Geophysical and hydrogeological characterization of Sirino Lake (Basilicata, Italy)

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The Sirino Lake, almost elliptical in shape, extends for about 3 hectares with a 300 m length and a 150 m width; the depth varies according to the season but it doesn’t exceed 6 meters depth.

The Sirino Lake is placed on the SE side of the Mount Sirino tectonic window. The area is characterized by:

- a calcareous-siliceous marly succession attributable to Lagonegro I Unit (Calcari con Selce, Scisti Silicei, Galestri);
- massive glacial debris accumulations, refer to the last Wurm glacial phase,
- slope and/or landslide debris,
- silty-clay sediments (waterproofing the bottom of the lake).

Concerning the genesis of Lake Sirino, it is linked to the evolution of a large landslide that involved siliceous shale and marl present upstream of the lake (Boenzi & Cherubini, 1993; Guerricchio & Melidoro, 1981, Grassi et al., 2001).
Why is Sirino Lake so interesting?

Naturalistic valence
(Pollino national park)

Hydraulic instability

1994

High hydrogeological risk

High seismic risk

GEOPHYSICAL AND HYDROGEOLOGICAL CHARACTERIZATION OF SIRINO LAKE (BASILICATA, ITALY)
In the last century, the Sirino lake was affected by many pipings, as a result of sudden openings of sinkholes, which resulted in the almost total lake depletion.

Following sinkholes opening, the “Sotto il Lago II” water source can increase the water flux up to 300 l/sec.

The hydraulic instability combined with the geomorphological and seismic risks recognize the entire area as exposed to potential flood and landslide due to new episodes of siphoning.
To estimate the thickness of the impermeable layer under the lake;
to identify the presence of eventually seepage phenomena under the lake or possible water escape routes through the lake shores;
to provide information about subsurface water circulation.

Integrated geophysical surveys:
- an electrical resistivity tomography (ERT), at 10 m spacing, both on land and water-covered area,
- a self-potential (SP) survey around the lake shores and the surrounding area
- a Ground Penetrating Radar (GPR) survey along lake shores where the piping phenomena occur.
ER profile between downstream and upstream lake shores
- 210 m of electric cable placed into the lake
- the cable floating on the water by means of a series of PVC bottles was used
- Syscal junior 48 channels
- Wenner, Wenner-Schlumberger and Dipole-Dipole arrays
- electrodes spacing: 10 meters
- water electrical conductivity and temperature were measured along ERT profile
Apparent electrical resistivity data inverted by means res2Dinv (Loke and Barker, 1996).

- water electrical resistivity (50 Ωm) and bathymetry constrains
- distorted finite element grid: the upper part of the mesh was used to model the water layer.

Geophysical survey: Electrical resistivity tomographies (ERT) on water
Geophysical survey: GPR on lake shores

- GSSI SIR-2000 Instruments
- 40 MHz antenna and 400 MHz antenna for investigating lake shores and finding possible areas affected by sinkhole phenomena
- Radargrams processed with Reflex-w software

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The **400 MHz** radargram shows:
- two **horizontal reflectors** located respectively at an estimated depth of 0.8 and 1.6 meter
- two **sub-surface anomalies**, at a distance of 27 and 35 meter, where sinkholes are present (red circle)
- a zone with a similar e-m behaviour located at 50 meter from the origin (green circle)
- a zone, between 100 and 125 meter, characterized by **strong and chaotic reflections** (red line), probably due to the presence of filling material.

The **40 MHz** acquisition (blue line composed by F12-F13-F14-F15 segments) shows:
- at least **three main sub-horizontal continuous reflector** due to presence of interfaces with different lithological composition.
- a **hyperbolic anomaly** is located between 90 and 110 meter of the radargram (yellow line)
Two non-polarizable electrodes, a multimeter, an electric cable, bentonite mud for electrical potential (mV) and resistance (Ω) measurements in leap frog configuration. Electrodes spacing of 25 m, 226 measurement points. Topographic effect correction. SP map obtained by data interpolation with Surfer 8 software.

- Negative values down to -350 mV and positive ones up to 200 mV.
- The SP negative values identify the areas characterized by a downward water flow.
- SP positive values represent water accumulation zones.
Conclusions

- The comparison among geophysical data, lithostratigraphy obtained geognostic drilling, and gamma-ray log allows us to reconstruct the geological and hydrogeological setting underneath the Sirino Lake, on its shores and the surrounding area;

- ERT underlines the presence of permeable soil layers under the lake with a maximum thickness of about 30 m;

- moreover ERT shows the presence of a more permeable body on the southern shore of the lake (where the water body spill occurs) that may be represent the hydraulic connection with the “Sotto il Lago II” source;

- form GPR data it results that debris deposits show some discontinuity zones that may represent possible water route escape allowing the lake depletion;

- SP data indicate that the principal water flow pathways are from Flinty Limestone (Calcari con Selce) massif of Mt. Sirino towards the Sirino Lake and from the lake towards beneath areas;

- finally, to clear understand the phenomenon that affected the lake it is necessary to collect piezometric data and more data on the southern shore.
GRAZIE

PER L'ATTENZIONE!