Journal of Hydrology 539 (2016) 223–236

Contents lists available at ScienceDirect

Journal of Hydrology

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

# 3D geological modeling of the Kasserine Aquifer System, Central Tunisia: New insights into aquifer-geometry and interconnections for a better assessment of groundwater resources

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ARTICLE INFO

*Article history:*
Received 28 February 2016
Received in revised form 13 May 2016
Accepted 16 May 2016
Available online 25 May 2016
This manuscript was handled by Corrado Corradini, Editor-in-Chief, with the assistance of Christophe Darnault, Associate Editor

*Keywords:*
3D geological modeling
GeoModeller
Kasserine
North-east Algeria
Aquifers
Interconnection

SUMMARY

The challenge of this study was to create a 3D geological and structural model of the Kasserine Aquifer System (KAS) in central Tunisia and its natural extension into north-east Algeria. This was achieved using an implicit 3D method, which honors prior geological data for both formation boundaries and faults. A current model is presented which provides defendable predictions for the spatial distribution of geology and water resources in aquifers throughout the model-domain.

This work has allowed validation of regional scale geology and fault networks in the KAS, and has facilitated the first-ever estimations of groundwater resources in this region by a 3D method.

The model enables a preliminary assessment of the hydraulic significance of the major faults by evaluating their influence and role on groundwater flow within and between four compartments of the multi-layered, KAS hydrogeological system. Thus a representative hydrogeological model of the study area is constructed. The possible dual nature of faults in the KAS is discussed in the context that some faults appear to be acting both as barriers to horizontal groundwater flow, and simultaneously as conduits for vertical flow. Also discussed is the possibility that two flow directions occur within the KAS, at a small syncline area of near Feriana.

In summary, this work evaluates the influence of aquifer connectivity and the role of faults and geology in groundwater flow within the KAS aquifer system. The current KAS geological model can now be used to guide groundwater managers on the best placement for drilling to test and further refine the understanding of the groundwater system, including the faults connectivity. As more geological data become available, the current model can be easily edited and re-computed to provide an updated model ready for the next stage of investigation by numerical flow modeling.



## 1. Introduction

In north African nations such as Tunisia, geological exploration under cover remains the most difficult challenge to success in finding continuing water resources, geothermal energy sources, oil and gas, and mineral resources. Securing these resources nationally means long term commercial self-sufficiency and prosperity. To achieve such goals, understanding the geometry of the subsurface by way of 3D geological modeling is essential. Modeling is also essential for ongoing infrastructure projects such as underground storage and mitigation of natural hazards related to sub-surface geology. 3D geological modeling is a tool increasingly used as a means for synthesising all available data and data types, leading to a better understanding and more realistic representation of a given geological setting. Its usefulness has been demonstrated through many different approaches, and these are widely discussed in the literature (Houlding, 1994; Mallet, 2002; Wijns et al., 2003; Wu et al., 2005; Caumon et al. 2009; Kessler et al. 2009; Fernández et al. 2004; Gjøystdal et al. 1985; Saksa 1995; Groshong, 2006; Mallet 1997, 2002; Calcagno et al. 2008;

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http://dx.doi.org/10.1016/j.jhydrol.2016.05.034
0022-1694/

Courrioux et al., 1998, 2001; Martelet et al., 2004; Maxelon and Mancktelow, 2005; McInerney et al., 2005; Gibson et al., 2010, 2011, 2013; Raiber et al., 2012, 2015; Moya et al., 2014).

In central Tunisia, which is characterized by an arid climate, water is a vital and often a limiting factor for adequate livelihood. Groundwater is largely considered as one of the most important current and future natural water sources (Hamzaoui-Azaza et al., 2013; Hassen et al., 2016). In order to preserve this precious resource, and as an aid to better management, the volume of these aquifers needs careful evaluation by assessment of their geometry, structure and connectivity.

The Kasserine Aquifer System (KAS), located in arid zones of central Tunisia, covers an area of about 1300 $Km^2$ centered on the Kasserine region, and comprises four compartments. From NE to SW they are: the Plain and the Plateau of Kasserine, Oum Ali-Thelepte and Feriana-Skhirat (Fig. 1). The KAS represents a multi-layered system of five hydrogeological units from Cretaceous to Quaternary age, including three main regional reservoirs, namely the Plio-Quaternary, the Middle (Mid-) Miocene sandstone and the Cretaceous limestone.

The KAS is composed of variable thicknesses of varying lithologies comprising marls, sands, sandstones, clays and limestone. The upgradient system comprises an unconfined Mid-Miocene sandstone layer with variable thickness ranging from10 to 300 m, while in the downgradient system, the aquifer is confined. The downgradient system is overlain by marls exceeding 400 m thickness.

