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Contributions of geophysics to geothermal prospecting in the Essaouira basin: Seismic reflection

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Abstract –The exploration and understanding of the origins of geothermal sources require an understanding of the lithological nature of the subsurface terrain and its mode of deformation. This understanding can only be achieved through powerful studies such as geophysical studies, specifically seismic reflection surveys. Seismic reflection is a technique that provides insight into the vertical and lateral variation of formations with different types of deformation, namely faults and fractures, which can play a crucial role in the circulation of geothermal fluids. Seismic reflection can detect these structures and help understand their influence on the geothermal potential of a given area. By mapping the geological structure and identifying these key features, such surveys contribute significantly to the planning and development of geothermal resources. Understanding the subsurface geology through techniques like seismic reflection is essential for targeting drilling locations and optimizing geothermal reservoirs' exploitation. In summary, seismic reflection surveys are indispensable tools in geothermal prospecting, providing valuable information about subsurface conditions and geological features that impact the feasibility and effectiveness of geothermal energy extraction in a given terrain.

Keywords –Geothermal, Geophysics, Seismic Reflection, Basin, Essaouira

I. INTRODUCTION

The exploration of geothermal sources requires a thorough understanding of the lithological nature and subsurface deformation processes. This comprehension can only be achieved through in-depth studies such as geophysics, particularly seismic reflection. This technique enables the apprehension of vertical and lateral variations in formations, highlighting the various types of deformations present in a given terrain. By utilizing seismic reflection, researchers gain crucial insights into how faults and fractures influence the geothermal potential of an area. This approach is essential for understanding the complex dynamics of subsurface structures and their impact on the distribution of geothermal resources.

Essaouira basin 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).

The Essaouira basin, from the Paleozoic 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 (fig. 2).

II. MATERIALS AND METHOD

Seismic reflection relies on the use of seismic waves to study the Earth's internal structure. This technique involves generating seismic waves using vibratory trucks, hammers, or explosives, followed by the propagation and reflection of these waves. The reflected waves are then recorded by geophones to produce a profile for interpretation (Fig. 3). Interpretation can be carried out using seismic calibration techniques.

