

# VULNERABILITY OF THE KARST AQUIFERS: THE EXAMPLE OF THE MOUNT LA SPINA HYDROGEOLOGICAL SYSTEM IN BASILICATA (SOUTHERN ITALY)

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Basilicata is a small region of southern Italy, rich in good quality and as yet barely contaminated groundwater. On August of 1999 Ministry of Public Works, Basilicata and Puglia regions have signed an agreement program aims to regulate the water supply plan for water resources shared between these regions. This agreement represents the first and the only one reform for a common and sustainable use of water resources, in Italy (AdB, 2007).



Fig.1 – Interregional water supply system

Most drinking water comes from groundwater resources, that flows in the large and deep carbonate hydro-structures which form the main backbone of the Lucanian Apennines (Sdao, 2006).

One of the most important carbonate hydro-structure in this region is the Mounts di Lauria ridge, which extends along the boundary between Basilicata and Calabria. This hydro-structure is made-up by at least five huge aquifers which are characterised by peculiar hydrogeological and hydrodynamic features (Bianca et al., 2006; Manfreda et al., 2007) and supply the above mentioned interregional water supply system.

The central-eastern section of the northern area of Mounts of Lauria hydrogeological system is constituted by the carbonate hydro-structure of Mount La Spina (Fig.2). This hydro-structure extends in an ENE –ESE direction for a length of about 9 km and a maximum width of about 5 km.

The hydrogeological, geometric and hydrodynamic characteristics of the aquifer of Mount La Spina, the nature of groundwater circulation and the location of the main springs are strongly influenced by its geological –structural lay-out. From a geological point of view, the Mount La Spina aquifer is essentially made up of Mesozoic permeable dolomitic limestones and limestones belonging to the Pollino unit, which show different degrees of fissuring and, in places, karst features. This huge carbonate aquifer is delimited on all sides by almost exclusively tectonic contacts with less permeable geological formations and is widely crossed by faults with significant throw.

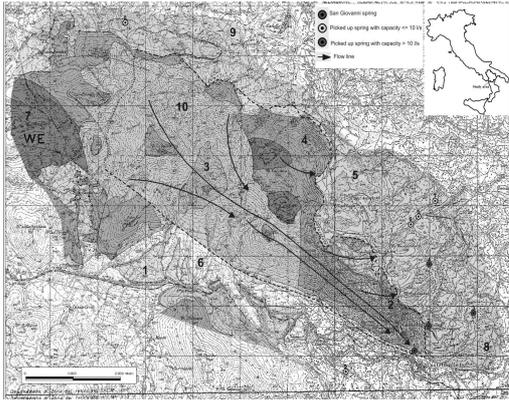


Fig. 2 – Hydrogeological map.

Detrital complex (1), Fissured calcareous subcomplex (2), Fissured calcareous dolomitic subcomplex (3), Highly fissured calcareous subcomplex (4), Conglomeratic Complex (5), Complex of fluvial lacustrine deposits (6), Fissured karstic calcareous subcomplex (7), Calcarenitic Complex (8), Clay-marl Complex (9), Highly fissured calcareous-dolomitic subcomplex (10)

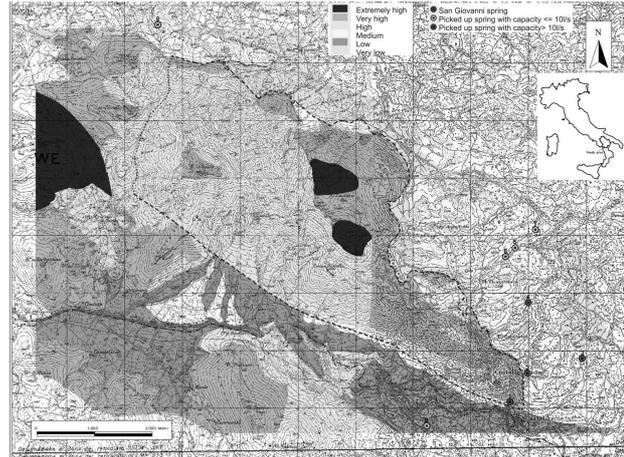


Fig.3 - Intrinsic vulnerability map of Mount La Spina hydrostructure

In particular, the investigated aquifer is delimited westwards by a NNW-SSE trending system of normal faults which shows an overall vertical throw of ca. 400 m, while along its southern edge the aquifer is delimited by the Castelluccio fault, a N120°-striking normal fault that puts into contact the high-permeability carbonate formations of the aquifer with the Quaternary low-permeability fluvial-lacustrine sandy-to-muddy deposits of the Mercure basin.

