

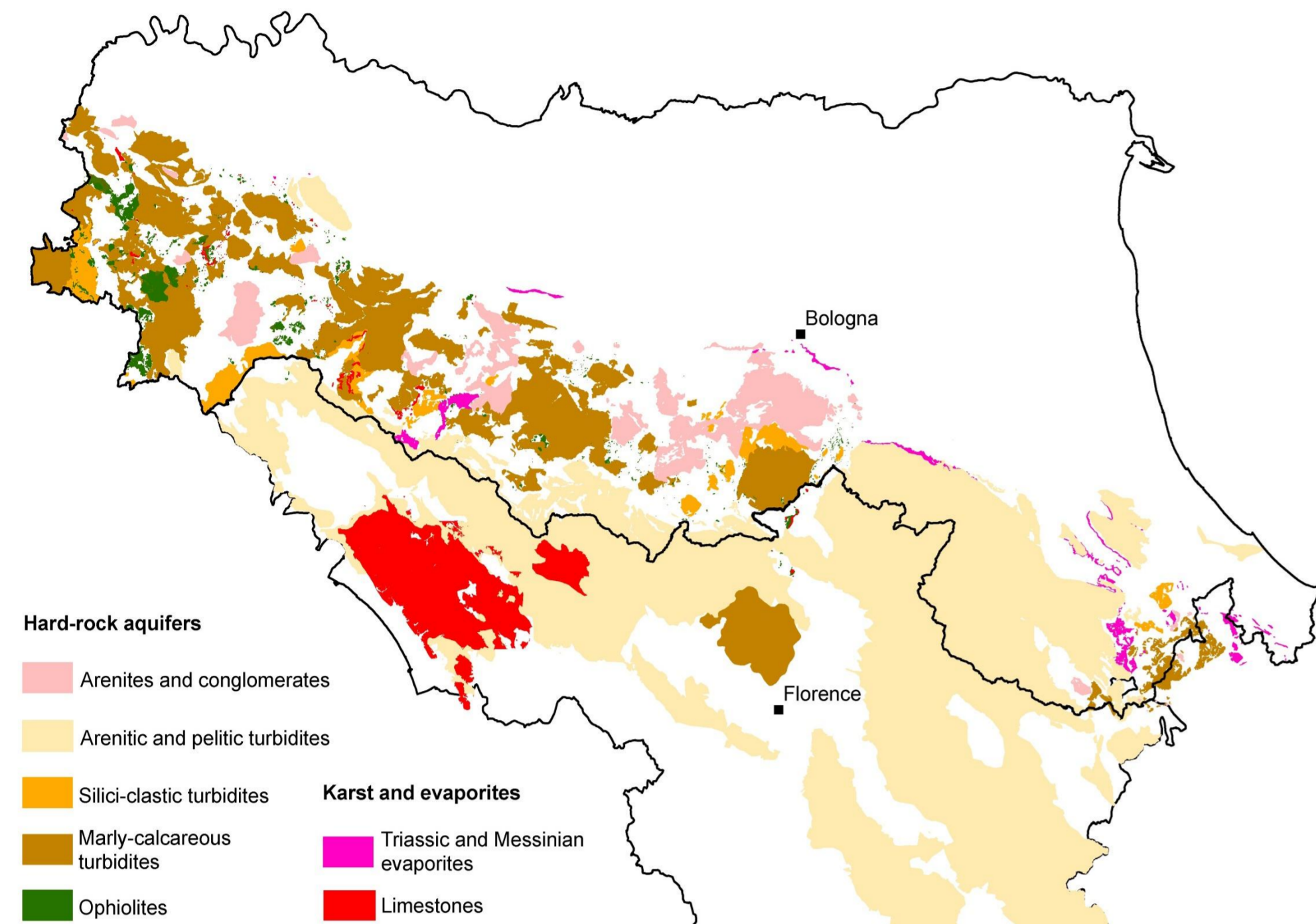
SPRINGS AS MAIN GROUNDWATER DEPENDENT ECOSYSTEMS

Marco Cantonati ⁽¹⁾; Alessandro Gargini ⁽²⁾; Stefano Segadelli ⁽³⁾; Nicola Angeli ⁽¹⁾; Daniel Spitale ⁽¹⁾; Maria Teresa De Nardo ⁽³⁾; Giulio Ercolessi ⁽³⁾

