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The geochemistry of groundwater resources in the Jordan Valley: The impact of the Rift Valley brines

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Abstract

The chemical composition of groundwater in the Jordan Valley, along the section between the Sea of Galilee and the Dead Sea, is investigated in order to evaluate the origin of the groundwater resources and, in particular, to elucidate the role of deep brines on the chemical composition of the regional groundwater resources in the Jordan Valley. Samples were collected from shallow groundwater in research boreholes on two sites in the northern and southern parts of the Jordan Valley, adjacent to the Jordan River. Data is also compiled from previous published studies. Geochemical data (e.g., Br/Cl, Na/Cl and SO_4/Cl ratios) and B, O, Sr and S isotopic compositions are used to define groundwater groups, to map their distribution in the Jordan valley, and to evaluate their origin. The combined geochemical tools enabled the delineation of three major sources of solutes that differentially affect the quality of groundwater in the Jordan Valley: (1) flow and mixing with hypersaline brines with high Br/Cl ($>2\times10^{-3}$) and low Na/Cl (<0.8) ratios; (2) dissolution of highly soluble salts (e.g., halite, gypsum) in the host sediments resulting in typically lower Br/Cl signal ($<2\times10^{-3}$); and (3) recharge of anthropogenic effluents, primarily derived from evaporated agricultural return flow that has interacted (e.g., base-exchange reactions) with the overlying soil. It is shown that shallow saline groundwaters influenced by brine mixing exhibit a north–south variation in their Br/Cl and Na/Cl ratios. This chemical trend was observed also in hypersaline brines in the Jordan valley, which suggests a local mixing process between the water bodies.

1. Introduction

Water resources in the Jordan Rift Valley (Fig. 1) are influenced by mixing with deep brines that typically have a Ca-chloride composition (Starinsky, 1974). For example, the salt budget, and hence the chemical composition of the Sea of Galilee (Simon

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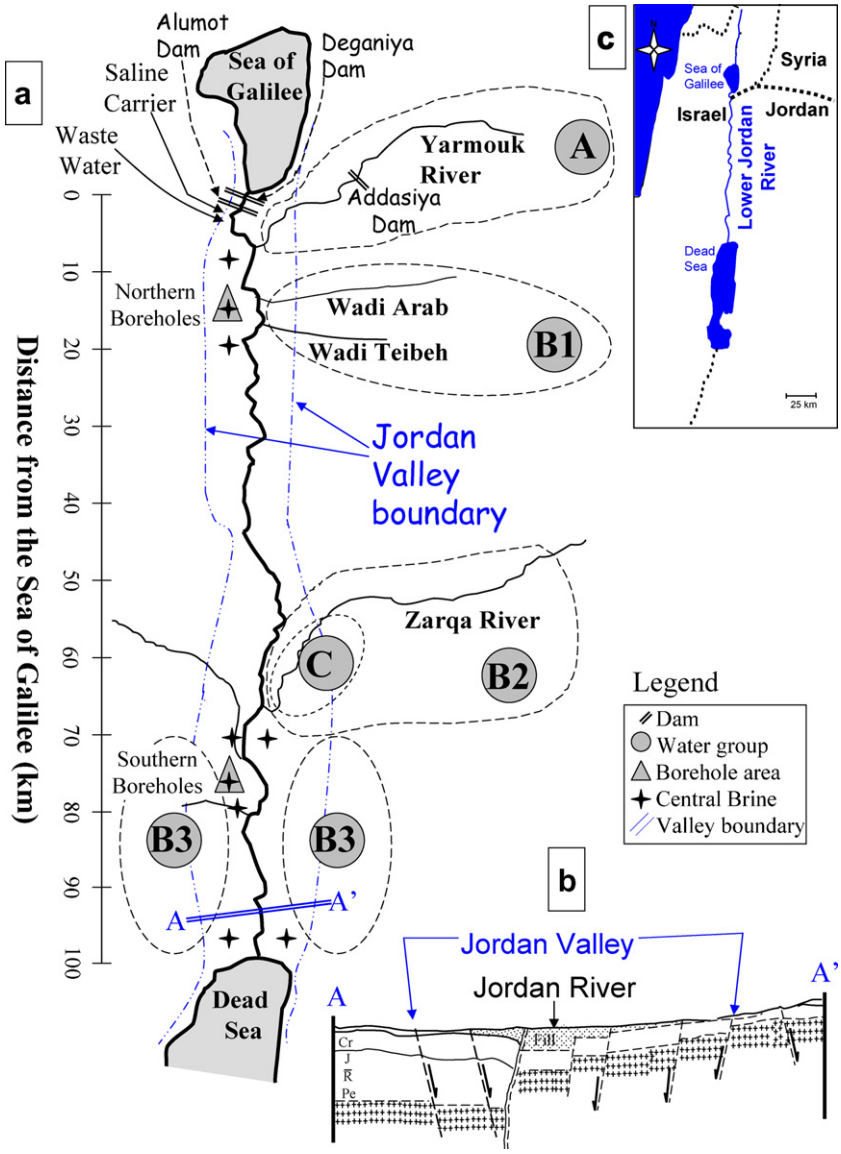

Fig. 1. (a) Schematic map of the research area with the geographic location of brine samples, shallow boreholes and the different water groups in the Jordan Valley; (b) schematic geological cross section of normal faults existing both in the valley's margins and the valley itself, adjacent to the river (after Garfunkel and Ben-Avraham, 1996); and (c) location map of the Jordan Valley.

and Mero, 1992; Kolodny et al., 1999; Nishri et al., 1999) and the Dead Sea (Starinsky, 1974; Stein et al., 1997; Gavrieli et al., 2001) are largely controlled by mixing with these deep brines. Although these brines likely influence the salinity and chemical composition of groundwater between the Sea of Galilee and the Dead Sea, their role in this area has not been fully investigated.

Here the chemical and isotopic compositions of shallow groundwater in the lower Jordan Valley, between the Sea of Galilee to the north and the Dead Sea to the south are investigated (Fig. 1). The objectives of this study are to characterize the chemical composition of shallow groundwater as well as to evaluate the impact of deep saline brines on the geochemistry of shallow groundwater in the Jordan Valley.

To achieve these goals, a large geochemical and isotopic database is used, composed of major and minor ion distributions, Sr ($^{87}Sr/^{86}Sr$), B ($\delta^{11}B$), S ($\delta^{34}S$) and N ($\delta^{15}N$) isotopes. The variations of Sr isotopic ratios in groundwater provide useful