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SIG Contribution in the Making of Geotechnical Maps in Urban Areas

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Abstract. The use of Geographic Information Systems (GIS) has spread to several science areas, from oceanography to geotechnics. Its application in the urban mapping was intensified in the last century, which allowed a great development, due to the use of geographic database, new analysis tools and, more recently, free open source software.

Geotechnical cartography struggle with a permanent and large environment re-organization in urban area, due to new building construction, trenching and the drilling of sampling wells and holes. This creates an extra important and largest volume of data at any pre-existence geological map. The main problem results on the fact that the natural environment is covered with buildings and communications system. The purpose of this work is to create a viable geographic information base for geotechnical mapping through a free GIS computer program and open source, with non-traditional cartographic sources, giving preference to open platforms. QGIS was used as software and “Google Maps”, “Bing Maps” and “OpenStreetMap” were applied as cartographic sources using the “OpenLayers plugin” module. Finally, we also pretend to identify and delimit the degree of granite’s change and fracturing areas using a “Streetview” platform.

This model has cartographic input which are a geological map study area, open cartographic web archives and the use of “Streetview” platform. The output has several layouts, such as topography intersection (roads, borders, etc.), with geological map and the bordering area of Guarda Urban Zone. The use of this platform types decrease the collect data time and, sometimes, a careful observation of pictures that were taken during excavations may reveal important details for geological mapping in the study area.

1. Introduction

The data collection and the methodology used for this achievement are the most important factors in cartography, in general and geotechnical in particular. This is a slow phase that may affect the maps’ realization as it requires time and money supply to achieve the goals successfully. The methods used in geological engineering should be supplemented with direct methods, and indirect prospection, according to the complexity of the area under study, the type and purpose of the map. The final phase comprises selection, analysis and data interpretation [1].

Geotechnical mapping in urban areas has been progressively suffering very important advances. The diffusion of Geographic Information Systems (GIS), intensified in the last decade of the last century,



has provided a significant step in developing geotechnical mapping by means of the use of geographical databases and new analysis tools [2]. In terms of GIS, the growing need for a more complete and diverse information seems to positively favour the open source software. On the other hand the need to become competitive before commercial software led to the emergence of free software, "Free Open Source Software" [3]. Also highlight the emergence of web platforms (geographic database), which somehow provide mapping. From these stands out the Google with its various platforms, Bing Maps, the igeo website "Direção Geral do Território" (DGT) and the OpenStreetMap.

We intend to show in this paper that using free open source software (QGIS) and cartographic data from an open platform (OpenStreetMap), we can create a viable basis for the preparation of geotechnical mapping in urban areas, not despising the end that is intended or the accuracy of the official cartography.

2. Application of Geotechnical Cartography

Geotechnical mapping has a wide range of applications, both in engineering and in terms of regional and territorial planning [4]:

- At the territory planning level, integrated maps with various geological and geotechnical aspects, regional local and urban, at medium and small scales, are elaborated. Noteworthy are the selection of appropriate local maps, environmentally friendly or sustainable, compromise solution maps between technical aspects, economic and environmental problems and solution maps during the phases of development, design and construction.
- At the engineering level, maps of previous or feasibility studies for selection of location works or paths that contain information and data for the design and construction work are elaborated.
- There are also maps with inclusion of geotechnical cuts or profiles drawn up to large scales, such as, location maps of surveys and investigations carried out, dynamic process maps (landslides and subsidence), unstable areas and geological risks, geotechnical suitability maps for foundations and supports, slope maps in excavations and location maps and quality of materials loans.

3. Computer Applications and GIS

There have emerged in recent times, a set of computer applications in the field of geotechnical mapping [1], in particular:

- In the automatic processing of data;
- The preparation of maps of individual elements or factors or combined;
- In the preparation of databases;
- In the continuous updating of maps with data and information;
- In preparing 3D models and simulation of actions on the ground.

The correct use of these applications was done, for example, by the city of Oporto, having been drawn Geotechnical mapping at the scale of 1:10 000, supported by a GIS, composed of nine thematic maps [5].