(1) Museo delle Scienze, Limnology and Phycology Section, Via Calepina, 14, 38122 Trento. marco.cantonati@mts.tn.it, nicola.angeli@mts.tn.it, daniel.spitale@mts.tn.it (2) Alma Mater Studiorum Università di Bologna, Dipartimento di Scienze della Terra e Geologico-Ambientali, via Zamboni 67, 40126, Bologna. alessandro.gargini@unibo.it (3) Regione Emilia-Romagna, Servizio Geologico, Sismico e dei Suoli, Viale della Fiera, 8, 40127 Bologna. ssegadelli@regione.emilia-romagna.it; mdenardo@regione.emilia-romagna.it.

KEY WORDS: Hard-rock aquifers, DSGD, Biodiversity, springs, northern Apennines, diatoms, benthic algae, cyanobacteria, water mites, copepods, ostracods, hydrochemistry, SAL springs.

The term **Hard-Rock Aquifers** includes granite, metamorphic or layered sedimentary rocks bearing low permeability intervals, characterized by a medium-low permeability at the scale of each groundwater body. They are characterized by strong discontinuity of the hydrogeological properties with the presence of highly permeable zones or bands due the presence of tectonic structures or alteration caused for example by deep-seated gravitational deformation (DSGD). This category does not include fractured karst, evaporites and rocks with primary porosity not negligible.



Hydrogeology

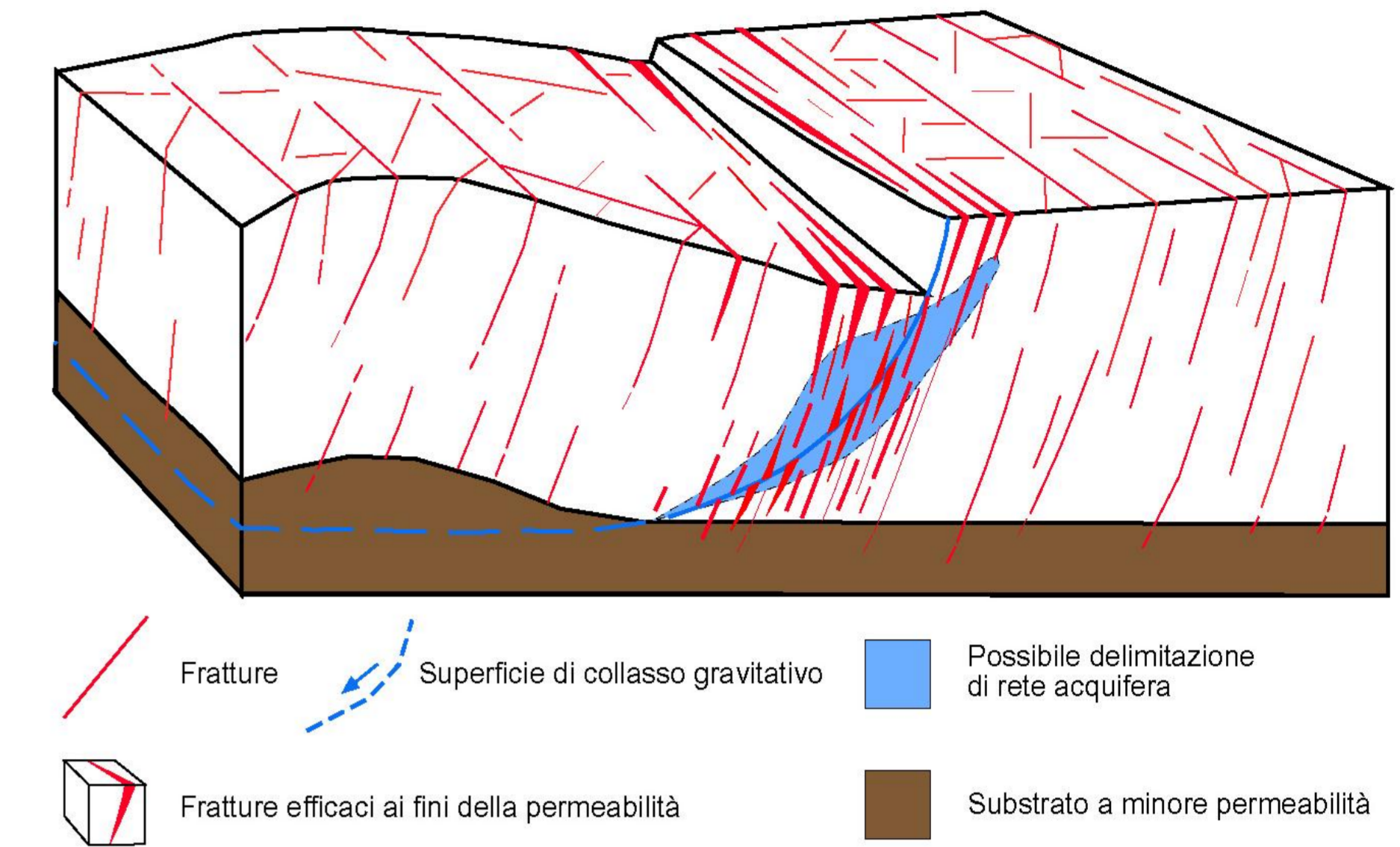
Stefano Segadelli, Maria Teresa De Nardo & Alessandro Gargini

