

## Descrição Geral e Objetivos do Projeto de Infraestrutura

### Introduction

The Collaboratory for Geosciences (C4G) is a distributed research infrastructure (RI) that promotes the networking of researchers and the sharing of equipment, data, collections and tools in Solid Earth Sciences (SES). C4G comprises the disciplines of geology, hydrogeology, geochemistry, geodesy, geophysics, geomechanics and geomathematics, and provides services in the transversal areas of georesources, natural hazards and the environment, for the Portuguese territory (both onshore and offshore) and elsewhere. C4G integrates a very comprehensive but scattered range of human and material resources, boosting their value to the research community, to industry and to the Society at large.

C4G includes all the relevant SES players in Portugal: LNEG is the national geological survey, with competences in georesources, geologic hazards, coastal monitoring and geo-environment; IPMA is the national authority for earthquake monitoring and geomagnetism, and is in charge of marine geology research; DGT maintains the national geodetic network. In addition C4G encompasses six universities and one private institution. A novel e.infrastructure will be implemented to harness the power of the distributed resources, easing effective collaboration, allowing remote access to products and services, and acting as a national node of the ESFRI EPOS e.infrastructure.

C4G will promote better usage and optimization of the already existing research infrastructure and will assemble enough critical mass to generate new scientific services and research.

### Objectives and Action Plan

C4G aims at:

- ? Capacitating the Portuguese SES community for excellence;
- ? Invigorating the relationship between governmental agencies, industry and academia;
- ? Promoting training in SES.

These goals will be pursued through three major vectors:

- ? Integration across disciplines and institutions;
- ? Creation of a culture of service providing with a "one stop shop" approach;
- ? Building a prosperous relationship between C4G and its stakeholders.

C4G will allow scientific, technical, industrial and public administration professionals to answer key questions on georesources, natural hazards, environment and fundamental Solid Earth Sciences. C4G will provide the backbone infrastructure to advance the understanding of Solid Earth processes across different time and length scales, physical interfaces (solid Earth ? atmosphere, solid Earth ? hydrosphere, deep Earth ? Earth surface), spatial domains (continents and oceans), and specialized disciplines.

Technical integration will be particularly challenging given the distributed nature of C4G. Members of C4G are mobilized to actively work towards integration. C4G will participate and contribute to the integrative solutions developed by EPOS, ensuring that they are adequate to Portugal and avoiding unnecessary duplications of efforts. New solutions will be developed for the disciplines not included on EPOS, securing easy articulation with the remaining C4G/EPOS structure.

Most C4G institutions already provide services both to industry and governmental authorities. LNEG provides information and consultancy on geology, geophysics, and hydrogeology to private companies, municipalities and governmental agencies in support of georesources, geohazards, environmental monitoring, engineering and land planning decisions and policies. IPMA monitors the seismicity at a national level, and several C4G institutions contribute to the assessment of seismic hazard and risk reduction. Universities offer a wide range of products and services. The integration promoted by C4G will increase the quantity and quality of the services provided. C4G will enhance knowledge transfer from academia, through governmental agencies, to regional and local administration, private companies and industry. In return, academic institutions will benefit from the feedback received from the societal end of the chain, adapting timely to a society in permanent evolution.

C4G will make a diagnostic of the current interaction with stakeholders. These include public entities and authorities, private companies involved in the exploration and exploitation of primary raw materials, water and energy resources, public and private entities that need to rely on proper earthquake risk knowledge, etc. The relationship with stakeholders will be strengthened via R&D projects, development of new C4G products and services (P&S), dissemination of consulting opportunities, and promotion of training opportunities specifically designed for the stakeholders needs.

Resource scarcity is a major concern that modern societies currently face. How can exploration methods be improved for the discovery and characterization of natural resources? Which new areas, both in the continents and in the oceans, are expected to conceal new resources? How can the current models of natural resources generation be improved? What are their cycles? How can the accessible resources be reassessed and their exploitation improved? These broad questions are relevant to a number of georesources, namely water, heat, hydrocarbons, and raw materials (metals and non-metals). How can we reuse and recycle raw materials, including the targeting of critical raw materials in exploitable resources? C4G ? as an interdisciplinary infrastructure making use of expertise in geology, geochemistry, geophysics and remote sensing ? will collect the all the existing information about natural resources (raw data and derived results) into catalogues, accessible through a web portal. This will provide an integrated picture of the Earth?s sub-surface to emerge across the different disciplines represented. In addition, C4G will through its multidisciplinary character, search for new georesources using state of the art technology.

