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The role of the transition from confined to roofed aquifer in the development of anoxic conditions; the Mountain Aquifer, Israel

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The Mountain Aquifer of Israel is one of the nation's main sources of potable water. The aquifer is composed of a thick sequence of karstic limestones and dolomites interbedded with some chalky and marly units (the Judea Group). One of the latter separates the aquifer into upper and lower sub-aquifers. The recharge area of the aquifer is the Judea and Samaria Mountains, while the present natural outlets are the Taninim Springs, at the north-western extension of the aquifer. However, most of the water is pumped from the aquifer in a series of pumping fields spread over most of its eastern and central parts. Generally, the water flows westwards, from the recharge area towards the foothills and further west below the coastal plain of Israel. Here the flow direction changes to the north-west. West of the recharge area, below the coastal plain, the aquifer is confined by bituminous Senonian chalks (the Mount Scopus Group). Generally the water in the aquifer is of high quality, with a minor salinization component along the flow path. High salinity, low quality water bodies are found at the western margins of the aquifer. These are believed to be trapped ancient seawaters. The southern extension of the aquifer, south of the city of Be'er Sheva, contains an ancient brackish water body. Pockets of anoxic, H2S-containing water, slightly hotter than their surroundings, are found within the fresher part of the upper sub-aquifer. Anoxic conditions also characterize the brackish waters in the southern extension of the aquifer. Hydrogeological and geochemical evaluations of the transition from oxic to anoxic areas indicate that the anoxic conditions develop only at those sites that meet the following criteria: 1) Presence of an organic rich unit with low permeability (aquitard) that overlies the aquifer. In the present case, this unit is part of the Mount Scopus Group. 2) Transition from confined to roofed conditions within the aquifer.

Leakage from the overlying aquitard is possible in the roofed part (leaky aquifer). 3) Seepage of organic-rich water into the aquifer. Oxidation of the dissolved organic matter present in the seeping water consumes the dissolved oxygen in the aquifer. Organic matter oxidation continues through bacterial sulfate reduction with H2S as a product (evident through sulfur isotopic ratios). These exothermic reactions also results in some heating. In the present case, the source of the organic matter is the bitumen within the Mount Scopus chalks. 4) The seeping water comprises a relatively large portion of the water volume. Such mixing ratio is needed in order to enable full consumption of the dissolved oxygen present in the aerobic portion of the mixture. A slow flow rate in this part of the aquifer is thus an essential condition. From an aquifer management point of view, in order to maintain the high quality of the water in the aquifer, care should be taken to maintain the confining conditions below the bituminous aquitard by avoiding over pumping.