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Seawater intrusion or saltwater extrusion: a glance into deep flow systems in coastal aquifers

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The carbonate aquifers of Puglia (Gargano promontory, Murgia, and Salento Peninsula, Southern Italy) are coastal in type. They belong to the Apulia platform that is the upper part of the Apulia Foreland, which consists of a well-bedded succession of Jurassic–Cretaceous carbonate rocks from about 3 to 5 km thick. The groundwater flow systems are regional, with a hydraulic bottom limit constituted by saltwater, almost where the hydraulic heads allow. The discharge occurs through brackish focused coastal springs.

The chemical composition of salt ground waters, not systematically sampled over the last 40 years in deep wells reaching saltwater beneath freshwater in the three aquifers, is different from that of present seawater. Salt waters show the diagenetic result of water-interaction processes as Na+-Ca2+ or Mg2+ base-exchange, SO42- reduction, and solution of evaporite salts. However, the most effective tracers in the recognition of diagenesis relate to carbonate-water interactions: the progressive diminution of the rMg/rCa ratio, related to dolomitization processes of the carbonate formations, accompanied by dissolution and re-precipitation involving the different carbonate species, the consequent enrichment in Sr2+ because of incongruent dissolution of carbonates, and the enrichment of Li+, may be connected to a parallel increase of the aging of salt waters. A few isotope data (δD and δ18O, 14C, 13C, 87Sr/86Sr isotope ratio) related to saltwater samples from Salento aquifer support such hypothesis. As matter of fact, not any salt water so far sampled in the three aquifers, both inland and near the coast, resembles present seawater. With the aim of understanding the flow system of salt waters, the chemical composition of the salt water end-members drained by the numerous focused brackish springs, which border the Adriatic and Ionic coasts of Gargano, Murgia and Salento, has been defined by End Member Mixing Analysis (EMMA). The saltwater end-member hypothesised by EMMA for some coastal springs (outflowing close to the borders of the Murgia and Gargano aquifers) and by considering also their Sr isotope ratio, is deeply diagenized and does not relate to any of the salt waters sampled within the karst coastal aquifers. The same occurs for a saltwater end-member that seems a CaCl2 brine, hypothesised for some springs of Salento aquifers. A saltwater with chemical characteristics like those hypothesised for Murgia and Gargano was sampled in a deep well (oil exploration well) reaching the Mesozoic carbonate basement sunk under huge clay fillings in the Tavoliere region, adjacent to Murgia and Gargano aquifers.

All the above findings suggest that nearly all brackish water outflowing into the sea through springs conveys old saltwater components different from present seawater. This circumstance poses a series of interesting questions on the "seawater intrusion" in coastal aquifers: really, it seems that we should instead consider "saltwater extrusion".