Natural disasters are among the events that inflict higher human and economic losses upon societies. This adverse impact is expected to escalate given the increasing population densities in coastal areas and in large urban centers, often more exposed. A better understanding of the dynamics of our planet calls for integrated studies from the Earth?s inner layers to the Earth?s outermost surface, which will contribute to improved monitoring, preparedness and response in case of disasters. Earthquakes have affected Portugal repeatedly throughout history. How are large earthquakes generated in a slowly deforming environment like Iberia? When and where can we expect the next large earthquakes to occur? What ground motion levels should we prepare for? To answer these questions again an interdisciplinary approach is required, involving seismology, geodesy and geology among others. C4G will support dedicated scientific studies and the future development of integrated operational monitoring systems by facilitating the access to data and metadata of different type of sensors (e.g., seismic and GNSS networks). In this respect, a priority investment of C4G will be the densification of the existing GNSS network, with geodetic sensors preferably collocated with seismic sensors, in order to permanently monitor the present-day deformation of the three most potential active faults in Portugal (Messejana, Vilariça e Vale do Tejo).

In a country where 85% of the GDP is generated in coastal regions and where the coast is home to 75% of the population and to most significant infrastructures, understanding the physical processes of coastal erosion and predicting its consequences is of prime relevance. Climate change, sea level variations and extreme events (e.g. floods and draughts) are all issues that the C4G present and future products and services can contribute to address.

Monitoring the quality of the environment and predicting impacts using quantitative, numerical, physical-based tools are imperative efforts for the next decades. How do carbon and other volatiles cycle through the Atmosphere, Water and Solid Earth? How do landscapes and ecosystems react to human induced changes? Which are the most important and strategic water bodies in the sub-surface? What processes affect subsurface water and its quality? When and how will space weather events perturb human activities, such as radio and GNSS signal transmission, air navigation, or the functioning of satellites? These are examples of central topics calling for the integration of datasets, resources and expertise, which is available in C4G. Several groups have been developing research on the impacts of mining (active and abandoned), assessing ecotoxicological risks in currently active and abandoned industrialized areas, including our cities. Some of these activities have large impacts in water resources quality and protection and in the definition of natural protected areas.

Topics of expertise within C4G with direct impact on society include: environmental impacts and remedies, detection and monitoring of contaminated areas, CO<sub>2</sub> storage, exploration-exploitation benefiting of mineral resources (both ores and industrial raw materials), evaluation of mineral reserves, development of innovative tools in hydrocarbon exploration and reservoir modelling, evaluation and exploration of other georesources such as geothermal energy and shale gas, seismic monitoring, assessment and mapping of natural hazards and risks, monitoring of space weather conditions, installation and maintenance of geodetic GNSS networks (including several in Africa and Asia) and development and setup of e.infrastructures.

C4G will back up, structure and stimulate training at all levels. This task is made easy by the diversified C4G composition. Universities have an innately fluid relation with academic education. Governmental laboratories are

naturally proficient with the public and private sectors. C4G will network currently ongoing training initiatives and fill existing gaps. C4G training initiatives will aim at students of all levels, pre-university teachers and educators, R&D professionals in industry and in the private sector, authorities with public responsibilities (civil protection, firemen, regional and local administration, etc.) and journalists. C4G will emphasize communication with the society in general and with strategic partners in particular. Web platforms will be developed for internal and external communication. Access rules will be widely disseminated. A general education and outreach program will aim at increasing the awareness and preparedness to SES issues.

#### Internal organization and Governance

The C4G community is structured by two sets of perpendicular pillars: a vertical structure, by disciplines (WGs); and a horizontal structure, transversal to all disciplines (LAs). This structure safeguards: 1) the specialized expertise inside disciplines that is required to push the boundaries of knowledge, and 2) the integrated multi-disciplinary vision that is required to tackle complex solid Earth problems. WGs aim at networking and integrating RIs inside the scientific disciplines of C4G. Transversal LAs have two goals: 1) to promote a healthy interaction of C4G with society, and 2) to address themes of scientific and societal relevance that crosscut all C4G disciplines.

Working groups encompass researchers and facilities inside disciplines of C4G, namely:

- WG1. Seismic data and networks;
- WG2. Geophysical exploration;
- WG3. Laboratories of rock physics and geomechanics;
- WG4. Geodetic data and networks;
- WG5. Geochemical and mineralogical laboratories;
- WG6. Magnetic data and observatories;
- WG7. Geological data and laboratories;
- WG8. Geomathematics infrastructures;
- WG9. Remote sensing;
- WG10. Paleomagnetism laboratories;
- WG11. Marine seismic reflection and Bathymetry laboratory (new);

WG11 was created by the integration of the RI SEISLAB in C4G after the evaluation of the proposed RI, as recommended by FCT. WGs will maintain, reinforce, network, and optimize resources inside scientific domains, facilitating mobility, promoting the exchange of knowledge, defining strategies of common interest, and providing services for other WGs and third party stakeholders. WG products and services will be provided through thematic nodes of C4G, which can be centralized at one institution or distributed.