In addition to the cartographic component, this model also has an alphanumeric computer database, called Geodata / W 2.0. This relational database brings together all existing information and allows consultation of the elements of geotechnical prospection work. The document also includes an extensive specification with the description of all the factors considered in their development and in the statistical treatment of land of test data. The maps are scanned in GIS support [6].

4. Free Open Source Software

As mentioned above, a Free Open Source Software has emerged in the last decades, now well accepted by the current GIS users.

The Open Source Software, or Open Source, intends to stimulate the error detection, creation, modification and research of new features, in order to develop and improve the program.

The Open Source projects involve people with different programming capacities and needs, such as academics, students, interface designers, authors' documentation for programmers' users in order to create a complete product. This is a development methodology that allows access to the source of a product, namely the goods and knowledge.

In the Free Software the issue is ethical and social, being the free nature of the programs important. There are free applications but whose code is not open, as is the case of SPATIAL COMMANDER (Germany), Forestry Gis (Wisconsin department of natural resources-USA), Google Earth (Google-USA), ArcExplorer (ESRI-USA), TNTlite (microimages, Inc.-USA) and TatukGIS Viewer (TatukGIS Poland) [3].

The best known Desktop GIS Open Source are: GRASS GIS, Quantum GIS, uDig, OpenJUMP and gvSIG. Some of which are targeted to specific fields of application, such as the developments in C++ and Java that have a high degree of flexibility, as a result of standardized interfaces and the ability to be able to be launched within service oriented architectures.

The growing need for a more complete and diverse information seems to positively favour the Open Source software, table 1. On the other hand the need to become competitive before commercial software, led to the emergence of free software, Free Open Source Software.

Table 1. Advantages and disadvantages of Open Source GIS, [3].

Open Source SIG	
ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> • Free software • Open code • Easy Acquisition • No mandatory updates • Non restricted use • Contribution of the academic and business community 	<ul style="list-style-type: none"> • Graphical Component • Installation and configuration • Operability • Technical support • Learning support • Formation

5. Coordinate System QGIS, EPSG

The indication of the reference systems in QGIS, can be made by using the EPSG identifiers, defined by the "European Petroleum Search Group" (EPSG) and the National Geographic Institute of France (IGNF), largely referred to by used in Geospatial Data Abstraction Library (GDAL). The EPSG identifiers or codes are present in QGIS database and can be used to specify the reference system.

The website of DGT, http://mapas.igeo.pt/igp/epsg_codes.html, is a list of EPSG codes used in Portugal and its correspondence with national systems. Here are presented only the relative to Portugal Continental:

Portugal Continental - Global Systems:

- EPSG: 4936 (ETRS89 / geocentric coordinates)
- EPSG: 4937 (ETRS89 / 3D coordinates Geographic)
- EPSG: 4258 (ETRS89 / 2D coordinates Geographic)
- EPSG: 3763 (ETRS89 / PT-TM06)

Portugal Continental - Local Systems:

- EPSG: 4274 (Datum 73 / 2D coordinates Geographic)
- EPSG: 27493 (Datum 73 / Hayford-Gauss)
- EPSG: 4207 (Datum Lisbon / 2D coordinates Geographic)
- EPSG: 5018 (Datum Lisbon / Hayford-Gauss)
- EPSG: 20790 (Datum Lisbon / Hayford-Gauss with false origin - Military coordinates)

Regarding Global systems used by Google, Bing, OpenStreetMap and other platforms of this type, the most used are:

- EPSG: 4326 (Datum WGS84 / Geographic Coordinates)
- EPSG: 3857 (WGS84 Datum / Pseudo Mercator)

6. Quantum GIS-QGIS

Quantum GIS (QGIS) is an Open Source Geographic Information System. It is an official project of the Open Source Geospatial Foundation (OSGeo), licensed under the GNU General Public License (GPL). Currently runs on multiple operating systems, Linux, Unix, Windows, Mac OSX and Android. It is developed using the QT toolkit (<http://qt.nokia.com>) and C ++, which allows it to have a friendly graphical interface easy to use.

