Hydrogeology of the shallow aquifers at Wadi el-Ghussein, NE Jordan

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The research aimed to better understand the hydrogeology of the alluvial shallow perched aquifers in Wadi el-Ghussein in Tulul al Ashaqif area of the northeast Badia of Jordan.

Many generations of local Bedouins have dug wells by hand in the wadi and exploited the available water, which helped to support their water requirements. Recent studies have suggested that these aquifers are renewable, widespread and can be used as a water resource, provided that they are managed in a sustainable manner. This requires a full understanding of the hydrology of the aquifer.

Several techniques were used to collect data needed to better understanding of the hydrological situation in Wadi el-Ghussein. Total station surveys were used to draw a detailed topographic map for the study area, and hydrometers were used to check the elevation of the groundwater, and to draw ground water contours directly.

Very low frequency geophysical equipment (VLF) were used to determine the lateral extents and depths to the groundwater level along different profiles of the wadi and under the basalt pavements where direct measurements were not available. Samples of groundwater were collected for geochemical modeling and to check for the quality of the water.

Analysis of the results of data led to determine the flow directions of water, which were confirmed by geochemical modelling.

The general groundwater flow direction is from outside the wadi (basalt pavement) towards the center of the wadi and from the NW towards SE along the course of the wadi. Within the wadi, are where recharge and discharge (towards deeper aquifers) were clearly detected. Geochemical modeling confirms these conclusions.

VLF data analysis also indicates that lateral extents of water is limited to the wadi bed, except in limited areas such as meanders where groundwater extends under some points of the basalt pavement.

Water quality is close to the permissible Jordanian and World Health Organization (WHO) standards, and the plot of the chemistry of the sampled water on the Piper diagram led to it's classification as carbonate water.

The physics of mantle geochemical heterogeneities

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There is now enough geochemical data along mid-ocean ridges and in deep drill cores to attempt an interpretation in terms of fluid dynamics without having to resort to stringent assumptions. Although the creation of mantle heterogeneities by recycling oceanic plates into a mantle differentiated early in Earth's history is reasonably clear, how they get disbanded remains unresolved. Stirring by mantle convection and length-scale reduction by friction along the lithospheric plates concur to make the mantle look, not homogeneous which is an improbable situation, but well-stirred in a statistical sense. Melting under mid-ocean ridges and in plume conduits are other powerful mixing processes. The origin of heterogeneities in oceanic basalts was a central preoccupation of geochemists for decades, but statistical tools make it now clear that they simply reflect a combination of the two leading geodynamic sets of processes taking place at mid-ocean ridges and at subduction zones. I will review the interpretation of heterogeneities along mid-ocean ridges and show how their spectrum is dominated by Lagrangian stretching and refolding in mantle convection, eventually leading to the well-stirred, memory-less pattern observed on the SE Indian Ridge. Lithospheric plates may cool the mantle, but they do not mix it. There would certainly be a lot to learn about mantle convection from an ambitious international initiative of dense resampling of mid-ocean ridges. The time series represented by lava piles such as those produced in Hawaii carry a weaker signal essentially because complex rheology makes the dynamic of the plume conduit chaotic and averages out the small wavelengths fluctuations. Understanding the details of the lower mantle heterogeneities is therefore still better achieved by high-resolution seismology.