The Apennine springs and aquifers that supply them, although representing a minority within regional groundwater resources, have strategic importance: they can not be replaced and supply best-quality drinkable water.

For these reasons, the Apennine springs require the adoption of policies for conservation and environment monitoring, with respect to recharge areas as defined by experimental and innovative methods.

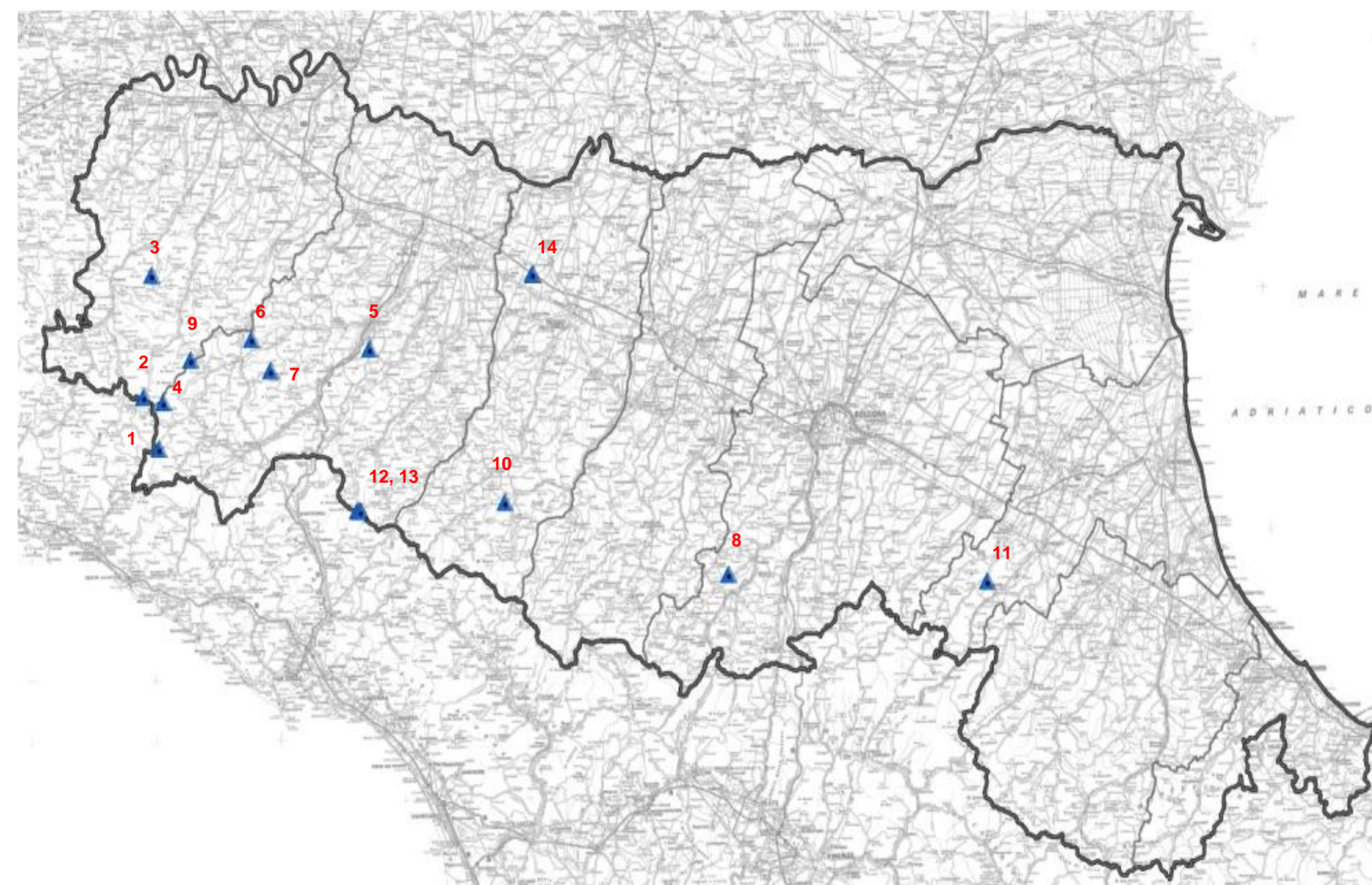
The contribution of the Emilia-Romagna Geological Survey and University of Bologna is aimed at defining the spring geological hydrostructure, and to the classification of groundwater flow system that discharges next to the outcropping area by using a hydrological-exhaustion-based method to identify the hydrogeological basin and to foster the territorial conservation of the capturing structures.

