A spatial data warehouse to predict megaliths slabs sources: mixing geochemistry, petrology, cartography and archaeology for spatial analysis

Armazém de dados espaciais para prever a proveniência de lajes de megalitos: misturando geoquímica, petrografia, cartografia e arqueologia em análise espacial

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Abstract

MEGAGEO - Moving megaliths in the Neolithic is a project that aims to find the provenience of slabs used in the construction of dolmens. A multidisciplinary approach has been carried out with researchers from the several fields of knowledge involved. In this work it is presented a spatial data warehouse specially developed for the project, which comprises information from national archaeological databases, geographic and geological information and new geochemical and petrographic data obtained during the project. Redondo area is used as a case study for the application of the spatial data warehouse to analyze relationships between geochemistry, geology and the dolmens of the region.

Keywords: Spatial data warehouse, Geochemistry, Geoarchaeology, GIS, natural resources

Resumo

O projeto MEGAGEO tem como objetivo estabelecer a proveniência das lajes utilizadas na construção de antas. Nesse sentido foi constituída uma equipa multidisciplinar, com investigadores das diferentes áreas de conhecimento envolvidas. Neste trabalho é apresentado o armazém de dados espaciais criado especialmente para este projeto, constituido por informação dos arquivos arqueológicos nacionais, cartografia geológica e geográfica a diferentes escalas, e os novos dados geoquímicos e petrográficos obtidos durante o projeto. Usando a área do Redondo como um caso de estudo, são apresentados aqui os resultados obtidos e a aplicação do armazém de dados espaciais para analisar as relações entre geoquímica, geologia e as antas daquela região.

Palavras-chave: Armazém de dados espaciais, Geoquímica, Geoarqueologia, SIG, recursos naturais

Introduction

Databases are used as a general tool for storing and processing data, independently of origin, type or content. More recently geographic information systems (GIS) have been introduced not only as a cartographic tool, but also as a way for analysing spatial data. The combination of these two disciplines is giving way to new insights in the analysis of geoscientific systems where spatial data warehouses can play an important role (Bedard & Han 2009; Stefanovic 1997; McHugh, 2008).

The problem of solving the linkage of the lithic constituents of dolmens to rock outcrops has not been enough addressed in the literature, therefore the project “MEGAGEO: Moving megaliths in the Neolithic" gathered a multidisciplinary team, including geologists and archaeologists with a new approach to address this issue.

Based on the national database of megalithic tombs, a set of three study areas was chosen. The aim was to conduct detailed studies trying to identify and characterize outcrops and quarries that might have been the source of slabs used to build the dolmens. These studies included detailed mapping, petrographic and geochemical analysis of samples from outcrops, quarries and dolmens.

A geographic information system (GIS) and a spatial data warehouse were designed to allow the visualization and analysis of all the spatial information gathered. In this work we present the first results of the application for this approach, giving special emphasis to the geochemical results obtained in one of the study areas, the Freixo-Redondo area (Figure 1).

The data sources

A data warehouse must be built from several sources and provide the most complete information about the process it aims to characterize.

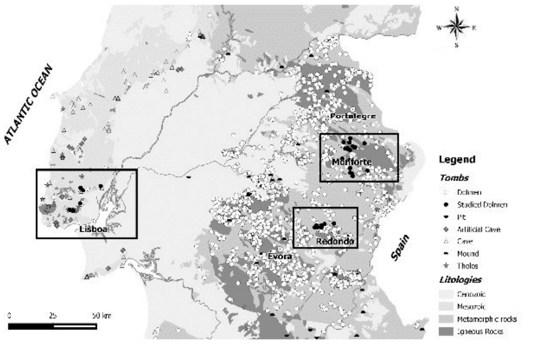

Figure 1. Location of the three MEGAGEO project case study areas.

Coexistence of spatial information (e.g. dolmen location or sample location) with non-spatial information (e.g. Sr content of a sample or geological description of an outcrop), implies that the various dimensions of a system can have a great complexity. Some of this information can be classified as geometric, some as non-geometric and the other as raster information, based on the Bedard & Han (2009) classification.

