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Extended Abstracts

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title: **The aquifer succession in the northwestern sector of the Calabrian Crystalline Basement (Southern Italy)**

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INTRODUCTION

The aim of this work is to reconstruct the aquifer succession in crystalline basement and in northwestern post-orogenic sedimentary sequences of *Calabria* (southeastern *Sila* and *Crati* river Basin). A hydrogeological study allowed the identification of the different aquifers existing in the area and the definition of their geometric characteristics and of the relationship between surface water and groundwater.

We have collected the hydrogeological and stratigraphical information recorded in the Italian Law N.464/84 Well National Database, available at the Geological Survey of Italy (Land Resources and Soil Protection Dept. of ISPRA). The data (e.g.: location, maximum depth of survey, aquifer succession, well mouth elevation) relative to hundreds of wells executed in *Cosenza* province, have been organized in a specific electronic format, geo-referenced and reported on topographical and geological maps at different scale.

GEOLOGICAL-STRUCTURAL SETTING

In the study area, transgressive Tertiary and Quaternary sediments (Miocene-Present) overlying Pre-Tortonian units of Calabrian-Peloritan Arc, extensively outcrop.

Calabrian-Peloritan Arc is considered a fragment of the Cretaceous-Paleogenic alpine belt, with European vergence, overthrusted, in the Lower Miocene, on the inner units of the forthcoming Neogenic Apennine belt, with African(*Adria*)vergence (Amodio et al., 1976).

Crati River Valley is an asymmetric half-graben, originated during Pleistocene extensional tectonic activity, with a N-S trend in the southern part and SW-NE trend in the northern part (Lanzafame & Tortorici, 1981; Ghisetti & Vezzani, 1983; Tortorici et al., 1995).

The geological succession of the study area can be summarized (Tansi et al., 2005), from bottom to top (Figure 1), as follows:

- Acid intrusive complex (Paleozoic): they are composed of quartzdiorite, quartzmonzonite, granite and granodiorite rocks. Often, granitic outcrops are intruded into metamorphic rocks.
- Biotite and garnet-biotite gneisses and schists (Paleozoic): gneisses and biotitic schists, frequently with garnet, are the prevalent lithotypes. Granitic and pegmatitic veins and masses are also included within metamorphic rocks.
- Calabrian marine deposits (Tortonian to Calabrian): they consist of sands and sandstones, sands and clays, and sands and conglomerates with gravel intercalations. In the upper part of the Miocenic series, a thin limestone, rich in algae, occurs. The deposition of these sediments was almost undisturbed by tectonic movements, with the only exception during the regional uplift phase. Often, they lean directly on metamorphic rocks.
- Post-Calabrian deposits: they are composed of conglomerates, pebbly sands and sands, deposited on surfaces which eroded older formations representing remnants of ancient marine terraces. Finally, from Holocene, alluvial sediments have filled up the Crati depression. Sometimes colluvial and eluvial deposits occur.

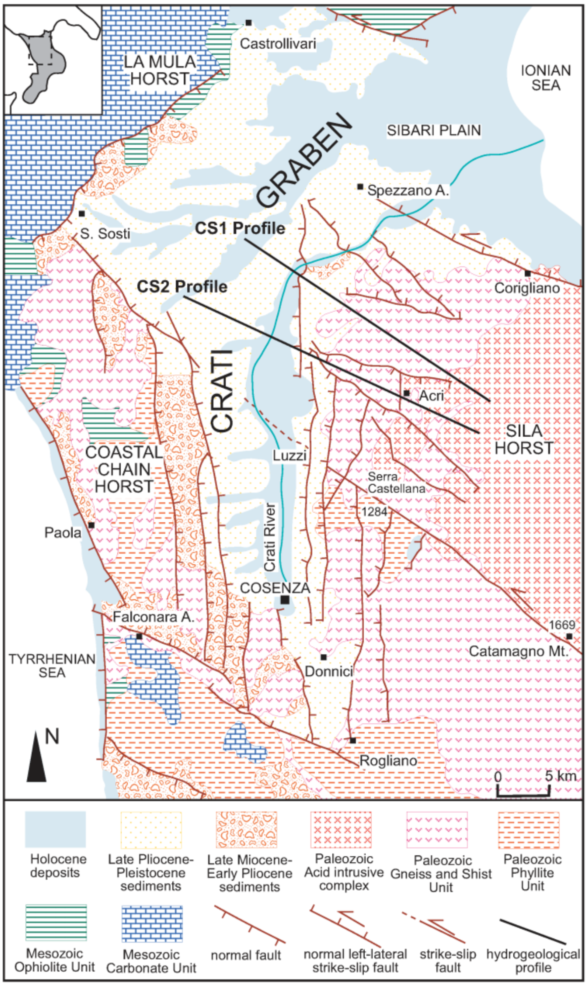

Figure 1. Lithostratigraphic and neotectonic sketch map of northern Calabria (modified after Tansi et al., 2005). The NW-SE trending black lines represent the traces of the provided hydrogeological profiles (CS1 and CS2).