The initial goal of the creator of QGIS software, Gary Sherman, whose first version appeared in 2002, was to provide a GIS model to view data of various kinds but with space character. Currently it still is used by many just to visualize raster and vector data in various formats. There have been added new features through supplements. Currently QGIS offers many common features with other GIS programs.

It consists of a core part, containing a set of pre-installed internal modules, and a second part comprising external modules. External modules are present in the official repository PyQGIS and can be easily installed using the installer Python plugin [7].

7. Results and discussions

7.1. Case Study - Integrated Map

The integrated map contains a Geological map and a non-traditional cartography sources.

The Geological map used was the LNEG 203-sheet Guarda, in the scale of 1:25 000 which derives from the map 1:50 000, 1963. The map is referenced to the datum of the Lisbon IGeoE, Hayford-Gauss projection. The data for this map is in vector format, ShapeFile format. This format has the advantage that it is interpreted by most GIS, containing two major components: the graphic component, which contains the geometric definition, and the descriptive component, that characterizes through several attributes the graphic component. In the case study, the graphic component is constituted by polygons, being each one characterized by a code, (UC_cod), and the respective attributes associated to this code. The table is editable and can be complemented with field observations that lead to the refinement of the respective geometric shapes.

Next, to complete a base of viable geographic information, using non-traditional cartographic sources, giving preference to open platforms, QGIS was used as software and as cartographic sources, Google maps, Bing maps and OpenStreetMap.

Map data, was used in raster and vector models. Vector data came from the OpenStreetMap platform and the geological map. Raster data was originated from the Bing Maps platform.

For raster data it is necessary to have the plugin available - OpenLayers plugin. This module provides access to the platforms of Google Maps, Bing Maps, Apple Maps, among others.

The procedures were as follows:

- For raster data, by selecting the OpenLayers plugin module, it was selected the aerial image of Bing Maps, because it proved to be a better graphic quality.
- For vector data, it was imported the information provided by OpenStreetMap urban area under study, the city of Guarda. The file obtained comes in a "OSM" format [8]. This file contains various themes or layers (Figure 1), which can be filtered obtaining thereby the desired topics.

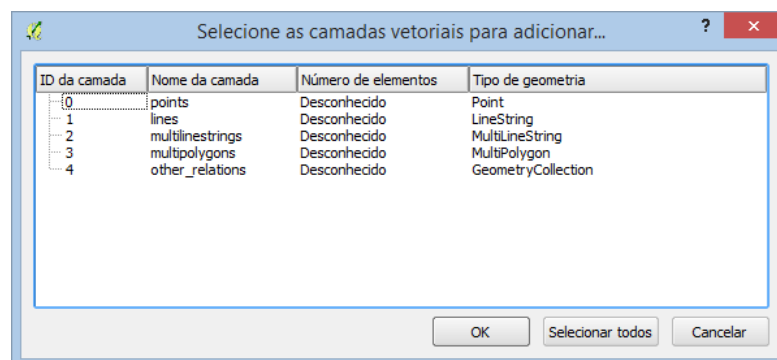


Figure 1 - Vector layers OSM file.

The themes are divided geometrically in points, lines and polygons. Each subject has an attribute table, from which one can refine the results. Taking the example of the subject lines, the associated table is shown in Figure 2.

