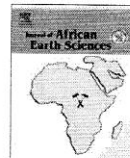




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Statistical categorization geochemical modeling of groundwater in Ain Azel plain (Algeria)

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ABSTRACT

Water analysis data of 54 groundwater samples from 18 uniformly distributed wells were collected during three campaigns (June, September and December 2004). Q-mode hierarchical cluster analysis (HCA) was employed for partitioning the water samples into hydrochemical facies. Interpretation of analytical data showed that the abundance of major ions was identified as follows: $\text{Ca} \geq \text{Mg} > \text{Na} > \text{K}$ and $\text{HCO}_3 \geq \text{Cl} > \text{SO}_4$. Three major water facies are suggested by the HCA analysis. The samples from the area were classified as recharge area waters (Ca–Mg–HCO₃ water), transition area waters (Mg–Ca–HCO₃–Cl water), and discharge area waters (Mg–Ca–Cl–HCO₃ water). Inverse geochemical modeling suggests that relatively few phases are required to derive the water chemistry in the area. In a broad sense, the reactions responsible for the hydrochemical evolution in the area fall into two categories: (1) evaporite weathering reactions and (2) precipitation of carbonate minerals.

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1. Introduction

Variation in groundwater chemistry is mainly a function of the interaction between the groundwater and the mineral composition of the aquifer materials through which it moves. Hydrochemical processes, including dissolution, precipitation, ion exchange, sorption, and desorption, together with the residence time occurring along the flow path, control the variation in chemical composition of groundwater (Apodaca et al., 2002), that can be modeled by inverse geochemical models (Sharif et al., 2008). Inverse geochemical modeling is commonly used to reconstruct geochemical evolution of groundwater from one point in an aquifer to another point located in the inverse direction along the groundwater flow path. Recently, inverse geochemical modeling has been used to investigate the chemical evolution of groundwater along the flow path by numerous investigators (Plummer et al., 1990; Rosenthal et al., 1998; Perry, 2001; Eary et al., 2002; Güler and Thyne, 2002; Savage and Bird, 2002; Lakshmanan et al., 2003; Lecomte et al., 2005; Dai et al., 2006; Dhiman and Keshari, 2006; Mirecki, 2006; Clark and Journey, 2006).

Inverse geochemical modeling in PHREEQC (Parkhurst and Appelo, 1999) is based on a geochemical mole-balance model, which calculates the phase mole transfers (the moles of minerals

and gases that must enter or leave a solution) to account for the differences in an initial and a final water composition along the flow path in a groundwater system. At least two chemical analyses of groundwater at different points of the flow path, and a set of phases (minerals and/or gases) which potentially react along this flow path are needed to populate the program (Charlton et al., 1997). A number of assumptions are inherent in the application of inverse geochemical modeling: (1) the two groundwater analyses from the initial and final water-wells should represent groundwater that flows along the same flow path, (2) dispersion and diffusion do not significantly affect groundwater chemistry, (3) a chemical steady-state prevails in the groundwater system during the time considered, and (4) the mineral phases used in the inverse calculation are present in the aquifer (Zhu and Anderson, 2002). The soundness or validity of the results in the inverse modeling depends on a valid conceptualization of the groundwater system, validity of the basic hydrochemical concepts and principles, accuracy of input data into the model, and level of understanding of the geochemical processes in the area (Güler and Thyne, 2004).

In this study, hydrogeological and hydrochemical information from the groundwater system are integrated and used to determine the main factors and mechanisms controlling the chemistry of groundwater in the area. The main issues that will be addressed by this study include: (1) the validity of statistical clustering techniques in classifying the samples into hydrochemical facies on a regional scale and (2) development of a hydrochemical model for the region.

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