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Definition of sectors vulnerable to contamination by shallow groundwaters at the region of Pedras Salgadas, Vila Pouca de Aguiar, north of Portugal

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INÍCIO

ABSTRACT: We used a combination of geomorphological, geological, hydrogeological and geophysical parameters to define sectors vulnerable to contamination by surface waters. Definition of these sectors is essential for the establishment of correct protection zones to mineral water sources and aquifers. The example presented in this paper is concerned with the protection of mineral waters in the region of Pedras Salgadas (North of Portugal).

1. INTRODUCTION

The region of Pedras Salgadas (Vila Pouca de Aguiar) is located in the North of Portugal, about 40km far from the Spanish border (Fig.1).

The Pedras Salgadas area is situated inside a large scale graben related to the major Hercynian fault Verin-Régua-Penacova (Claverol, 1987).

This graben follows the NNE-SSW direction and is crossed by graben-horst system with ENE-WSW direction (Fig.2) (Sousa Oliveira and Portugal Ferreira, 1996). Fractures with NW-SE to NNW-SSE and WNW-ESE are also important in the area.

The geology (Fig.3) is characterised by post-tectonic granites, (relative to the third phase of stress (F_3) of the Hercynian orogeny), which have been intruded in Silurian metamorphic formations of the Peritransmontano domain (Ribeiro, 1974). The central part is also characterised by sedimentary Cenozoic deposits (with thickness 4 to 5m) with arkoses, clays, river terraces, flood and coluvial deposits (Sousa Oliveira, 1995).

Drainage is controlled by the rio (river) Avelames which follows the directions of fractures in the region.

There are important mineral-water resources in the area, represented by 4 hydromineral poles, in Pedras Salgadas, Cardal, Romanas and Sabroso. These mineral waters have a CO_2-Na^+-HCO_3^- chemical facies characteristic of the Transmontana Hydromineral Province, Peritransmontano District (Portugal Ferreira et al.,1984). Some of these poles are currently being exploited (Pedras Salgadas).

The location of hydromineral poles is determined by geological structure of the area; these poles are situated in the areas of the longitudinal graben (NNW-SSE) where subsidence is significant and at the intersection of this graben with the transverse graben-horst system (the so-called "subsidence cells" of Sousa Oliveira and Portugal Ferreira, 1996); a relation seems to exist between the occurrence of hydromineral poles and cover deposits (Figs. 2 and 3).

Some localities are potential pollution sources because of their geographical position , practiced land use and limited sanitary conditions.

The protection of these mineral water resources against the contamination by surface waters is essential for its preservation.

Field studies are necessary to characterise the

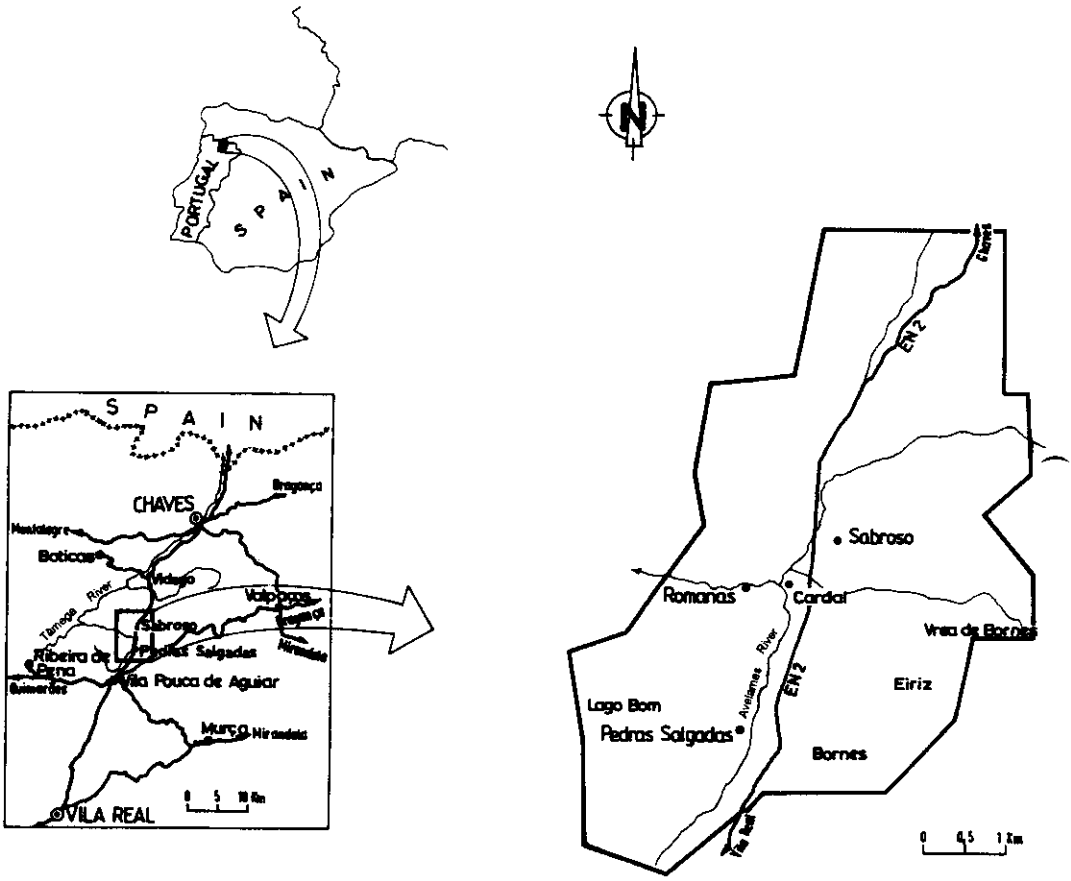

Figure 1 - Geographic setting of the Pedras Salgadas area.

lithologies, densely fractured areas, the direction of the main families of fractures, areas with important sedimentary cover, the most representative flow trajectories of shallow groundwaters, runoff, transmissivities (permeabilities) of cover deposits and of bedrock, hydraulic heads, etc.