Only an integrated hydrogeological-ecological approach allows to lay the foundations for conservation actions and for the monitoring of springs, understood not as simple points of aquifer-system discharge but as complex GDEs (groundwater dependent ecosystem).



EBERs (Exploring the Biodiversity of Emilia-Romagna springs) is a three-years-lasting (2011-2013) Project fostered and funded by the Geological Survey of the Emilia-Romagna Region. Its main goal is an exploratory investigation on the biota of selected springs of the Emilia-Romagna Region. It is characterized by a multidisciplinary approach with the aim of spring-habitat characterization and advancement to disseminate an improved awareness of the role of this resource in the territorial and thematic planning. Fourteen springs were considered for the EBERs Project, selected on the basis of the following criteria: - location in different types of nature preserves; - occurrence of deep-seated gravitational deformations in slopes; - representativeness of the ecomorphological and hydrochemical spring types occurring in the study area; - availability of medium-term data series; - location within the main Hard-Rock Aquifers types; - location in the different altitudinal belts and with permanent hydraulic regime; - springs in natural or near-natural conditions.

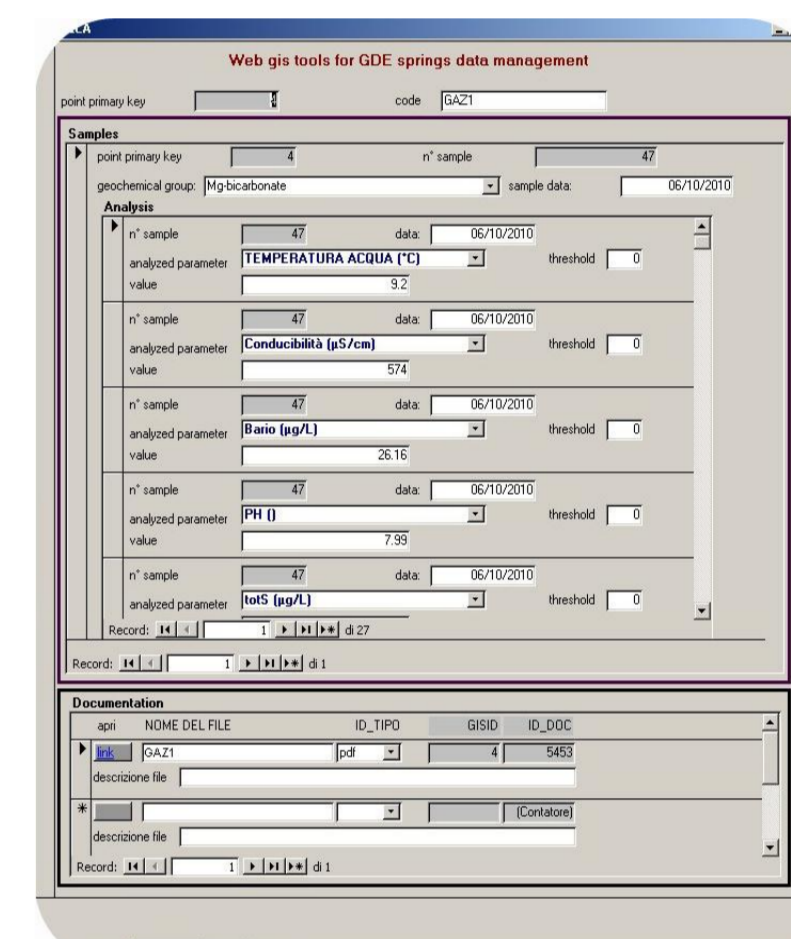
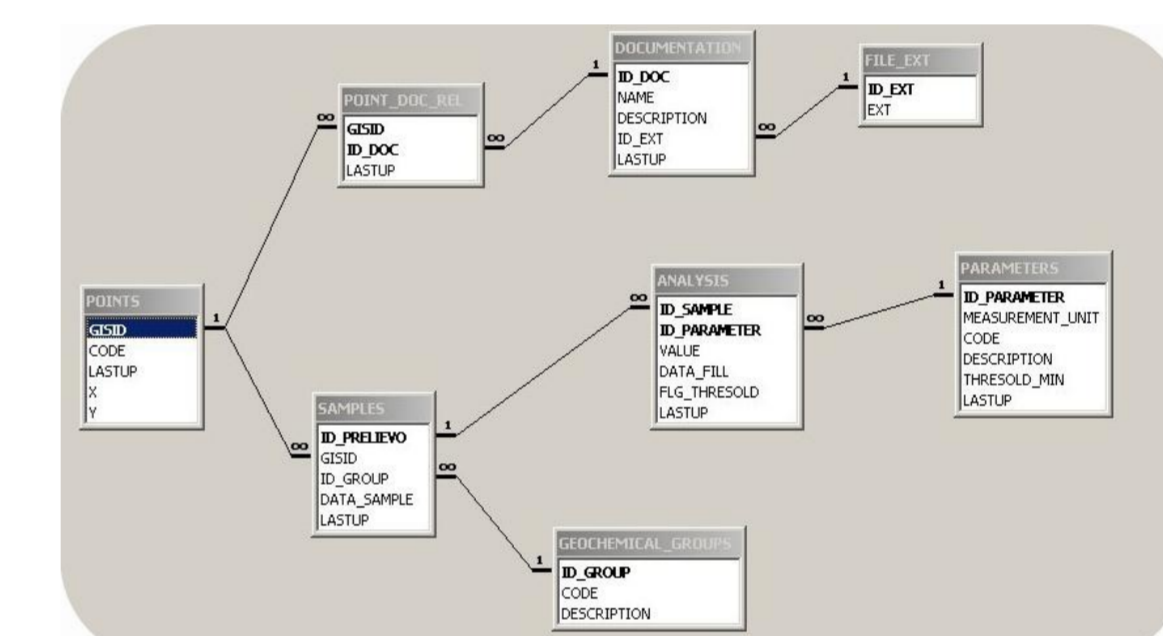
Springs sampled for the EBERs Project



Web-gis tools for GDE springs data management

Giulio Ercolessi

The mission of the Geological Survey consist in the development of geo-referenced database. The organization of data in a structure is necessary for updating, processing and consulting using webgis. Groundwater resources within the Emilia-Romagna Apennines make up a theme that is well suited for such modeling; this allows to intersect groundwater dataset with other thematic maps for a better understanding of the environmental dynamics.



Diatoms

Horst Lange-Bertalot (University of Frankfurt), Marco Cantonati & Nicola Angeli

This incredibly diverse group of microalgae can provide a wealth of useful information on water quality.

Biodiversity: The analyses are still ongoing but at present the database includes almost three-hundred (297) taxa belonging to 60 genera! The detailed analysis of the materials has pointed out several taxa likely to be new to science. These are being carefully studied at the moment. EBERs confirms seepages to be the spring type richest in species (60 taxa found in the Lago Scuro holocene spring, 13). Diatom assemblages evidently react to geogenic variables, such as pH and alkalinity, with low alkalinity springs hosting a high number of mostly acidophilous taxa while mineral springs (Poiano, 10) are colonized by a reduced number of brackish water species. Also the effects of nutrient (nitrate) increases are evident, with the nutrient enriched Fontanile Valle del Re (sun-exposed spring head, 14) hosting a few taxa partly overlapping with the saline Poiano spring.