Integral to the setting of the KAS is a fault network characterized by discontinuities on seven principal faults. As such, the KAS presents many geological interpretation challenges, due partly to the presence of the faults which have little surface expression, and also to the limited data availability in the large scale of the study area including its extent into the north east of Algeria. To date no application of 3D geological modeling has been attempted in the KAS at a regional scale, and yet many questions and issues have been raised. To resolve the challenges and clarify the characteristics of the geological and hydrogeological systems, 3D geological modeling of the KAS is now applied to: (1) verify the geological mapping in 3D for the study region, (2) assess the geometry and volume of the aquifers, (3) define the possible connections between the Cretaceous limestone, Mid-Miocene sandstone and Plio-Quaternary aquifers, (4) discuss the influence of faults on the connectivity between the four compartments of the KAS, and (5) to construct a conceptual model with a consistent flow scheme of the groundwater, ready for future 3D hydrogeological flow modeling.

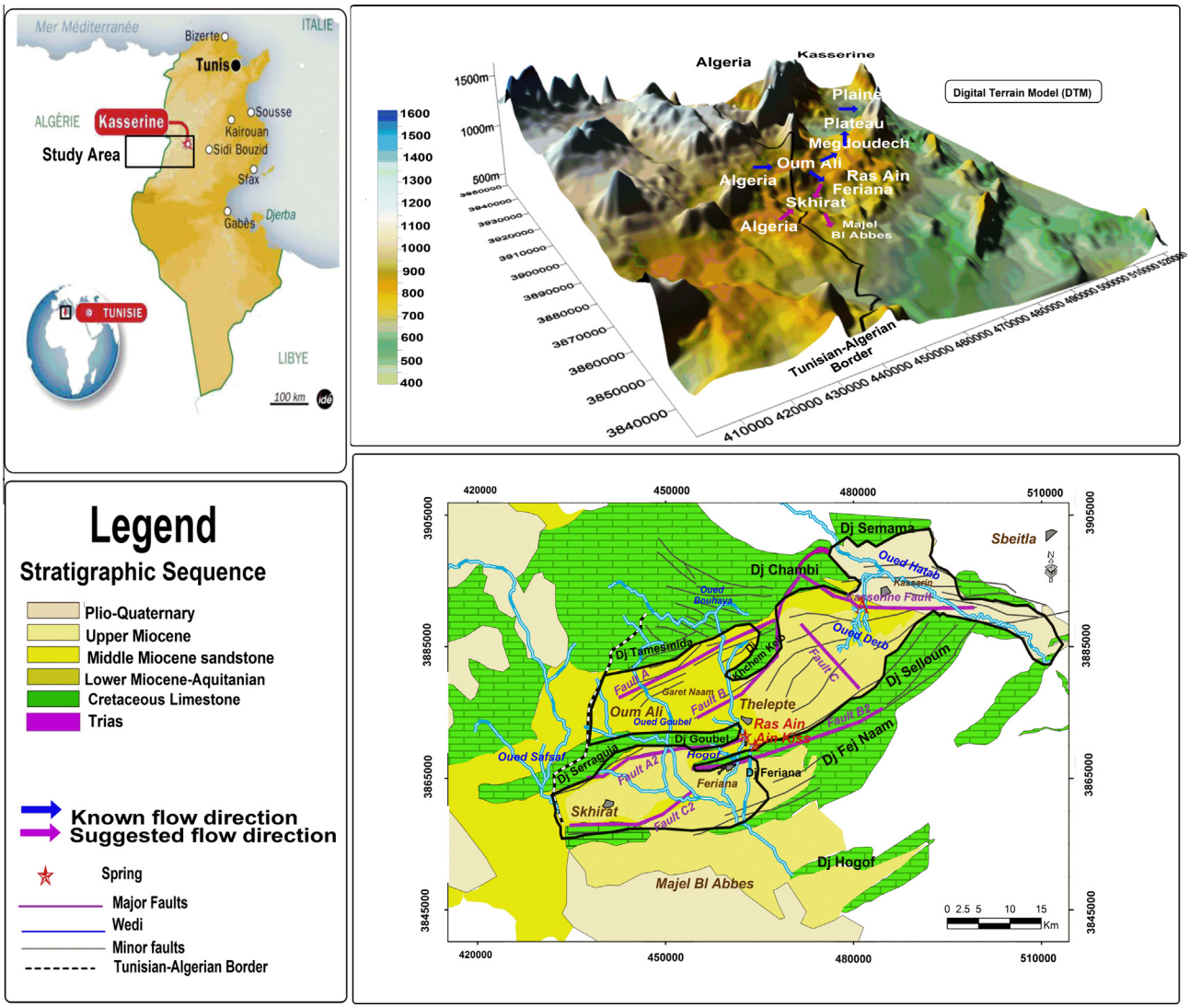


**Fig. 1.** Study area: Digital Terrain Model and geological map of the KAS.