

PROJECT: Data collection to GIS analysis in earth sciences
TEAM: Paula Teves-Costa (Seismic Risk) ; Paula Redweik, Cristina Catita, Joel Dinis, Mário Cachão, Carlos Marques da Silva (Spatial Analysis of Trace Fossils) – DEGGE & DG/FCUL
PARTNERS: Municipality of Lisboa ; QREN – PORLisboa ; Huelva University

### **Context:**

The democratization of georeferenced data is allowing a growth on GIS studies, for planning and decision-making purposes. In earth sciences (e.g. geology, geophysics) the data has a crucial role in terms of developing scientific conclusions, based on GIS analysis. Often the main issue is the collection of data and their transformation to adjust to specific methodologies.

During the master degree on Geomatics Engineering two projects were developed to solve earth sciences issues to scientific conclusions and practical results : Seismic Risk and Paleontology.. In both cases data were collected and official data were put together to make GIS analysis. In the first project data were suitable for the use RISK-UE methodology, for geophysics purposes. In the second one all the data were collected and afterwards, the usage of different approaches allowed an update of past studies about the location of trace fossils, for paleogeographic (paleontology) purposes.

### **Objectives:**

A georeferenced Project has the same source, data with geo-position relatively to an origin and a cartographic representation. The two case studies share a sequence of steps having a similar appearance to other case studies:

- Study of the state of the art (location, past methodologies, past studies);
  - Data collection or official data on the case study location;
  - Transform data to make it suitable for a specific methodology;
  - Application of methodologies and a comparison with other methodologies
  - Draw conclusions about the results and compare the results with past studies;
-

---

## Description of the project:

The two projects are developed in this document. Each project needs an individual explanation:

### **Project A :**

**Theme :** Natural and Technological risks at the city of Lisbon – Estimation of damage scenarios on building stock after a seismic event

**Team :** Edgar Barreira, Paula Teves-Costa, Rachid Omira

**Duration :** 1 year

**Partners :** FCUL (DEGGE), Municipality of Lisbon, QREN – PORLisboa

**Publications & Conferences:**

- 10<sup>th</sup> ESRI Portuguese Users Meeting (2012) – “GIS applied to seismic vulnerability studies of building stock” (*in portuguese*) ;
- Lx\_Risk Conference (2011) – “Estimation of damage scenarios to the city of Lisbon” (*in portuguese*)
- 8<sup>th</sup> National Congress on Seismology and Engineering Seismology (2010) – “Seismic vulnerability of the housing building stock of Lisbon” (*in portuguese*) ;

A funding project was created to identify natural and technological risks at the city of Lisbon. A workpackage was developed to update the seismic vulnerability of building stock, after the last, ten years ago. In the past, the city of Lisbon was affected by strong earthquakes and the well-known November 1<sup>st</sup> 1755 earthquake was the biggest one. Other seismic events occurred and the city needs to know what the most vulnerable neighborhoods are during and after an earthquake. The study presents the seismic behaviour for two different seismic scenarios, in terms of the estimated damage. The applied methodology, which was developed during the RISK-UE project, attributes a vulnerability index for each typology that will be used for damage grade estimation using the European Macroseismic Scale (EMS98).

RISK-UE is considered to be “an advanced approach to earthquake risk scenarios” and was developed to estimate vulnerability and fragility models for the prevailing European built environment. The method defines some issues to understand its application. Building vulnerability is a measure of the building damages, depending on ground shaking, assuming a specified intensity.

To apply this methodology two official data sets were used and both had a deep study to adjust to RISK-UE application. INE (Portuguese Official Statistics Institute) and CML (Lisbon Municipality) databases were the sources to create a master database suitable to apply the RISK-UE methodology. Each database has different attributes and different geographical features, but in the whole both have all the information to estimate the seismic risk through the RISK-UE method. The ArcGIS and Matlab software were used to create a GIS tool for managing this information.

Afterwards, the objective was to join the two former databases, to create a master database. However it was not possible to do it in a simple way because INE uses statistical boundaries (census track units) and CML database use the real position and the contour of each building. When both databases are joined, buildings and census track units are integrated. This integration allowed a comparison between INE and CML data.

The final information on the buildings was obtained visiting 2500 buildings, with the final purpose of knowing the extreme cases of vulnerability of each class (maximum and minimum).

---

---

After this, some criteria were established to obtain the last version of the master database. The new created database is performed using the census track as work unit cell. To make the results more accurate, an empirical factor was introduced in order to take into account the influence of the topography and the surface geology.

The final aim of this study is to estimate the damage suffered by each type or class of buildings. The damage will be a function of the assigned intensity produced by an earthquake scenario (an event with a certain magnitude generated at a certain epicentral distance). From the master database, after the vulnerability index calculation, the damage for each typology (as a function of macroseismic intensity) was estimated. Damage data were collected and compiled in a single-intensity database.

