

## Evolution of Seawater Intrusion in Coastal Aquifers of Pontina Plain (Italy)

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### ABSTRACT

In the last ten years it has been carried on a research project on the evolution of seawater intrusion in coastal aquifers of Pontina Plain (Italy). As a matter of fact groundwater in the coastal plain between Sabaudia and Terracina, south of Latina, Latium shows a number of problems, including salinization deriving from sea water intrusion or from different processes and from the superimposition of themselves. The test site is an area of about 80 km<sup>2</sup>, most part of which coastal and wetland since the beginning of the previous century. In the last fifty years, when the wetland became a plain, they have been stood up in it many different human activities like industrial firms, and agricultural plantations, which represent the most part of fruits and vegetables feeding people of Centre Italy. The effects of groundwater overexploitation on seawater intrusion and on groundwater resource availability start nowadays to be sensitive. In this paper are presented and discussed the results of the study, which involved the analysis of 4891 stratigraphical reports, 91 VES (Vertical Electrical Soundings) utilizing the Schlumberger electrode array, driven in 2004, starting from the results of two previous geophysical investigation campaigns achieved in 1952 first, and in later sixties later, 45 logs meter by meter (CTD data, TDS and PH measurements), 58 groundwater level measurements, driven in 2004, 15 isotopic analysis on ground water samples. As it could be well understood it has been adopted a multisystem approach based on the integrated application of different investigation methods to set up the actual framework of seawater intrusion and the evolution it has had in the last fifty years.

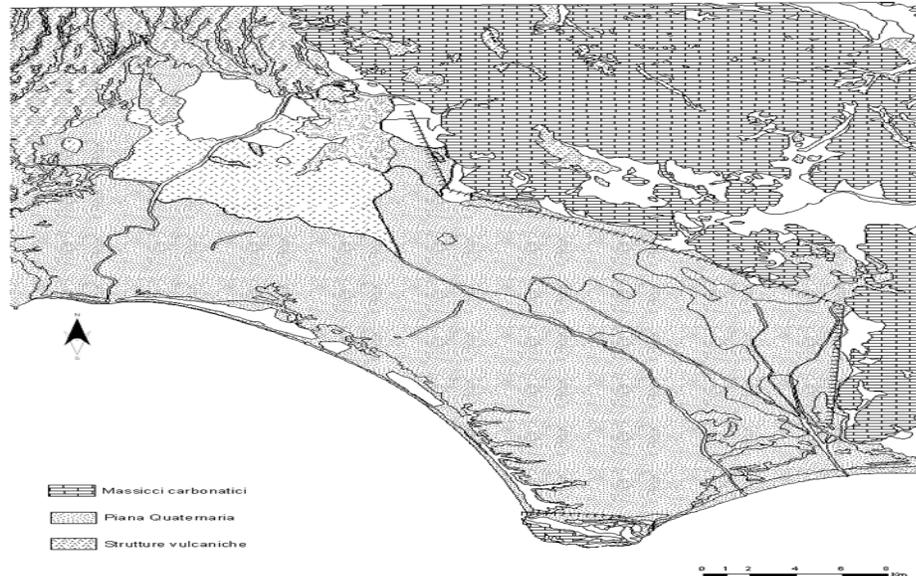
### INTRODUCTION

Groundwaters in the coastal plain between Sabaudia and Terracina, at the south of Latina, in the Latium region (Italy) show a number of problems, including salinization deriving from sea water intrusion, and from different processes. The test site is an area of about 80 km<sup>2</sup>, most part of which coastal and wetland since the beginning of the previous century. In the last fifty years, when the wetland became a plain, they have been stood up in it many different human activities like industrial firms, and agricultural plantations, which represent the most part of fruits and vegetables feeding people of Centre Italy. The total territorial crop's water requirement is about 20\*10<sup>6</sup> m<sup>3</sup>/a, mostly satisfied by groundwater withdrawals; but the area is nowadays crossed by two main nets of irrigation canals, because complementary irrigation is an highly efficient resource to increase such yields. In this umid region, the periodic occurrence of droughts of different intensity is one of the most important factors in the variability of crop yield.

The uncontrollable withdrawal and the release of contaminants is slowly but continuously leading to the deterioration of the resource. A particular question of the Pontina plain which worry, because of its incidence on the resource, is a remarkable expansion of kiwi and mais growing in the last ten years. Thanks to a favourable clima and the water availability for the irrigation, they constitute a good profit, but on the other side, they increase much the total water abstraction per year and the effect of enriching soils of nitrates coming from crops fertilization.

## GEOLOGICAL AND HYDROGEOLOGICAL FRAMEWORK

Geologically the area is included in an ancient tectonic hollow, over 800 meters deep, and covered by recent Quaternary deposits, made of sands, silts and clays. More ancient outcroppings are located along the south west coast and are represented by organogeneous limestones or Pliocene and Pleistocene clay. (Figure 1)



**Figure 1. The geological sketch**

Stratigraphic data collected by the interpretation of deep borehole and geophysical investigation show that above the Mesozoic–Cenozoic limestone deposit, characterized by normal faults sets, the following sequence is found (Accordi, 1967):

- Upper Pliocene clay passing to calcarenite in the sectors closer the Lepini ridge.
- Lower Pleistocene clay - Middle Pleistocene littoral deposits passing to saltier transitional deposits. These sediments contain large amounts of reworked pyroclastic deposits.
- Marine and transitional clays, sands and gravels deposited during the Upper Pleistocene. Northward of the Plain, volcanic activity of the Colli Albani complex was initiated.
- Large amounts of peat deposited in the continental fluvio-lacustrine basins during the Holocene.