The base of the post-orogenic succession is transgressive (Tortonian) on units of Calabrian-Peloritan Arc. Calabrian sedimentation is related to a subsidence phase of the Crati basin, which began in late Pleistocene and led to the ingression of the Pliocenic Sea on the present Crati valley. The Calabrian cycle ends with a regressive phase, coincident with a general uplift of Calabria region, leading to the emergence of the Crati basin and to the formation of large marine terraces.

HYDROGEOLOGICAL SETTING

This work represents a contribution to the reconstruction of the hydrogeological features of the study area. In this area, in fact, there is not an exhaustive groundwater flow characterization and the hydrodynamic properties of the aquifer are not well defined.

The study area falls into a Mediterranean climate zone (warm and dry summers; cold and rainy winters). Data coming from the thermo-pluviometric station at *Torano Scalo* show that mean annual temperatures (1960–1990 period) average 15.9°C, with the maximum value in July (25.3°C) and the minimum in January (8.6°C). Precipitations (1921-1990 period) are mainly (60%) concentrated from November through February; mean total annual precipitation is 838 mm, with the maximum monthly cumulative value in December (126 mm) and minimum in July (9 mm).

In the final part of Crati valley, once marshy and malarial, there is an artificial reservoir, obtained through the damming of the Crati River (ARSSA, 1996). Crati River, with its tributaries, is the most important river system of the area and flows initially in the northward direction, then in northeastward direction and finally flows into Ionian Sea.

Analysis of piezometric surface carried out in the study area (Celico et al., 2005) allowed to recognize, at large scale in high and middle Crati valley, the presence of a preferential groundwater drainage axis matching the paleo-bed of the Crati River (*Cassa per il Mezzogiorno*, 1977). In the inner part of Crati River Valley (Sibari Plain), the trend of isopiezometric lines and the flow directions allows to evidence the presence of substantial water contributions from carbonate reliefs, in north-western sector, through the Castrovillari Plain; while, in the hydrographical right, a preferential drainage axis directed towards the coast is evident.

On the basis of sedimentological and permeability features (Celico et al., 2005), we can recognize the following hydrological complexes:

- Igneous complex: it consists of Palaeozoic acid intrusive rocks, as granites. Aquifers are often discontinuous. The dimensions and the hydraulic potential of these groundwater bodies vary with the presence of open fractures; generally, permeability decreases with depth, both for the reduction of rock weathering blanket and for the closure of fractures, due to the increase of lithostatic load and/or filling. Permeability degree: medium-low.
- Metamorphic complex: it consists of rocks with different metamorphic grade, such as gneisses and schists. Hydrogeological characteristics are similar to those of the previous complex, even if in this case the weathering blanket is not present. Permeability degree: medium-low.
- Plio-Quaternary marine deposits:
  - Conglomeratic-sandy complex: it consists of clastic deposits, incoherent or poorly cemented and regressive (Lower Pleistocene). They have a good transmissivity, but, due to the fragmentation of groundwater flow, they have a less hydrogeological potentiality. Permeability degree: medium-low.
  - Clayey complex: it consists of transgressive marine deposits (Upper Pliocene-Lower Pleistocene). They represent a permeability boundary for the sandy-conglomeratic complex, which they are underlain to. Permeability degree: impermeable.
- Quaternary complex: it consists of clastic deposits, generally incoherent, with variable granulometry, predominantly sandy. The occurring aquifers are porous, heterogeneous and anisotropic; they host groundwater bodies, locally hydraulically independent but glob-

ally with unitary flow, which can have interactions with surface water bodies and/or be fed by neighbouring hydrogeological structures. Permeability degree: medium-high.

These complexes, then, show variable degree of permeability also within the same formation, depending on several factors including: fracturing degree, for rocks whose permeability has a secondary origin; structure, texture and mineralogical composition of grains, etc., for rocks having a primary permeability. Groundwater flow is very articulated, depending from the extreme heterogeneity of these deposits. Locally, groundwater circulation occurs in multilayer systems.

AQUIFER SUCCESSION

To define the hydrogeological features of the study area, two hydrogeological profiles, with NW-SE trend (Figure 1) were constructed using GIS software. To perform the stratigraphic profiles, we have conducted, at first, a bibliographic study with the aim to acquire an exhaustive picture about the depositional sequences of the investigated area (Cortese, Viola, 1900; Lanzafame et al. 1975; Cassa per il Mezzogiorno, 1967-1972). These data were properly integrated with the stratigraphic information of wells. Aquifer features derives from different sources; isopotential levels, position and number of aquifers have been taken from the Well National Database, while punctual and linear sources represented on the sections, have been taken from geological and topographic maps. Finally, to define the pattern of the regional aquifer, reference is made to Celico et al. (2005).