The conspicuous groundwater flows inside this aquifer with mean discharges of about 500 l/s and gush out from several scattered springs, most of which are not adequately exploited or even uncollected. One of the most important spring groups is located at San Giovanni and is made up of some springs which gush out along the tectonic contact with the Castelluccio fault, so representing a typical fault-spring case. The San Giovanni springs are located along a steep slope at an altitude of between 480 m e 504 m, and are at least 150 m in length with a width of 50 m. They are made up of at least 7 normal permanent springs together with many others of a temporary nature. The groundwater is mainly, if not efficiently, collected for drinking purposes and irrigation use. Therefore, knowledge of the vulnerability of the aquifer is very important in achieving sustainable management of this precious water resource (Bianca et al., 2006; Sdao, 2006; Manfreda et al., 2007). Indeed, the main goal of this study is to assess the intrinsic vulnerability to pollution of the Mount la Spina aquifer and the San Giovanni springs by an accurate hydrogeological mapping (Rapti Caputo & Sdao, 2004). The investigation has been based on detailed geological, geomorphological and hydrogeological surveys of both the whole aquifer and the spring area, integrated by a remote-sensing study and a large-scale geostructural analysis. In particular, the assessment of the intrinsic vulnerability to pollution has been carried out in three different study phases and on site investigations:

1. definition of a hydrogeological conceptual model on the basis of geological, morphological and hydro-geological studies, geo-structural relief, aerial photo analysis, elaboration of hydrologic data and discharge of main springs;
2. identification of parameters useful for the vulnerability assessment, choice and application of the methodological approach most suitable for individuated hydrogeological systems couplet with available parameters;
3. intrinsic vulnerability evaluation and drafting of thematic maps using GIS spatial analysis.

Based on the lithological and hydrological characteristics, and the extent of fracture and karst phenomena, in the examined area some complexes have been distinguished, the main of which are represented by: 1) the Calcareous Complex formed by the Mesozoic carbonate formations of the Mount La Spina aquifer, and 2) the Fluvial-lacustrine Complex made up of the low-permeability

deposits of the Mercure basin. The Calcareous Complex is subdivided in several sub-complexes, based on the different degrees of fissuring and/or karst phenomena.

The definition of the mode of groundwater circulation and the geochemical characteristics of the groundwater resource has been carried out by weekly piezometric samples obtained by piezometers at a depth of between 16 and 31 m below ground level and located upstream of the spring and a constant monitoring of both the water flow and the chemical physical parameters of groundwater.

Taking into account the complexity of the studied hydro-structure, the method GNDCI-CNR, based on territory zoning in terms of hydrogeologically homogenous areas adapted to the specific hydrogeological conditions of the carbonate Mount La Spina aquifer was chosen and applied to assess the intrinsic vulnerability to pollution of the aquifer (Rapti Caputo & Sdao, 2004).

The parameters used in the valuation of the intrinsic vulnerability to pollution of the aquifer, organized within their relative thematic maps are: a) the lithological composition and level of fissuring of the hydrogeological complexes, b) the occurrence and the intensity of the karst phenomena, c) the hydrogeological and hydro-dynamic characteristics of the aquifer and the spring area, d) the permeability of the dolomitic limestone masses and the velocity of the presumed discharge of the groundwater, e) the depth of the piezometric surface of the ground level, and f) the presence of springs. The analysis and interpretation of data relative to the parameters mentioned above, the spatial superimposition carried out using GIS instruments, integrated with the work protocol proposed by the method GNDCI-CNR and adapted to the investigated area, have been used to identify and map the following different degrees of intrinsic vulnerability, ranging from *very low* to *extremely high*, of the carbonate hydro-structure of Mount La Spina:

1. *extremely high*: for areas with highly fissured karst limestone with evident surface karst forms and presence of highly fissured limestone;
2. *very high*: for areas with scarce surface cover and with highly fissured limestone and highly fissured dolomitic limestones;
3. *high*: for fissured limestones and dolomitic limestones;
4. *medium*: for areas characterised by calcarenitic and conglomeratic formations;
5. *low*: for areas with successions of fluvial-lacustrine deposits;
6. *very low*: attributed to clayey formations.

This study allows us to argue that the hydrogeological and hydrodynamic characteristics, the nature of groundwater circulation and the intrinsic characteristics of vulnerability of the Mount La Spina carbonate aquifer are strongly influenced by the geological and structural framework of the area.

The final result of this research is the chart of intrinsic vulnerability to pollution of the aquifer (fig. 3), which represents an important operative cartographic document in the development of a correct policy of territorial and environmental planning and an efficient safeguarding of groundwater resources. The map of the intrinsic vulnerability highlights that the Mount La Spina aquifer is particularly vulnerable to pollution, its level of vulnerability varying from high to very high (Fig. 3). Moreover, the principal alimentation areas of the groundwater are characterised by high and very high levels of vulnerability, while the San Giovanni spring group is located in an area of elevated intrinsic vulnerability. The high vulnerability to pollution is confirmed by the periodic contamination of the groundwater by coli form bacteria that causes the strong degradation of the water quality.

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