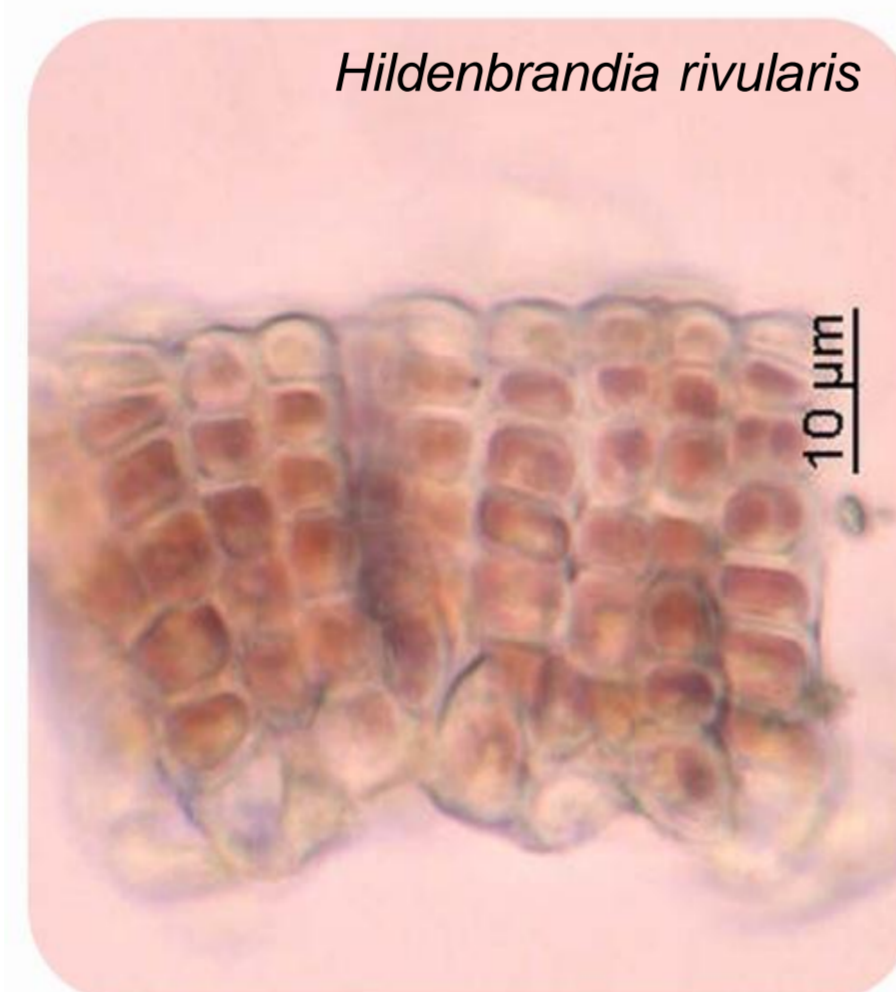


Non-diatom benthic algae including cyanobacteria

Marco Cantonati

Colourings and or structures (different types of thalli etc.) formed by benthic algae were found in the majority of the springs. The most important groups are cyanobacteria, green algae (sent to Elliot Shubert, The Natural History Museum, London), and rhodophytes. Analyses just started.