	osm_id	name	highway	waterway	aerialway	barrier	man_made	other_tags
0	16114338	Acesso A25/A23	motorway_link	NULL	NULL	NULL	NULL	"lanes"=>"1", "on...
1	19804010	Acesso A 25	motorway_link	NULL	NULL	NULL	NULL	"lanes"=>"2", "on...
2	23211835	NULL	motorway_link	NULL	NULL	NULL	NULL	"oneway"=>"yes"
3	23230321	VICEG	trunk	NULL	NULL	NULL	NULL	"junction"=>"Tou...
4	23230749	NULL	primary	NULL	NULL	NULL	NULL	"oneway"=>"yes..."
5	23230751	Avenida do Rio Diz	secondary	NULL	NULL	NULL	NULL	"bicycle"=>"yes"...
6	23230935	Avenida Monsen...	primary	NULL	NULL	NULL	NULL	"oneway"=>"yes..."
7	23230937	Avenida Monsen...	primary	NULL	NULL	NULL	NULL	"oneway"=>"yes..."
8	23230939	Avenida Monsen...	primary	NULL	NULL	NULL	NULL	"oneway"=>"yes..."
9	23230940	Avenida Monsen...	primary	NULL	NULL	NULL	NULL	"oneway"=>"yes..."
10	23231006	Largo Frei Pedro	primary	NULL	NULL	NULL	NULL	"oneway"=>"ho"...
11	23479218	Rua Comandante...	residential	NULL	NULL	NULL	NULL	"oneway"=>"no"
12	23578024	NULL	primary	NULL	NULL	NULL	NULL	"maxspeed"=>"5..."
13	24368040	Acesso A 25	motorway_link	NULL	NULL	NULL	NULL	"oneway"=>"yes"
14	24404175	Acesso A25/A23	motorway_link	NULL	NULL	NULL	NULL	"lanes"=>"1", "la...

Figure 2 - Attribute table associated with the theme line

The streets and roads in general, are obtained from the theme lines. From the theme polygon it is obtained administrative areas, land use, etc...

The edge of the residential area of Guarda was extracted from the theme polygon, giving rise to the theme - GuardaAreaResidencial, keeping the subject lines unchanged. The selected topics should be stored in shape file format for better handling and consistency.

In Figure 3 this theme is superimposed on an aerial image, obtained from Bing.



Figure 3 - QGIS, OpenStreetMap- Overlay GuardaAreaResidencial with aerial image

Yet, in Figure 4, the Residential Area, obtained from the OpenStreetMap platform, was superimposed on the geological map in shapefile format and on the Bing Roads, thus taking advantage of the various layouts that different platforms offer.

