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***Research Article***

# Geothermal exploration of the Essaouira basin by studying the Quaternary aquifer

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***Abstract*** **–** Geothermal energy, an eco-friendly power source tapping into Earth's internal heat, is a renewed ancient solution poised for robust development. Evolving with modern advancements, it provides a sustainable and versatile energy solution by perpetually renewing heat from the Earth's subsoil, enabling applications such as heating systems, networks, and electricity production.

In the Essaouira basin, a focused study assesses geothermal potential by gauging the Quaternary reservoir's temperature. Using advanced techniques like Schoeller and Gigenbach diagrams, alongside established formulas and hydrogeochemical data, the analysis estimates the aquifer's temperature.

The study reveals an average reservoir temperature of approximately 85°C, indicating significant geothermal potential in the Essaouira basin. This finding not only emphasizes local prospects for sustainable energy but also holds broader implications for global efforts in adopting cleaner practices. The perpetual renewal of Earth's heat underscores geothermal energy's role in meeting the increasing demand for environmentally responsible power sources, marking a crucial step towards a more sustainable energy landscape

*Keywords – Geothermic, Aquifer, Quaternary, Renewable Energy, Essaouira Basin*

## I. INTRODUCTION

The onshore Essaouira basin is the central element of the large Mesozoic El Jadida-Agadir coastal basin or "South-West Moroccan basin" [13]. It is bounded to the north by the Doukkala basin, to the northeast and east by the Western Jebilet and Haouz sills, and to the south by the Agadir basin (now the Western High Atlas). To the west, the basin opens onto the Atlantic Ocean. In other words, the Essaouira basin is located on Morocco's Atlantic coast, at the western end of the High Atlas chain.

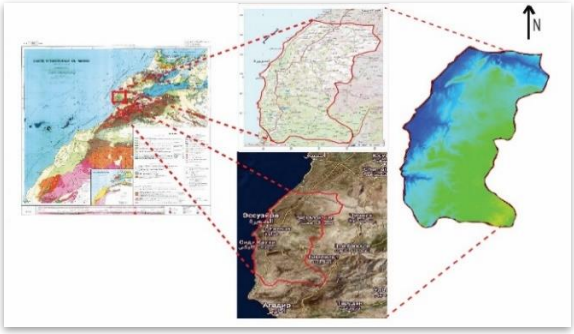

Fig. 1 Geographical location of the Essaouira basin [9]

The Essaouira basin, from the Triassic to the Quaternary, is made up of numerous reservoirs that have been revealed by numerous geophysical studies, oil drilling tests and hydrogeological surveys. These reservoirs are grouped into hydrostratigraphic units and may be of either hydrogeological or hydrogeothermal interest [13].

The Quaternary water table is located in alluvial formations, recent dunes, shell limestone or calcareous sandstone. Its outlets are springs, exhaures, discharges into the sea and abutments with permeable Cretaceous limestone.

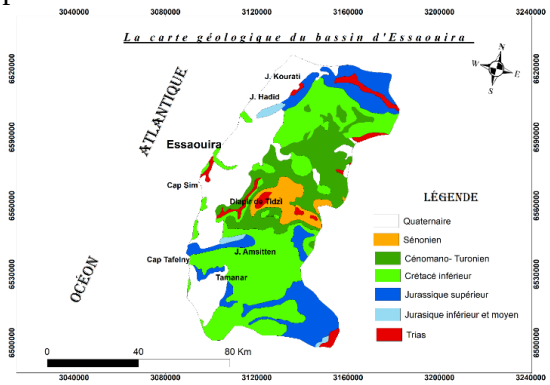


Fig. 2 The geological map of the Essaouira basin [9]

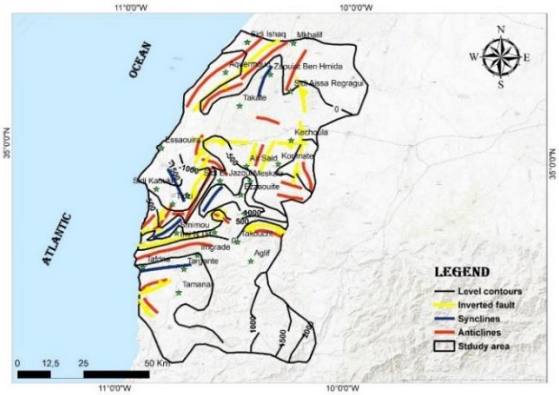


Fig. 3 Structural map of the Essaouira basin [9]

## II. Materials and Method

The method adopted in this study is the determination of the geothermal characteristics of the Quaternary-age aquifer using various diagrams, namely the Schoeller diagram (Fig. 4), Gigenbach diagram (1988) Na-K-√(Mg) [8] with the application of certain formulas established by various authors, such as those corresponding to the Geothermometer Mg/K² (Fig. 5), in order to study and estimate the temperature characterizing this aquifer.