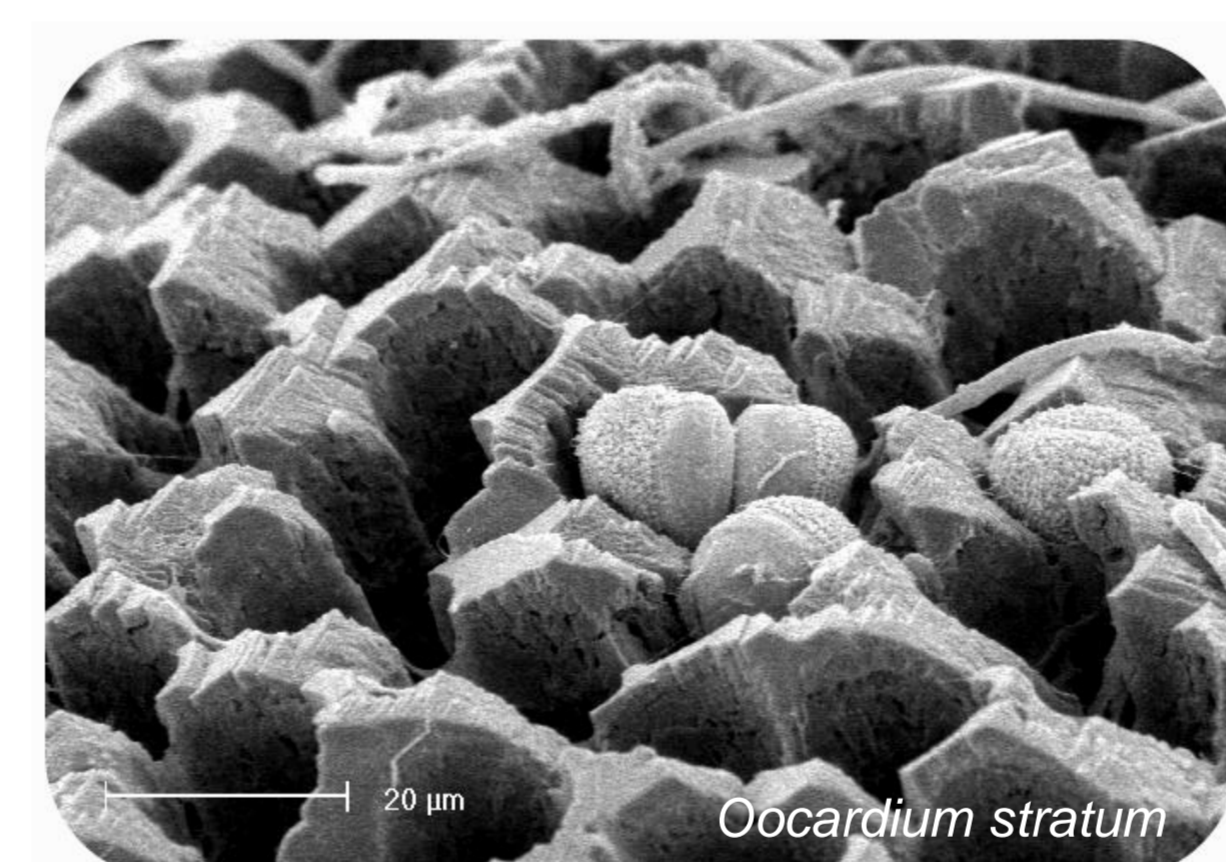
The red alga *Hildenbrandia rivularis*, recently shown in the southeastern Alps to be a characteristic species of 'Low-altitude, mostly shaded, slightly N-enriched rheocrenes with carbonate chemistry', was found in four EBERs springs (Penna, 1; Nero, 4; Lagacci, 9; Mangiapane, 3).



Chemical analyses (major ions, nutrients including phosphorus fractions, trace elements and heavy metals)

Jacopo Gabrieli, IDPA-CNR, University of Venezia

The conductivity gradient of the springs studied (13-11560 $\mu\text{S cm}^{-1}$) extends over three orders of magnitude. In spite of its strikingly high (11.2) pH value, the Monte Prinzerà (5) spring just appears to be enriched with sodium and chloride. The two mineral springs (Poiano, 10 and Riolo, 11) are characterized by high sodium, chloride, and sulphate values. They also showed high total phosphorus (TP) values. TP enrichment is otherwise rare, even in the agricultural lowland Fontanili that are contaminated by nitrate and chloride. The Monte Nero (4) and Ciapa Liscia (2) springs, both coming to daylight on ophiolitic rocks, are enriched with sodium, magnesium, chromium, nickel, arsenic, uranium, molybdenum, cadmium, antimony, titanium.



SAL-springs' algae

Eugen Rott, University of Innsbruck

Springs' Associated Limestones (SAL) or petrifying or tufa springs are one of the two spring types indicated as priority habitat by the European Union Habitat Directive (92/43/CEE). In both SAL springs considered for the EBERs Project we detected free CO_2 which caused variable pH depletion, and traces of the living biocalcifying desmid alga *Oocardium stratum*. In Monte Carameto spring (6) we found minute *Oocardium* calcifications in the seepage area, and more extended (solid) calcifications with living *Oocardium* in the deepest waters of shaded segments of the whole course of the adjacent spring stream. In Labante spring (8) the *Oocardium* cells were very small, and identification had to be confirmed in the lab. In the two SAL springs we observed no essential calcifiers besides *Oocardium*.



