Journal of African Earth Sciences 205 (2023) 105013

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Integrated gravity and resistivity investigations of the deep Hammam Bradaa aquifer, Northeast Algeria: Implications for groundwater exploration

Rahma Khadri [a], Abdelhamid Khedidja [a,*], Djamel Boubaya [b], Nafaa Brinis [a]

[a] Laboratory of Mobilization and Management of Water Resources (LMGRE), Department OfGeology, Institute of Earth Sciences, University of Batna 2, Algeria
[b] Water and Environment Laboratory, Department of Earth and Planetary Sciences, Larbi Tebessi University, Constantine Street, 12002, Tebessa, Algeria

ARTICLE INFO

Handling Editor: DR Damien Delvaux

Keywords:
Guelma
Groundwater
Gravity
VES
3D gravity inversion

ABSTRACT

Recently, the Guelma region, located northeast of Algeria, has been facing an unusual water shortage. To bypass this situation, a geophysical study using gravity and resistivity has been initiated to enhance the understanding of the geology and hydrogeology of the deep structures of the study area. In order to accomplish this, a residual gravity anomaly map has been constructed by removing from the Bouguer anomaly map a regional gravity gradient using the upward continuation technique. For the purpose of validating the Vertical Electrical Sounding (VES) interpretation, two soundings were conducted near boreholes with known lithology. The Hammam Bradaa deep aquifer of the Guelma region is composed of limestones that belong to the Constantine neritic domain. The Constantine neritic domain is covered by thrust nappes and outcrops in some places of the study area as tectonic windows. The exact geometry such as depth and lateral extent of the aquifer are not well known. Since limestones are characterized by high densities and resistivities relative to the host rock, the combining of gravity and VES was able to accurately map their extension among the other lithologies composing the geological section. Multiscale edge detection of gravity data known as "worms" made it possible to highlight the principal lineaments across the study area which may contribute to the recharge of the Hammam Bradaa aquifer. The 3D Gravity inversion enabled the mapping of the spatial configuration of limestones that are characterized by positive gravity contrast relative to the host rocks. A vertical density slice extracted from the 3D gravity inversion, running from north to south, reveals a significant thickness of limestone beneath Hammam Bradaa which suggests a strong potential for groundwater resources. The geo-electric section, constructed from the interpretation of VES data and calibrated with well lithology, enabled the mapping of the depth to the top of limestone beneath conductive alluvium and marls.

1. Introduction

In recent years, with the accelerated droughts, Hammam Bradaa, like other regions of Northern Algeria, has been experiencing a significant water scarcity. Insufficient precipitation has resulted in a shortage of surface water resources, making it challenging to meet the increasing water demand. Groundwater remains the most viable solution to meet water needs. However, the high cost of drilling needs a comprehensive surface study to identify suitable locations for boreholes. Therefore, the use of indirect methods such as geophysics becomes imperative. This study is therefore focused on the combined use of gravity and vertical electrical soundings (VES) for characterizing the deep neritic limestones aquifer of Hammam Bradaa in the Guelma region. It is well known that potential field geophysical methods suffer from the problem of non-uniqueness of the solution. Multiple geological models of different natures can correspond to the same observed data. The use of a single geophysical method to address any geological problem may potentially result in erroneous interpretations. However, by combining two or more geophysical techniques, the ambiguity caused by the non-uniqueness of solution can be significantly reduced. In this context, the combining of gravity and VES was successfully used to explore the deep aquifer of neritic limestones at the Hammam Bradaa site.Indeed, limestones are denser and more resistant compared to the other varieties of the surrounding rocks composing the geological section. This approach, which

* Corresponding author.
E-mail address: khedi73@yahoo.fr (A. Khedidja).

https://doi.org/10.1016/j.jafrearsci.2023.105013
Received 14 February 2023; Received in revised form 10 June 2023; Accepted 10 July 2023
Available online 15 July 2023
1464-343X/© 2023 Elsevier Ltd. All rights reserved.