The Pontina Plain sedimentary succession first developed from a marine depositional system to a transitional fluvial–coastal system, and then to a fluvial–continental depositional system (all of this within the Pliocene–Pleistocene). Therefore, the entire system is characterized by both vertical and lateral variability that is strongly reflected in its hydrodynamic trend.

Four different aquifers have been distinguished in. As a matter of fact there are two shallow aquifers made by sands the first, and by eluvial deposits the latter, which are separated by the deeper carbonatic one by a clay layer. The Sisto stream represents a drainage axis for these two Quaternary formation aquifers. The first, the dune aquifer (at the western zone of Sisto), in fact, floats on the sea and it is drained by the lakes, the sea and partially by Sisto stream, that delimits

the Pontina depression at south - west. The second one, corresponding to the inner band of the coast (to the eastern bank of Sisto), is constituted by fluvial marsh outcrops, and is characterized by a lower permeability ( $10^{-6}$  m/s). The composition of these strata is really variable, and as a consequence of it, the different hydraulic conductivity of them makes the aquifer a multistrata one. Nevertheless the groundwater circulation can be considered unique, thanks to water exchange among the different strata, the thickness of which is not defined, because of its geological complexity which makes it very variable from point to point inside the area.

The fourth and minor aquifer is a suspended one, and it is localized between the sea and the litoral sandbank (dunal cordon), characterized by low storage coefficient. (Conforto B., Di Ricco G., Sappa M., 1962)

### EXPLORATION APPROACH AND METHODS

The aim of the present work is the recognition, dating and genesis of groundwaters salinization. Its reliability results by testing the feasibility of different investigation methods to map spatial variation of it, in the last thirty years, and by comparing the results obtained by the interpretation of each detecting method afterwards described:

- ❖ Analysis of 4891 stratigraphical report on the local scale of the test site
- ❖ 91 Vertical Electrical Soundings  
Starting from the results of two previous geoelectrical investigation campaigns, a new SEV campaign has been important to locate the evolution of saltwater intrusion and a probable trend of it.
- ❖ 46 Temperature and conductivity logs  
The temperatures and conductivity profiles, building their trend along vertical and horizontal sections, have been very useful in the recognition of flow systems, preferential groundwater pathways and salinisation origin
- ❖ 15 Chemical and isotopic analyses on D and  $^{18}\text{O}$  composition of groundwater

### RESULTS

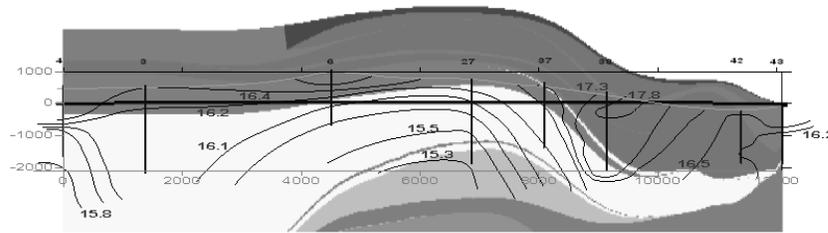
In the following figure 3 it is shown an example of overlaying the VES results on the geological section build up by the analysis of stratigraphical reports. On the other hand in the following figures 4 and 5 they are presented the results of different geoelectrical investigation campaign and the difference in electrical resistivity distribution between nowadays investigation and one carried on in 1967.

The other investigations carried on in this project was aimed to verify the results of geoelectrical investigation, and to be sure that electrical resistivity decrease is due actually to seawater intrusion.

### DISCUSSION AND CONCLUSIONS

As it can be well point out there are areas where electrical resistivity has decreased of more than 80% as in the shallower layer investigated as in the deeper one.

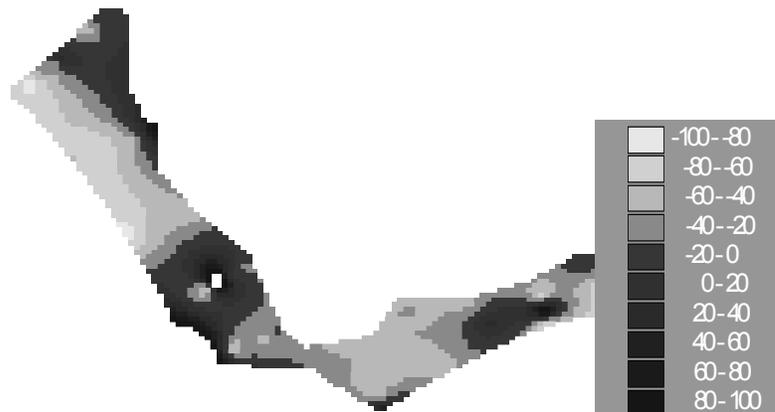
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**Figure 3 – Overlaying of geological section and geoelectrical interpretation**



**Figure 4 – Difference in percentage of electrical resistivity distribution between 2003 and 1967 investigation campaigns with Schlumberger array AB = 60 m**



**Figure 5 – Difference in percentage electrical resistivity distribution between 2003 and 1967 investigation campaigns with Schlumberger array AB = 1000 m**

#### **REFERENCES**

- Accordi B. (1966) - La componente traslativa ne/la tettonica dell' Appennino laziale - abruzzese. *Geologica Rom.*, v. 5, 355-406.
- Conforto B., Di Ricco G., Sappa M. (1962) – Indagine sulle acque sotterranee dell' Agro Romano e Pontino – parte seconda: Agro Pontino

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