A combination of Na/K and Mg/K² Geothermometer proposed by Giggenbach et al. (1983) in the form of ternary diagrams (Na/1000-K/100-√Mg) [8] is more suitable and reliable for estimating reservoir temperatures. The new formula (Giggenbach, 1983) is also better suited to low temperatures (T<100°C). The formula is as follows:

$$T°C = 4410 / (13{,}95 + log Mg/K^2) - 273.15$$

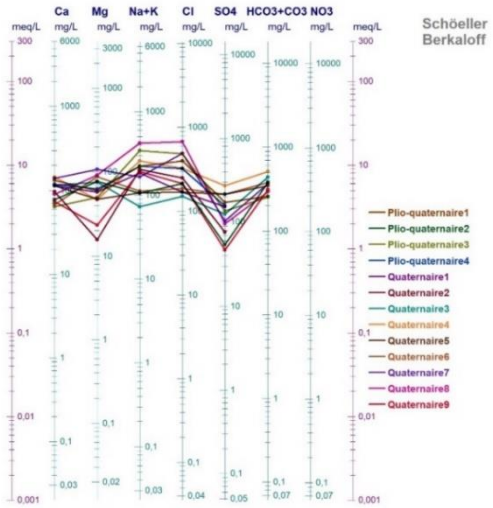


Fig. 4 Schoeller diagram applied to Quaternary waters

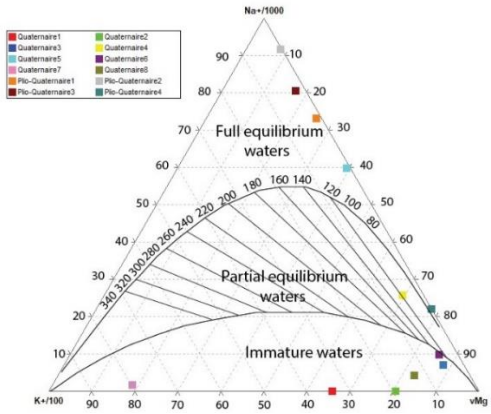


Fig. 5 Na-K-Mg1/2 diagram applied to Quaternary waters

## III. Results

The result of the Schoeller diagram applied to the waters of Quaternary reservoirs corresponds to the dominance of the chemical elements Na+, K+ and

Cl- over the other elements, but in low concentrations.

The Na-K--√(Mg) ternary diagram shows a significant distribution of Quaternary samples in all parts of the diagram. The reservoir shows that the water is in the process of evolving from immature waters where cation Geothermometer are not applicable, specifically (Quaternary 1, 2, 3, 6, 7 and 8) to partially and/or fully equilibrated waters. Temperatures in this aquifer range from 20 to 120°C.

Applying Gigenbach's formula to the waters of the Quaternary-age aquifer, we can deduce that this aquifer is characterized by a temperature of 57°C.

## IV. DISCUSSION

Analysis of the various results suggests that the Quaternary is characterized by an average temperature of 85°C. This reservoir is characterized by waters that are influenced by carbonate, anhydritic and evaporitic formations and, according to previous work, this aquifer is formed by carbonate formations (phosphates and limestones) as well as dune sandstones. This shows that the waters of this reservoir are most likely fed by waters from other aquifers (Triassic, Jurassic...) and that the increase in temperature is linked to this supply.

## V. CONCLUSION

Geothermal exploration in the Essaouira basin using hydrogeochemical data (Bahir, 2007) and studying the Quaternary-age reservoir has produced encouraging results. Analyses and interpretations allow us to estimate the temperature in this aquifer at 85°C, but it could be higher, as there is a possibility of a lowering of the temperature just under the effect of meteoric water. For accurate exploration and estimation, more hydrogeochemical data are needed to apply further diagrams and formulas.

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