Geophysical Research Abstracts,
Vol. 10, EGU2008-A-12208, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-12208
EGU General Assembly 2008

Geochemical evaluation and hydrochemical zonation for the Nubia aquifer in the Ganah area, El-Kharga Oasis, Egypt

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This study high-lights the physical and chemical characteristics of groundwater extrated from the Nubian aquifer horizons in the Ganah area. The groundwater in the Ganah area can be used for different applications according to its physical and chemical properties. To achieve this goal the hydrogeological conditions of the Nubian aquifer including well design, lithological composition, hydraulic parameters, well discharge, water level and aquifer balance have been taken into consideration. In order to fulfill the gap between the already existing wells, five deep vertical electrical soundings (VES) using the Schlumberger configuration were executed in order to delineate the actual aquifer geometry. In addition, thirteen water wells representing El-Ganah area were sampled and analyzed for major and trace elements. The results of the chemical analysis were used for geochemical evaluation, hydrochemical zonation and accurate estimation for subsurface temperature.

The hydrogeological characteristics and the resulting resistivity curves were jointly interpreted to produce two geo-electric cross-sections. These show that the Nubia aquifer can be sub-divided into two main horizons. The upper horizon is composed mainly of sandstone intercalated with shale and is characterized by a medium transmissivity (500 m^2/day). The lower horizon is sandstone and is characterized by a high transmisstivity (1000 m^2/day). The chemical analysis shows a sodium chloride water type of meteoric origin. Two types of hypothetical salt combination were differentiated. The first is NaCl, Na_2SO_4, $MgSO_4$, $CaSO_4$, $Ca(HCO_3)_2$ while the second is

NaCl, $NaSO_4$, $MgSO_4$, Mg $(HCO_3)_2$ $Ca(HCO_3)_2$. Most of the water samples belong to the first hypothetical salt combination. In order to identify the direction of the chemical reactions in solution the ionic activities of the constituent ions and the saturation indices of different minerals were calculated by using the AQUCHEM program. The results of calculation show that the sodium and chloride are the most active ions and so will form large amounts of their salts. The calcium and bicarbonate are the least active ions and so will form small amounts of their salts. Some of the calculated saturation indices of minerals have negative sign which indicates that these minerals are undersaturated in solution and going to dissolve causing well corrosion, while others have positive sign which indicates that these minerals are supersaturated in solution and going to precipitate causing well encrustation.

Thermal water is a source of heat energy and vapour condensation will produce fresh water. In this study a solution mineral equilibria approach involves the evaluation of the saturation state of a particular water composition with a large number of minerals as a function of temperature. If a group of minerals is close to equilibrium at one particular temperature the conclusion is that the water has equilibrated with this group of minerals and the temperature represents the aquifer temperature. An aqueous speciation program has been used to construct thirteen mineral equilibria diagrams. These diagrams indicate that the thermal waters in the Ganah area are not close to equilibrium with hydrothermal minerals. This reflects the mixing of water in different horizons, particularly the case where the well casing is not completely penetrating the aquifer horizons. The mineral equilibria diagrams also indicate an old equilibrium state for some of the minerals represented by crossing of their lines at log(SI/K) less than zero. This suggests some degree of equilibrium probably prior to mixing of water of different horizons. The mineral equilibrium diagrams reflect sub-surface temperatures ranging between 50˚C and 80˚C.

Taking into considerations the above mentioned field measurements, analytical procedures and the results of the paper, the recommendation are:

- Water extraction should be managed to keep the aquifer in good state.
- A periodical monitoring network should be established to follow up any abrupt changes in each of water level and water quality.
- The high water temperature in the aquifer must be used as thermal energy for different purposes.
- The high concentrations of iron, manganese, aluminum, zinc and potassium in some wells must be removed from water before using it for drinking purposes.