For this project a total of 22 databases were assembled to contribute to the final result. These databases include geographic information (roads, rivers, topography, localities, etc), geological information (geological mapping at different scales 50k, 500K and 1M, including cartographic formations and structures), archaeological information (location and types of tombs), and petrographic and geochemical data from samples collected in dolmens, outcrops and quarries specially selected for the purposes of the project.

The spatial data warehouse

A data warehouse is characterized by one or more star schemes (Kimball 2002; Caldeira 2012) that support the datamarts involved. For the project two datamarts were constructed in order to answer the questions that need to be addressed by the geologists or the archaeologist’s team. Examples of the questions that a geologist might want to be answered include: What are the samples that we have from outcrops? To what formations belong the samples that contain amphibole? What is the rare earth elements geochemistry of the samples that are in each geological formation? For the archaeologist's team the questions can be exemplified as: What type of tomb can I find in this region? What are the geological formations and the use of soils where the dolmens are placed? What is the silica content of the lithic fragments of the tombs of one region? What is the minimal distance between the probable source outcrops and the tombs?

Some of the dimensions created needed a thorough process of Extraction-Transformation and Loading (ETL) of information in order to allow teams to work with the most adequate information for their own purpose. An example of this is the transformation of chemical weight percentage of elements to a normalized description allowing archaeologists to understand the meaning of geochemical naming and data (e.g. peralkaline rocks named after the value of $(K_2O + Na_2O)/Al_2O_3 > 1$ or felsic rocks, intermediate and basic rocks named after SiO_2 content).

The outputs

Naturally one of the main advantages of having a GIS as a base for the analysis of data is the ability to produce maps combining the different information's that are being analyzed. In the Redondo-Freixo region a set of 32 dolmens are present of which 10 has been studied, and outcrop sourcing was conducted. Figure 2 presents the plot of the outcrops from Freixo region (Carvalhosa et al, 1986), with a 250m radius buffer. From the analysis of figure 2 it is possible to demonstrate that the studied outcrops can explain 7 out of 8 dolmens source of raw materials.

The geochemical characterization of the outcrops and dolmen samples can also be analyzed based on maps where the values of some elemental analysis are projected together with the analysis made in dolmen samples. In figure 3 a simple example of the analysis of igneous rock type (SiO_2 content) is presented for outcrops and dolmens.Two of four dolmens with geochemical analysis belong to the same silica group of nearby outcrops. Further analysis is being carried out to explain the results found. For this the data from petrography, and the chemical analysis of minor, trace elements and of dolmen samples and outcrops are being compared (Boaventura et al. 2015).

Conclusions

In a multidisciplinary project, such as this one, new frameworks have to be developed in order to find common tools for analyzing and interpreting data. The development of a large database including spatial and non-spatial information lead us to a development of a spatial data warehouse. This tool is being used has an aid to analyze the existing multidimensional information providing new insights in interpreting the geochemical and petrographic information related with the lithic source of raw materials from archaeological sites.