## **Project B :**

**Theme :** Spatial analysis of trace fossils for paleogeographic studies

**Team :** Ana Santos, Carlos Marques da Silva, Cristina Catita, Edgar Barreira, Eduardo Mayoral, Joel Dinis, Mário Cachão, Paula Redweik, Wilfried Linder

**Duration :** 2 year

**Partners :** FCUL (DEGGE / DG), Huelva University

**Publications & Conferences:**

- Master Degree Thesis – Edgar Barreira (2011)– “Técnicas automatizadas de extracção de dados icnológicos para apoio a estudos paleogeográficos – Caso de estudo da Foz da Fonte” (p.116) (*in portuguese*)
- FACIES (57:417-429) (2011) – “Photogrammetric and spatial analysis of a bioeroded Early Miocene rocky shore, western Portugal”
- e-Planning Forum (2011) – “Photogrammetry and Spatial Analysis applied on Paleontology” (*in portuguese*)
- Congress on Numerical Methods in Engineering (2011) – “Digital image processing of orthophotos for automatic collection of Ichnofossils data” (*in portuguese*)
- Iberic Congress on Paleontology (2010) – “Photogrammetry and Spatial Analysis of paleoichnological studies” (*in portuguese*)
- 13<sup>th</sup> AGILE International Conference on Geographic Information Science (2010) – “Spatial analysis of trace fossils for paleogeographic studies”

Geology, in general, and Paleontology, in particular, are typically areas with a low level of automation of collecting and treating data. Paleontology has, however, allowed relevant studies for the knowledge of the geological history of the Earth, correlating its knowledge with other Earth Sciences.

This work focused on an ichnological hardground with traces of past living organisms with high density of ichnofossils. In the past this hardground was described and studied qualitatively, based on a small number of isolated samples, restricting the conclusions one can draw from that.

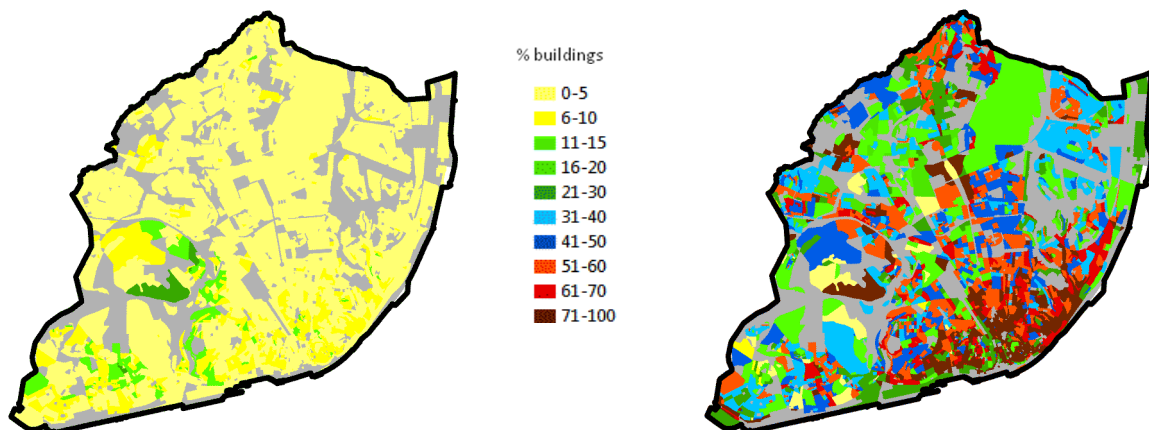
Therefore, the goal of the study is the development of a proceeding that permits the collection of data and the interpretation of spatial behavior on ichnofossil hardgrounds, in this case containing *Gastrochaenolites lapidicus* and *Gastrochaenolites torpedo*. This proceeding has been tested in a very specific case study: the Foz da Fonte beach. This site has been widely studied by experts who since last century have been giving their contribution to the development of theories about the geological history and the palaeogeography of this place.

---

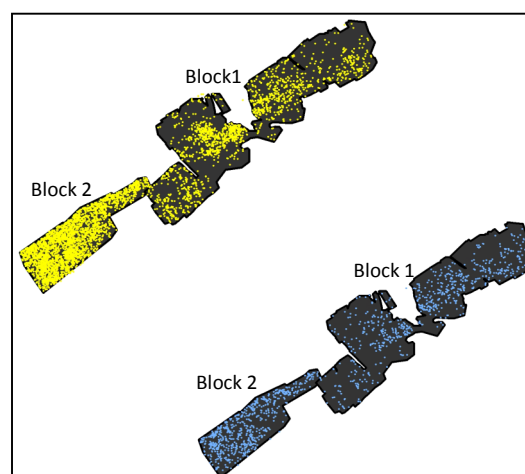
The proceeding involves three distinct areas: photogrammetry, digital image processing and spatial analysis. Using photogrammetry, the automated photo coverage of the hardground is made in order to obtain an orthophoto mosaic. Using digital image processing, the automated collection of specimens and their biometric characteristics is made without human intervention. This automation is developed for the two most frequent ichnospecies of our case study: *G. lapidicus* and *G. Torpedo*. Finally, the spatial analysis methods are applied to the collected population upon experts demands. Some advanced analysis were used, like the quadrant method, the Kernel density and the Rose diagram.

## Results:

The final results of each project can be seen in the Figure 1 (projeto A), and Figure 2 (projeto B).



**Figure 1.** Percentage of buildings, in each census track, suffering the same damage grade 3, with different sources and intensities : near (left), far (right)



**Figure 2.** Collection of centroids of each specimen (*G. lapidicus* and *G. torpedo*)