C4G transversal lines of action are:

- LA1. General coordination;
- LA2. Professional, technical and scientific training;
- LA3. Interaction with stakeholders, including industry;
- LA4. Communication and outreach, including promotion of public awareness and dissemination of access rules and services;
- LA5. Technical integration of existing resources;
- LA6. Integrated services for fundamental science;
- LA7. Integrated services for georesources;
- LA8. Integrated services for the mitigation of natural risks;
- LA9. Integrated services for geo-environment;
- LA10. e.infrastructure development and maintenance.

LA1 coordinates the different bodies of C4G and implements the collaborative vision of integration, transparent and participative decision-making, and open access to products and services (P&S). LA2 through LA4 strive for a healthy reciprocal relationship between C4G and society. LA5 through LA9 address the challenging tasks of transversal integration. LA10 builds and maintains the common e.infrastructure, that is fed by the different thematic nodes and where all C4G products and services (P&S) are accessible.

C4G multi-institutional and multidisciplinary nature requires bodies with different assignments, which validate each other and collaborate towards the same goals. C4G bodies are purposely diverse, encompassing both senior accomplished specialists and young dynamic researchers, scientists and technicians, as well as professionals experienced in the management of RIs (laboratories, networks, data centers, etc).

C4G decision-making body is the Coordination Board, where every institution is represented. The Executive Board is the management team responsible for the daily running of C4G. The team of LA leaders, coordinated by the Technical Director, writes an annual scientific report, which is supplemented by a financial report prepared by the Executive Board.

C4G counts with two external advisory boards that work and meet together: one scientific, composed of 3 members internationally recognized for their scientific work on SES, and one service-oriented, with representatives from the stakeholders. The annual report is presented to the external advisory boards, which give feedback to C4G.

C4G will hold an annual meeting to which all interested parties are invited. The annual meeting is a congregating event of open discussion. It serves to brainstorm, collect ideas, detect problems and align strategies.

#### C4G Implementation

C4G will undergo three stages: preparation, construction and operation. The first year (2017) will be dedicated to preparation and will serve to establish: 1) details of the open access policy, 2) specific products and services to provide, 3) structure of thematic nodes, 4) architecture of the e.Infrastructure, 5) active engagement of stakeholders, 6) mechanisms that ensure effective and efficient collaboration inside C4G, 7) details of the work plan, including clarification of participant roles, and 8) hiring of staff, including the Technical Director. The duration of the construction phase will depend on the intra-disciplinary integration maturity of each WG. We expect that the WG1, WG4 and WG7 thematic nodes will start to operate in 2019, others will follow. The e.Infrastructure will become operational in 2019.

Services that C4G will provide include:

- ? access to equipment (including portable pools) and laboratorial facilities;
- ? access to data repositories;
- ? access to data mining, modeling and visualization tools (hardware and software);
- ? data reduction analytical work for third parties;
- ? scientific consulting for private and public entities;
- ? calibration services;
- ? advanced training and knowledge transfer;
- ? chemical analysis of soils, waters, plants and rocks;
- ? geomechanical characterization of solid materials.

C4G will provide the following products:

- ? Level 0: raw data, e.g.: seismic waveform data, GNSS observations, results of mineral chemical analysis, geomagnetic daily variation curves.
- ? Level 1: data products derived from nearly automated procedures, e.g.: earthquake locations and magnitudes, time series of GNSS positions, shakemaps, local geomagnetic activity K-index values.
- ? Level 2: data products resulting from the investigations of individual scientists, e.g.: mapping of the deep Earth, earthquake catalogs, geological mapping of the Earth surface, georesources map (e.g. areas with potential for raw materials), mineralogical and geochemical data about potential ore occurrences, characterization of rock behavior during deformation and fracture, present-day secular velocity field and geodetic strain rate field, amplitude of seasonal signals due to loadings and other geophysical processes, co-seismic and post-seismic parameters, geo-hazards maps (earthquake, tsunami, liquefaction, landslides, coastal erosion), geotechnical risks mapping, contamination maps, groundwater availability and quality maps, hydrogeological models, ionosphere and troposphere maps, characterization of space weather events.
- ? Level 3: integrated data products resulting from complex analyses or community-shared products, e.g.: Earth structure imaging, stress and strain maps, multi-hazard maps, geological material characterization catalogue, metallogenetic and mine resource maps, warning systems for extreme events.