A. Figures and Tables :

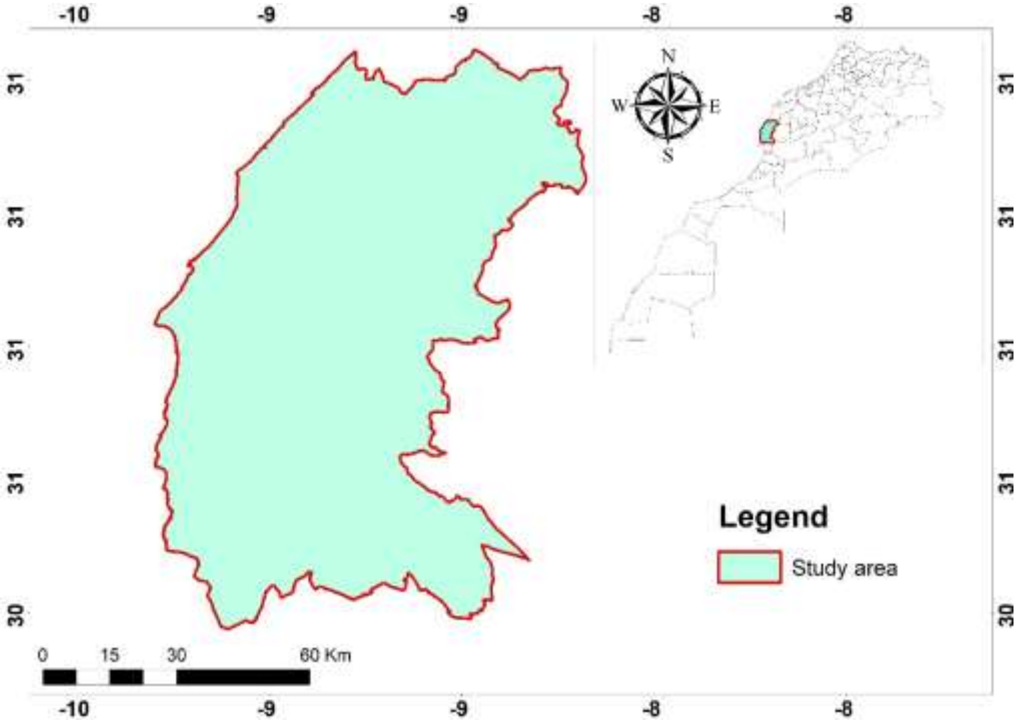

Figure 1. Geographical location of the Essaouira basin in Morocco

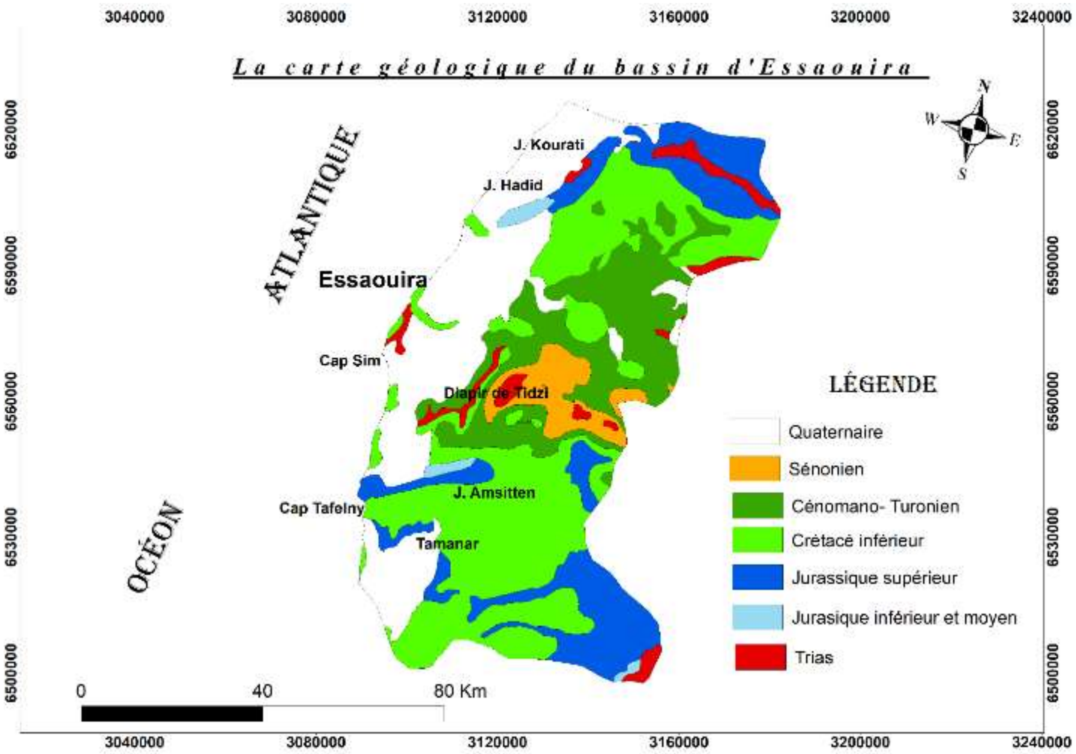

Figure 2. The geological map of the Essaouira basin [1]

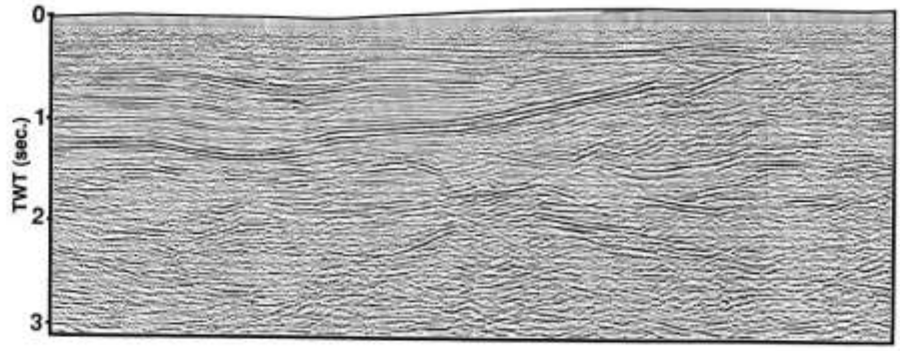

Figure 3. Example of a seismic profile obtained from the processing of signals recorded by geophones [9]

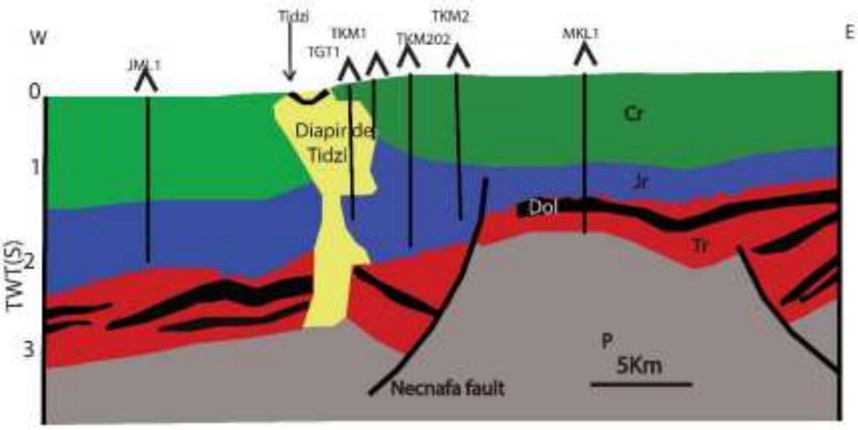

Figure 4. Interpreted seismic profile Modified, Cr: Cretaceous, Jr: Jurassic, Tr: Triassic, P: Paleozoic. The black corresponds to Dolerite (Hafid, 2000).

III. RESULTS

The seismic profile reveals that the Essaouira basin is formed by a thick Mesozoic-age series overlaying Paleozoic formations. The entire terrain is deformed due to numerous faults trending NE to NE-SW. Some faults only deform the Triassic and Paleozoic formations, indicating the presence of half-grabens, while others solely affect the Cretaceous formations, suggesting a probable association with the Alpine orogeny. Additionally, there are major faults deforming the entire terrain, strongly corresponding to Hercynian faults, which were reactivated as reverse faults during the Atlas inversion. Among these latter faults, they traverse all formations and may be responsible for the upward movement of heat from great depths towards the surface (Fig.4).

IV. DISCUSSION

The interpretation of the seismic profile reveals that the entire terrain is deformed due to numerous faults, with the presence of half-grabens. In Morocco, the causes of the increased geothermal gradient are primarily linked to deep hydrodynamics and tectonic factors: deep-seated faults affecting the basement, neotectonics, and Neogene to Quaternary volcanic activity (Zarhloule, 2004). Indeed, the presence of large faults in the Essaouira basin, as shown by the interpretation of the seismic profile, may play a role in transferring heat from great depths to the surface.

V. CONCLUSION

Geothermal energy is a form of renewable energy that harnesses the Earth's natural heat to meet various needs. The geophysical study of the Essaouira basin, using seismic reflection techniques and based on this seismic profile, has allowed us to deduce that perhaps the faults are responsible for the upward movement of heat.

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