Water mites

Reinhard Gerecke, University of Tübingen

This is the group of organisms that includes the highest number of species exclusive to springs (so-called crenobionts).

Biodiversity: Relatively-high number of species found (about twenty-five). Analyses are ongoing. The material is very promising. It includes two new records for Italy, and a species new for science, that is however already being described on the basis of previously materials collected for other projects.

With reference to stygobiotic species, the most striking result was the finding of large population of the typical interstitial, laterally compressed water mite *Frontipodopsis reticulatifrons*. This species is normally not found in springs (strictly bound to interstitial water).



Aquatic lichens

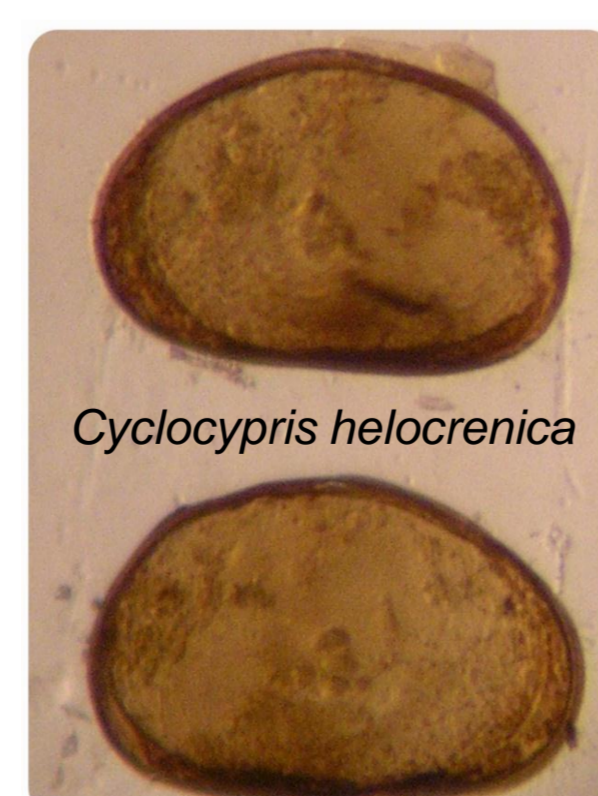
Juri Nascimbene, University of Trieste

Biodiversity: 5 species identified, almost all highly interesting: two are new reports for Italy (*Hydropunctaria scabra*, *Verrucaria madida*), and two are new for the Emilia-Romagna Region (*Verrucaria aquatilis*, *V. elaeomelaena*).

Ostracods

Giampaolo Rossetti, University of Parma

Biodiversity: Relatively-high number of species found (about twenty), with five new records for Northern Apennines' springs (the most relevant is *Cyclocypris helocrenica*, a species, that, as the name suggests, is typical of seepages). Most of the species found are crenobiontic but only few are stygophylous.



Mollusca

Fabio Decet, Belluno

Biodiversity: 18 species identified, 8 aquatic and 10 terrestrial, as it might be expected for transitional (ecotonal) environments such as springs. *Bythinella schmidtii* was the most common species. *Vertigo angustior* is a species included in the Appendix of the European Union Habitat Directive (EU-HD 1992).



Copepods, Gammarids, and Niphargids

Fabio Stoch, University of L'Aquila

Biodiversity: 23 taxa found, several of special interest.

Bioindicator copepod species, typical of Alpine springs of medium-high elevation (such as *Attheyella* - *Attheyella wierzejskii*, *Bryocamptus*; - *Rheocamptus zschokkei*; - *Arcticocamptus cuspidatus* and *Moraria - Moraria alpina*), reveal an unexpected, and so far undemonstrated, ecological resemblance between Emilia-Romagna and Alpine mountain springs. These microcrustacean assemblages should therefore be considered as a glacial relict fauna in the Aemilian Apennines.

One of the most relevant findings refers to the genus *Niphargus*, that finely splits up in a series of endemics (all new for science). Each of these species marks a hydrographic basin, as was the case for *Niphargus poianoi*, a stygobiotic species restricted to the saline gypsum waters of the Upper Secchia Valley. The gammarid *Echinogammarus veneris*, a brackish water species, was found in the spring emerging from the Riolo Gypsum (11).