By combining the results of all these studies, it would be possible to isolate vulnerable areas concerning surfacial contamination. In these critical areas (landfills, green houses, ETAR's or any other pollution sources) construction should never be allowed.

2. FIELD WORK / METHODOLOGIES

Geological mapping have been done at the 1:10.000 scale for characterisation of the different lithologies. From observation of these maps and aerial photographs (scales 1:50.000 and 1:25.000), the main families of fractures have been identified. The presence of these families, under the sedimentary cover (Cardal area), was confirmed by electromagnetic survey (VLF method, Geonics-EM16/EM16R equipment).

Several pumping tests were executed on

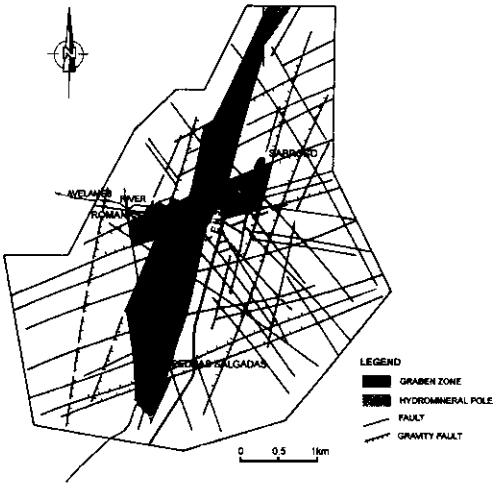

Figure 2 - Structural map of Pedras Salgadas area.

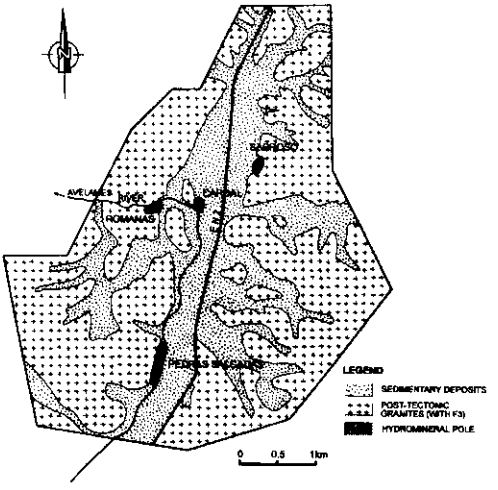

Figure 3 - Lithological map of Pedras Salgadas area.

boreholes at the Cardal region for transmissivity assessment (cover deposits and bedrock).

The geometry of the piezometric surface was determined from values of the hydraulic head at 246 sites, including springs, wells, galleries and so forth. Using piezometric contours we defined flow lines of shallow groundwaters.

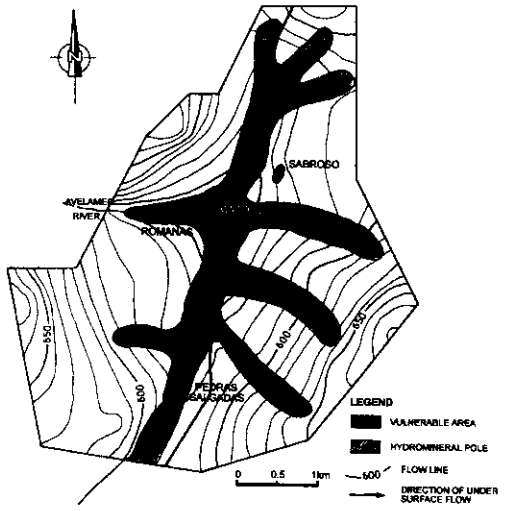

Figure 4 - Sectors vulnerable to contamination at the region of Pedras Salgadas.

3. RESULTS / FINAL REMARKS

In summary, we may considering the following:

- The flow of shallow groundwaters is determined by the direction of the fractures in area, namely the ENE-WSW and NW-SE; less important directions are the NNW-SSE and WNW-ESE. The major fault in the area (NNE-SSW direction), where the 4 poles of mineral water are located, acts as a collector of water from the other directions.

- The under surface flow is also conditioned by the geomorphology and cover deposits.

- Considering the geometry of flow lines, as well as the location of the Cenozoic deposits in the area and the direction of fracture systems (with transmissivities in order 10^{-2} to 10^{-3} m^2/s; Sousa Oliveira, 1995) and the position of mineral water poles, it was possible to isolate an area of high vulnerability to contamination (Fig.4), with Cardal located where all these parameters converge.

- In this area, potential contaminators should never be installed; far from this area, the location of such polluters should be carefully analysed, with a

complete characterisation of the area prior to installation.

- Some small villages are located at the vulnerable areas. Protection of water resources in these areas could start up with the improvement of sanitary conditions, the control of land use activities, etc, followed by the use of these areas in the establishment of protection zones to hydromineral poles, obligated by the Portuguese law.

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