

# SPRINGS AND GROUNDWATER FLOW SYSTEMS OF MARNOSO ARENACEA FORMATION IN THE ROMAGNA SECTOR OF NORTHERN APENNINES (ITALY)

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## INTRODUCTION AND STUDY SITE

In Northern Apennines (Italy) hard rock aquifers prevail on karst and porous aquifers. A big portion of the chain is formed by siliciclastic and calcareous turbidites, arenites and ophiolites, both effusive like basalts or intrusive like peridotites. These geological units constitute the most valuable groundwater reservoir of the area.

A plenty of springs discharge from these huge outcrops of hard rock aquifers; these springs originate from a variety of groundwater flow systems (GFS), connected to hydrogeological structures of different complexity and depth.

Some previous studies in different test sites of Northern Apennines (DE NARDO et al., 2007; GARGINI et al., 2008; CANUTI et al., 2009; PICCININI et al., in press) allowed to define a first outline of springs and GFS in these geological units: mean spring flow rate is low (VII-VI class of Meinzer), due to the dominant low-medium permeability of the rock mass; the GFS discharge is mainly stream-focused and represents the basis of surface waters environmental flows. Locally, in proper conditions, bigger springs occur, attaining discharges of 10-20 L/s during low flow conditions and so capable to sustain public water supply of local community.

The here presented investigation has been founded by the Public Agency responsible for watersheds hydrologic budgets (Autorità dei Bacini Regionali Romagnoli, Emilia-Romagna Region) and derives from the need to refine the watersheds hydrologic budgets and from an idea of the Geological, seismic and soil survey.

The study area (Fig. 1) has an extension of about 1800 km<sup>2</sup> and encloses the mountain sector of the following watersheds: Lamone River, Marzeno River, Montone River, Rabbi River, Bidente River and Savio River.

Marnoso Arenacea Formation mainly outcrops in the study area (Fig. 1), except for the south

eastern sector where other calcareous turbidites outcrop.

## MATERIALS AND METHODS

An investigation group formed by the authors has planned the hydrogeological characterization and springs/upreach streams monitoring activity on different test sites, in order to evaluate groundwater resources and to rank different GFS in terms of yield, base flow discharge, recession coefficient and hydrochemistry. The aim of the research follows two main goals: the hydrogeological mapping of groundwater resources in Northern Apennines, correlating discharge regime and base flow hydrological behaviour with lithology and geological structure, and the need to get an insight on groundwater balance on the involved watersheds.

Different springs databases have been collected from the Local Water Suppliers and have been analyzed and compared with the geological framework in order to select a sampling data set.

49 springs have been selected for a monitoring activity developed in the summer 2011, in order to measure the low flow conditions (and contemporarily the basic physico-chemical parameters) and to analyze the recession phase of the spring hydrogram. At two springs a continuous monitoring system has been set up, in order to get a more detailed recession curve.

Concerning the monitoring activity on streams, 24 stream sections have been selected for the measurement of flow rate during the recession phase of summer 2011, by means of an electromagnetic current meter. Each section has been measured from 3 to 4 times in the summer, in order to get the recession coefficient.

The watersheds have been divided in sub-watersheds, for which the "specific hydrogeological productivity  $P_i$ " (L/s\*km<sup>2</sup>) and the "coefficient of infiltration  $CI$ " has been determined, expressed, respectively, by the base-flow specific discharge (referred to the whole sub-basin) and by the ratio between the direct recharge and total rainfall inside the sub-watershed. Direct recharge for each sub-watershed has been estimated by

average summer discharge and recession coefficient according to the methodology of Gargini et al. (2008).

Rainfall and air temperature occurrence all over the area were defined, as contour lines, either as historical record (1960-2004) or in reference to the

hydrological years of investigation; from the raw data potential and actual evapotranspiration have been determined (according Thornthwaite & Mather 1957).

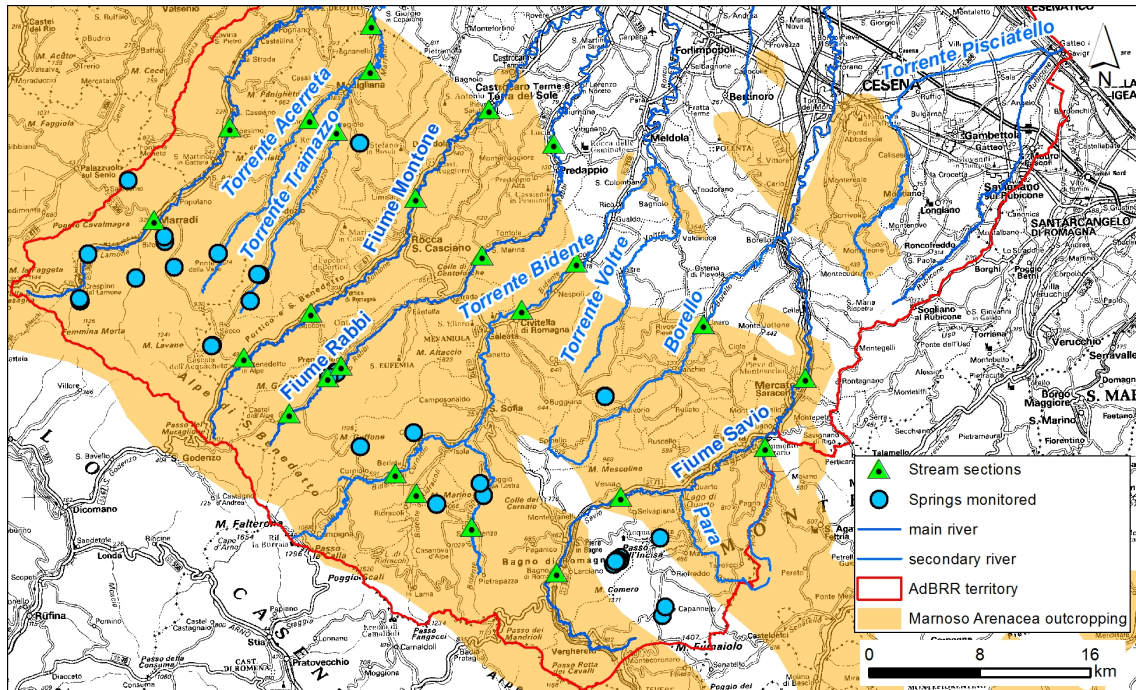


Figure 1 – Schematic map of the study area (scale 1:500,000).

## MAIN RESULTS

The main results obtained from the investigation are:

- a first census of springs used for public water supply on the study area;
- the hydrogeological characterization and parameterization of 49 springs, selected on the area for their importance (in terms of location, geological setting, flow rates, ...);
- the characterization of low flow conditions in the main streams of the study area;
- the hydrogeological classification of the different members of Marnoso Arenacea Formation and the definition of main hard rock aquifers in the study area;
- the hydrogeological productivity of the different sub-watersheds;
- the hydrogeological map for the studied area.

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