Two stratigraphic and hydrogeological profiles (Figure 2) were performed to define geometric relationships among geological formations and, where it was possible, among the crystalline basement and sedimentary sequences of the Crati River Valley.

In the Crati Valley, through hydrogeological and stratigraphic data, we have identified a series of small suspended and overlapped groundwater bodies, probably defining a multilayer aquifer; these groundwaters are hosted in gravel and sand levels and have a thickness of 5-10 meters. The dimensions and the hydraulic potentiality of these groundwater bodies vary with the not well-known horizontal extension of the layers in which they are stored, but probably they have a moderate potentiality, due to their low permeability. The blue clay formation generally represents the *aquiclude* level (Figure 2) of the sequences. The Crati River Valley aquifers are located below the riverbed, and therefore, presumably, the streamwater feeds the groundwater; this represents a potential contamination risk for this groundwater by the streamwater. Thus, for a correct water management and environmental protection, more analysis and verification must be properly carried on to evaluate the actual contamination risk.

In the hydrographical right of Crati River (CS1 Profile), the groundwater of multilayer aquifer has a more discontinuous trend. However, on the basis of the available data, it can be assumed that the aquifer is rather continuous, despite the presence of less permeable layers, which locally act as *aquitard* and sometime as *aquiclude*.

At greater depths (50 m in CS1 Profile and 100 m in CS2 Profile), it is noted the presence of a considerable aquifer of possible regional importance, hosted in light-brown sands and sandstones, separated from overlying layers by Plio-Pleistocenic clays (Figure 2).

On the other hand, the Crystalline Basement hosts a basal aquifer with a good lateral continuity and variable thickness (from 50 m to 100 m, Figure 2), even if, also due to the heterogeneity of these rocks, local groundwater circulation is very articulated. It is probable that a groundwater to streamwater exchange system is active among the water bodies of crystalline basement and those occurring in the Crati alluvial deposits. These *drainance* processes among them would improve the hydrochemical quality, contributing to dilution of potential contaminants in the alluvial aquifers.

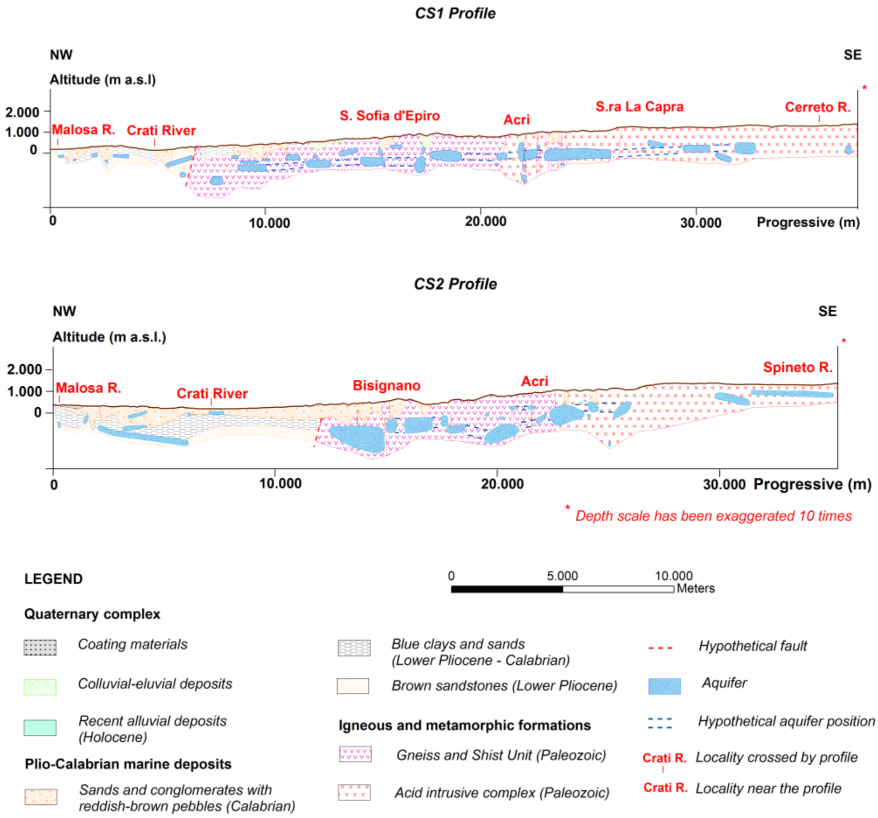

Figure 2. Hydrogeological profiles.

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