at GeoFCUL/IDL.

Whole rock analysis of major elements will be done with the PHILIPS PW-1480 X-Ray Fluorescence at GeoFCUL/IDL and trace elements with the Thermo Scientific ICap ICP-MS (Inductively Coupled Plasma Mass Spectrometry) at GET. Geochronological Dating of U/Pb will mostly focus on country rocks and mesocratic facies (lab under consultation) whereas Nd-Sr isotopic analysis of all rock spectrum will be performed with Thermo Scientific TRITON + TIMS (Thermal Ionisation Mass Spectrometry) at GET.

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PhD in Geophysics and Geoinformation Sciences

Title: Modelling the Mediterranean Outflow processes across scales.

Supervision

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Part of the proposed work will be done at IEO, Cadiz, Spain

Summary

The Mediterranean Outflow (MO) exits the Strait of Gibraltar after an intense interaction with the above Atlantic Inflow forced by strong tides on the narrow Strait. These interactions cause the inflow-outflow interface to oscillate and produce internal wave activity and mixing. After that, the MO plunges into the Atlantic as a gravity current that entrains ambient flow. This entrainment occurs on a relatively small area, yet it produces a remarkable effect on the upper ocean circulations noticeable several hundreds of kilometres westward through the generation of a beta-plume to which the Azores Current is part of (e.g, Peliz et al, 2007). Along its route downslope, the MO splits into several veins and undergoes a strong interaction with the bottom by even reshaping it (Sanchez-Leal et al 2017). The final fate of the MO as it interacts with canyons and capes on the southwest tip of Iberian Peninsula is to produce a vigorous eddy field (Meddies) at intermediate depths (e.g, Barbosa Aguiar et al 2013).

For all this complexity and relevance, the MO has long been considered one the most challenging spots for ocean circulation modelling, a paradigma for upscaling (influence of small processes on large scales). It is also the best known example of a gravity plume in the ocean interior, as well as the paradigma of intermediate water vortices. The Mediterranean Outflow is also a teste bed for the simulation and parameterisations of outflows in climate models (Legg, 2009). In particular, it has been demonstrated that the overflows are highly sensitive to the choice of vertical coordinates, vertical resolutions and vertical turbulent parameterisations. While terrain-following coordinates seem to preform better for margin processes, the isopycnal coordinates improve the representation of overflows.

In this study, we shall address the sensitivity of MO to the vertical coordinate, vertical resolution and vertical mixing parameterisations. We shall conduct simulations using two Ocean Models: the Regional Ocean Modelling System (ROMS) and the Modular Ocean Model MOM6.

ROMS has been extensively used for the simulations of the Gulf of Cadiz circulation at IDL, with a successful representations of many aspects of the MO (Peliz 2007, Peliz et al 2013, Aguiar et al 2013, Aguiar et al 2016). However, ROMS is build on terrain-following coordinates that allow only moderate resolution near the bottom. On the other end, MOM6 uses the recently developed vertical Lagrangian remapping algorithm (a variant of the Arbitrary Lagrangian Eulerian, Griffies et al 2020). It enables the use of any vertical coordinate, including geopotential, isopycnal, terrain-following, or hybrid/user-defined. MOM6 allows for a sensitivity study on the vertical coordinate and vertical resolutions. This way a complementary and comparable ensemble of model simulations will be conducted.

The ultimate objective is to advance the simulation skills of the MO through a modelling study on sufficiently large domains so as to cover all of the MO phases, and at sub-mesoscale grid resolutions (around one kilometre) to representa as close as possible the diversity of small scale processes. The model simulations should be able advance

our knowledge on MO formation processes, its interaction with the bottom and splitting, the eddy generation and its connection with the upper ocean currents.

The model simulations will be compared with a large data set of observations collected over the last decade by the Instituto Español de Oceanografia (e.g., Sanchez-Leal, 2020) that include extensive hydrographic observations, complemented with ocean current time series and high resolution records of flow parameters near the bottom collected on a series of landers.

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