

GEOPHYSICAL AND GEOCHEMICAL STUDIES ON THE SAN NAZARIO SPRING (PUGLIA REGION, SOUTHERN ITALY)

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The north-western part of the Gargano promontory (Puglia region, southern Italy) is characterized by the presence of a great variety of tectonic, morphological and hydrogeological elements. The main geologic outcropping unit consists of carbonate rocks, sometimes buried beneath sedimentary deposits in coastal areas. The carbonate basement permeability varies from moderate to high due to tectonic fracturing and karst processes. Particular interest deserve the coastal springs, characterized by considerable average flow rates and sometimes by significantly high temperatures (Cotecchia e Magri, 1966).

San Nazario spring is located at about 2 km from the southeastern shore of the Lesina lake, and it is one of the most important geosites of the region since water flows up at a temperature of about 27°C. The same hydrogeological unit hosts cold springs and data collected from deep wells show a great temperature variability. Indeed, water temperature values increase in wells located to the west of San Nazario spring, reaching values up to 55.6 °C near the Fortore River at a depth of about 550 meters (Maggiore e Pagliarulo, 2004).

Here we present preliminary results from geophysical and geochemical investigations aimed to study the hydro-geophysical proprieties of the subsoil and the origin of the thermal anomaly of the San Nazario spring.

Electrical resistivity tomography (ERT) and self-potential measurements were carried out along the NO-SE and SE-NO directions. ERT data were acquired using a multi-electrode system and electrodes were deployed at 5 m spacing. The acquisitions were always performed with both the dipole-dipole and Wenner–Schlumberger arrays. For the dipole-dipole array reciprocal measurements were also recorded. In addition, self-potential measurements were made in correspondence of the ERT electrodes position. Hydrogeochemical investigation involved the sampling and the chemical and isotopic analysis of 8 springs located in the area under study.

All the 2D resistivity models show the shallow portion of the subsoil characterized by medium-low resistivity values (3-50 $\Omega\cdot\text{m}$) confined at the base by more resistive material (up to 800 $\Omega\cdot\text{m}$). The shallow portion is interpreted as composed by sediments having different grain size and water saturation degree. Strong west-dipping resistivity gradients mark the transition to the resistive materials, associated to the carbonate basement. The same transition has, in contrast, a gentle dip southwards. Thus, the resulting resistivity imaging indicates that the top of the carbonate basement is located at significantly different depths along the two investigated directions, forming a structural high northward and eastward. Within this unit, a subvertical low-resistivity discontinuity, below the projected position of the spring is associable to a water bearing fractured zone. As for the self-potential data, assuming that the electrokinetic effect provides the major contribution to the signal, we applied the water table model (Fournier 1989; Revil *et al.*, 2003) to make inferences on the ground water flow. The most striking result is the detection of a dipolar self-potential anomaly in correspondence of the above mentioned subvertical low-resistivity discontinuity. This finding suggests the presence of convective flow.

Geochemical results indicate that the San Nazario spring is mainly fed by meteoric waters, infiltrating in the Gargano permeable structures with a minor contribution from sea water. Chemical and isotopic compositions of the San Nazario spring are similar to the ones calculated for the other sampled springs, indicating similar recharge processes. This finding has allowed us to quantify the thermal anomaly of the San Nazario spring, which was calculated by assuming the temperature of the adjacent springs as the background temperature. The calculation led to

a high anomalous thermal release, estimate of the order of 10 MW. Conversely, the anomalous temperature of the San Nazario spring is accompanied by an increase in helium and carbon dioxide contents, suggesting the possible input of hot deep gases as the cause of its high temperature.

To better image the structures governing the fluid circulation and to understand the origin of the Gargano's thermal waters, further geophysical and geochemical investigations are ongoing.

References

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