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Chemical features of the springs and correlations with faults in north-western area of como lake basin (northern italy)

Gambillara R., Terrana S., Monticelli D., Giussani B.

Dipartimento di Scienze Chimiche e Ambientali, Università dell'Insubria, via Lucini 3, I-22100 Como, Italy

The aim of this study is the reconstruction of the groundwater system in the north-western area of Lake Como and to understand the correlations among the water geochemistry, the lithology in which the water circulated and the fault zone in the this area. The study area is located in Lombardy, Northern Italy, and it extends in the N-S direction between Peglio and Menaggio (Como, Italy) and in E-W direction between San Siro and Carlazzo (Como, Italy), with a total extension of 200 Km^2.

This study aims at analyzing the role played by the faults and the fracture systems on the groundwater circulation. Understanding whether the main faults play as barriers dividing the aquifers or as drainage channels allows a better evaluation of water resources and of their potentialities for future exploitation and for their safeguard.

The choice of this area was determined by the abundance of springs, by the occurrence of important regional faults, like the *Tonale fault* and the *Grona fault* and others minor ones, by the occurrence of a boundary between the crystalline basement and the sedimentary cover and by the occurrence of fracture systems in this area.

The geological setting is characterized by the crystalline metamorphic basement of the Southern Alps (pre-Westfallian, Perotti, 1987), to the North of the Grona fault, and by a Permo-Triassic sedimentary cover, to the South of the fault (Bertotti, 1991). The tectonic setting is characterized by three important regional E-W trending faults:

the Tonale (Insubric-Periadriatic fault system), the Musso and the Grona faults. The Tonale fault divides the Pennidic and the Austroalpine (Alpine domain) from the Southalpine domain and it is a dextral strike-slip fault E-W oriented (Laubscher, 1983). The Musso fault is a E-W oriented intra-basement fault that separates rocks with different metamorphic grade (Gianotti & Perotti, 1986). The Grona fault is an important ESE-WNW oriented regional fault which divides the crystalline basement from the sedimentary cover.

Forty-five springs were sampled, 18 rising into the sedimentary rocks, 22 into the crystalline basement and 5 at the boundary between the two rock types. Chemico-physical parameters (pH, conductivity and temperature), ^{222}Rn and major, minor and trace elements were determined.

All of these parameters show wide variability. As an example, the temperature ranges from 4,6˚C (Cz2 spring) to 16,9˚C (Gz8 spring) pH varies between 5,41 (Gz2 spring) and 8,17 (Mn16 spring) and conductivity between 5,16 μS/cm (Ge1 spring) and 607 μS/cm (Mn3 spring). ^{222}Rn shows wide variations too, its concentration ranging from 1,68 Be/L (Gz5 spring) to 115,14 Be/L (Gz9 spring).

This large amount of information was dealt with employing Chebotarev diagram, ternary and binary diagrams and graphical presentations (contouring) in order to show the relationship with geologic and tectonic data. Chemometric techniques, like Principal Component Analysis (PCA), were also used to extract useful information.

Regarding the geochemical characteristics, three main groups of water (87% of the sampled springs) have been identified, whereas the remaining 13% is characterized by a peculiar hydrogeologic circuit. The group I (enriched in Ca^{2+} and HCO_3^-: weathering of limestones) and the group II (enriched by Ca^{2+}, Mg^{2+} and HCO_3^-: weathering of dolomite rocks) are characterized by carbonate rock circuits, whereas the group III springs (Si enrichment) circulate in crystalline rocks. All the circuits are superficial with the exception of the Mn7 and Mn9 springs (with Ca^{2+} and Mg^{2+} enrichment, rising in limestone rocks) which are from a deeper circulation controlled by the tectonic activity. The Mn15 and Cz4 springs are also controlled by the tectonic activity: this is confirmed by a high ^{222}Rn concentration.

Regarding the tectonic control on groundwater circulation, this work demonstrates that the tectonic activity, in this area, had an important role both as a barrier and as a preferential way for circulation, even if it is located in a carbonate rock area. In particular the E-W oriented systems, as Tonale fault and Grona fault, are a barrier for groundwater flow, whereas the NE-SW systems, as the minor Breglia fault, are a preferential way for the water. This faults are also a way for the gas ^{222}Rn, this is confirmed by the Mn15 and Cz4 springs.

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