#### Strategic relevance

##### Regional level

Environment, energy, natural hazards and sustainability are strategic priorities for all regions involved in C4G: Norte, Centro, Vale do Tejo and Alentejo. The C4G headquarters and e-infrastructure will be hosted by Região Centro (UBI), whose strategic priorities further include promoting job opportunities and increasing R&D initiatives. Covilhã, where C4G will be based, is a city with flourishing software and internet-related industries, which embraces the notion that service-oriented research e.infrastructures have a role in the development of the country's interior.

#### National level

The topics addressed by C4G are of national strategic relevance at all levels. The exploration, characterization, exploitation, recycling and efficient use of georesources are generalized strategic goals, inevitable in any agenda for sustainability. Geo-hazards (earthquakes, tsunamis, coastal erosion, floods, droughts, landslides, etc) and space weather threats (geomagnetic storms) are a main concern at national level. Monitoring environmental quality and predicting environmental impacts is mandatory at national level, and is also a European priority.

#### International level

C4G will boost the internationalization of Portuguese SES joining its European counterparts through its participation in the ESFRI RI European Plate Observing System (EPOS), promoting Portugal as a service provider in the international research arena.

#### **Atividade: 4 - Implementation of Services & Products**

##### **Descrição da Atividade**

C4G S&P will be implemented in two phases, depending on their current maturity (first set by end of 2018, second one by end of 2019).

Services to be implemented are:

Data Acquisition/Storage/Preservation/Quality Control

- Coordination of temporary seismic networks (including Ocean Bottom Seismometers - OBSs);
- Geodetic Data (GNSS; gravity);
- High-resolution surface surveying using LiDAR;
- Offshore seismic and bathymetric data acquisition;
- Acquisition of seismic reflection and refraction, gravity, magnetic prospecting data, and geochemistry data;
- Creation and maintenance of databases for data, products and associated metadata;
- Data curation.

Hazards

- Support to the identification, characterization and remediation/mitigation of geochemical risks;
- Integration of datasets to understand the composition, kinematics and dynamics of active faults;
- Multi-hazard assessment and mapping (earthquake, tsunamis, landslides, etc);
- Assessment of coastal erosion and rockfall and landslide hazards.

Georesources and Environmental Protection

- Access to processing software and networked interpretation to improve knowledge of the Earth sub-surface;
- Geomodelling services, namely integration of different datasets to solve geophysical inverse problems;
- Consultancy on offshore geological resources;
- Support to multi-criteria optimization of the activities involved in the life cycle of geo-resources availability ;
- Technical, experimental and general support to industrial activities within the mining sector.
- Technical support towards efficient use of resources and environment protection

General Support

- Access to electronic laboratories for geophysical equipment repair;
- Logistic coordination of lab facilities;
- Intercalibration of geological laboratories methodologies;
- Pools of mobile equipments for field data acquisition.

The following products will be implemented:

- Subsurface characterization database;

- Swath bathymetry and offshore seismic reflection datasets (not covered by confidentiality constraints);
- Positioning time-series for geophysical studies (secular and other signals);
- Database oriented to the characterization/valorization of geomaterials;
- Geomagnetic measurements and data products from COI Observatory;
- Catalog of geological material characteristics;
- Generalized stress and strain maps;
- Catalog of support available to industrial georesources and raw materials activities;
- Catalog of C4G resources and usage policy;
- Integrated catalogue of C4G Products;
- Integrated catalogue of C4G services;

This Activity will be led by the Technical Director, assisted by the Coordinators of LA 6 (Fundamental science; M. Bezzeghoud); 7 (Georesources; A. Fiúza), 8 (Natural Risks; L. Matias) and 9 (Environment; T. Carvalho). The additional effort over the three years (not including the staff hired by the project) is 13.4 PM, totalling 112.8 for this Activity.

#### Milestones (máx. 6)

Data	Designação dos milestones	Descrição
2017-09-30	S&P Implementation Roadmap	The roadmap will rank the S&P's according to maturity, identifying those that will be included in the first and second groups.
2018-03-31	Preliminary S&P Implementation Report	The report will document the progress made, highlighting the main challenges and recommending remedies
2018-09-30	First group of S&P's implemented	The first group of S&P's will be made available through the C4G portal
2019-06-30	Second group of S&P's implemented	The second group of S&P's will be made available through the C4G portal
2019-12-31	Final S&P Implementation Report	The report will describe the implementation process, including user's feedback and recommendations for further developments
2019-09-30	A document describing the products and services will be prepared (to be included in the C4G Brochure including the description of the infrastructure).	A document describing the C4G physical infrastructure for a broad audience will be produced

#### Recursos humanos do beneficiário

Nome/perfil	Participante		Conteúdo Funcional da Participação	Nº Pessoas-Mês					
	NIF	Designação		2016	2017	2018	2019	2020	Total