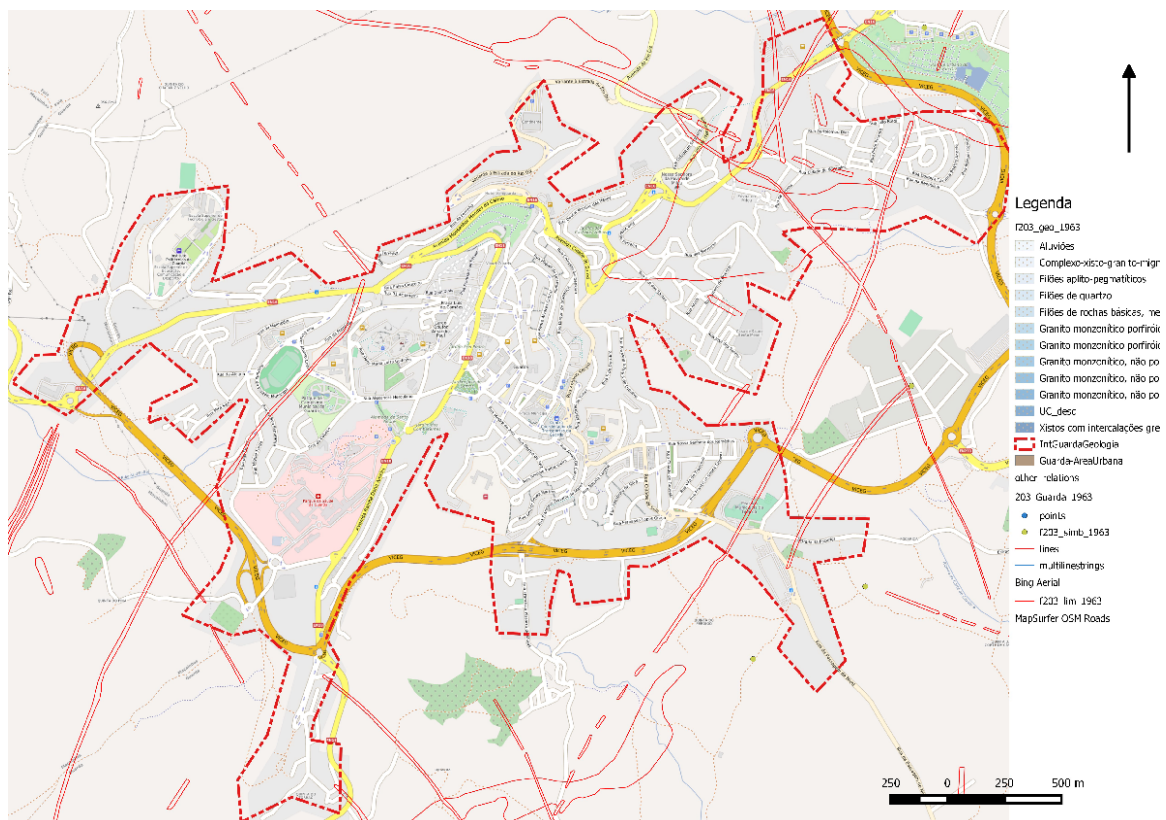


Figure 4 - QGIS, Overlay OpenStreetMap- GuardaAreaResidencial, Bing Roads and geological map

Finally, with this geographic information, we can develop a thematic map, for example, a map that identifies the areas of the degree of granite’s change and fracturing. For these we can use the platform of “StreetView”, in two ways: in google street view, figure 5 and 6, or integrated in QGIS, figure 7.



Figure 5 – Google Street View, building construction – Hospital of Guarda

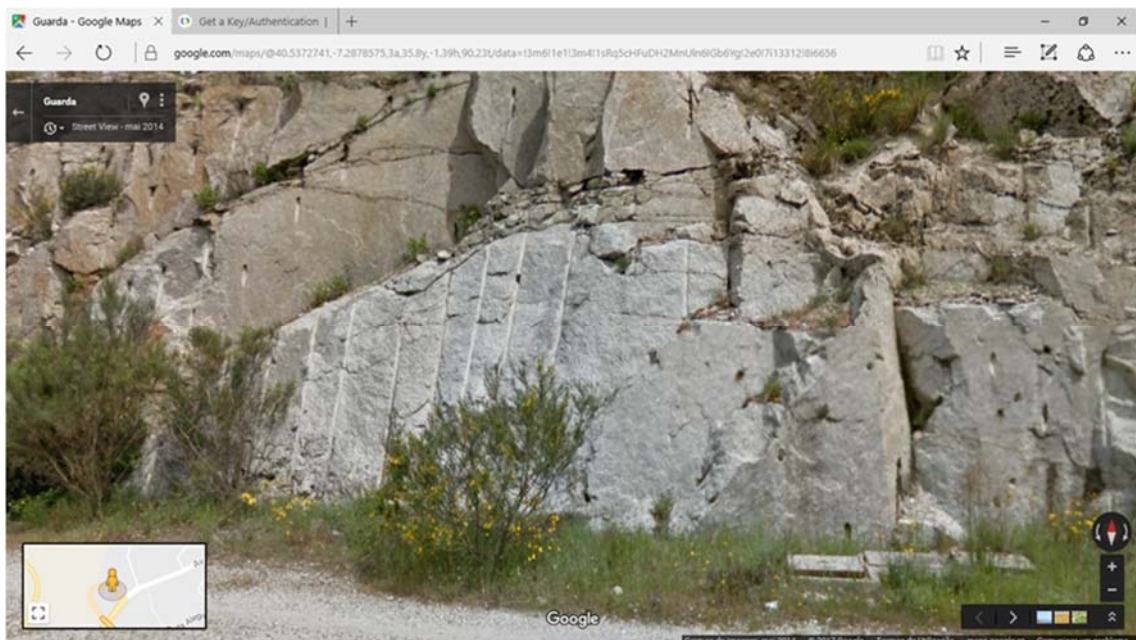


Figure 6 – Google Street View, granite (State of change of rocky massif w1 and w2)