Acknowledgements

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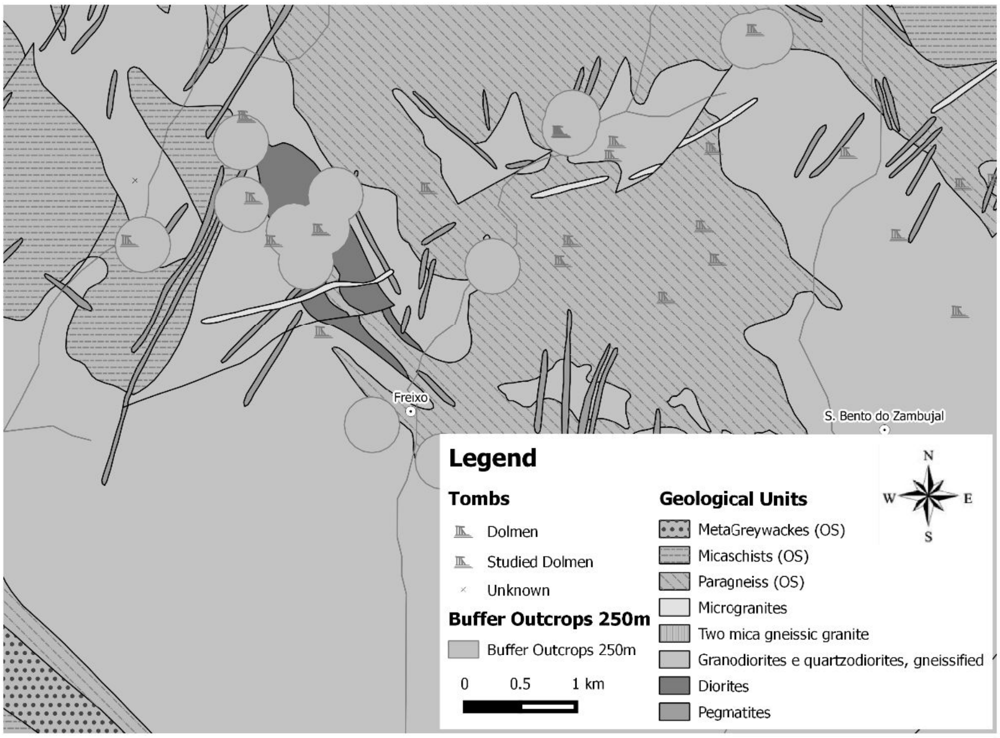

Figure 2. Location of selected outcrops with buffer and local dolmens in the Freixo Region.

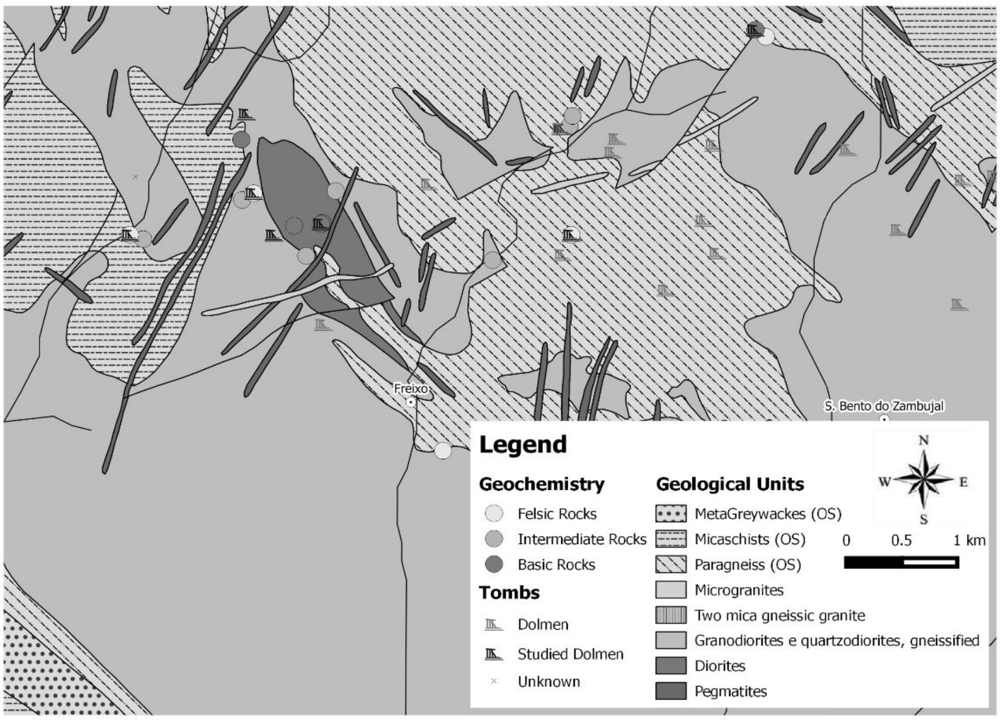

Figure 3. Spatial correspondence between silica rocks and dolmens composition in the Freixo Region.