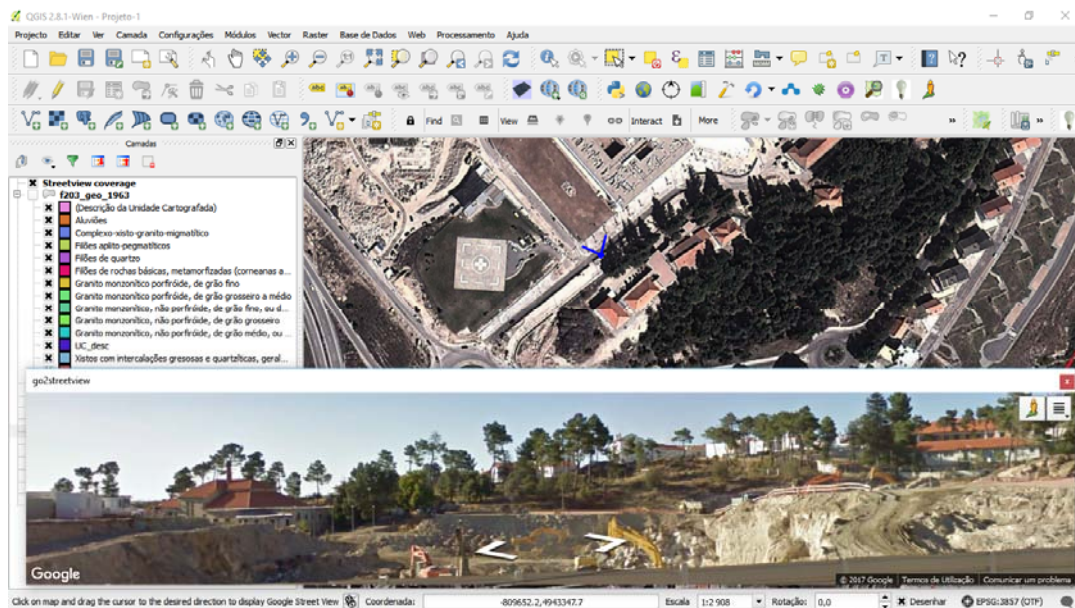


Figure 7 – QGIS with plugin “go2streetview”

To incorporate in QGIS, its required installing one of the plugins available for access the data from the platform “Google Street View”.

As can be seen, through the figures 5, 6 and 7, the "Street View" platform allows us to access images with great proximity and resolution in urban areas, in order to identify, in most cases, the degree of alteration of the rocky massifs.

Figures 5 and 7 show a peculiarity, the fact that the capture of the images occurred at the moment of excavation, allowing the visualization of the type of rock in the subsoil.

The model created had as a mapping input a geological map of the study area and existing free mapping in web data (Google, Bing, Igeo, OpenStreetMap, ...). As output, yielded some graphical output, demonstrating the possibility of overlay of several subjects, filtered from the web file.

The work thus allowed to generate a first set of maps in an interactive way, which will form the basis for the development of various thematic maps, risk maps, surface maps with geological information and diverse Geotechnical.

From this model new themes will be created, such as the delimitation of identifying areas of the degree of granite’s change and fracturing. For this case, data will be collected first in platform “Street View” and next it will be confirmed in the field, this will allow the upgrade of existing graphical data and also the corresponding alphanumeric database. In this way you can get a model with useful and current information for decision making in engineering work.

8. Conclusions

It was intended to highlight with this work that is possible to create a viable geographic information base for the preparation of geotechnical mapping, using cartographic sources from open platforms together with free software.

The use of this platform types decrease the collect data time and, sometimes, a careful observation of pictures that were taken during excavations may reveal important details for geological mapping in the study area.

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