GEOMORPHOMETRY 2021
PERUGIA, ITALY
SEPT 13 - 17 2021

Geomorphometric Analysis for Mapping Platforms of the Mazagan Corridor, Morocco

Nada Ait Ayad[1§], Adnane Habib[2], Khalid El Khalidi[1], Abdeloihab Choukri[1], Abdelmounim Charif[1]

1. LGMSS-URAC45, Department of Earth Sciences, Chouaib Doukkali University, El Jadida, Morocco
2. Optics & Photonics Center, Moroccan Foundation for Advanced Science, Innovation and Research (MAScIR), BP 1010, Rabat, Morocco

[§] nadaaitayad@gmail.com

Abstract— **The Mazagan corridor is located in the so-called Sahel-Doukkala and it is in the form of an elongated depression oriented N-S, , in which five platform surfaces are aligned in the principal direction and mainly formed by shell limestone and calcareous sandstones. For this purpose, the Digital Elevation Model was used as primary product to generate a digital map of these platforms and to infer the faults offsets in order to determine the displacements on the faults that border the Mazagan corridor. These faults, coupled with those of other authors, allow to build a synthesis map that highlights 3 families of faults. With a N-S tectonic constraint, the NNE faults delimit a collapse trough whose western limit constitutes the northern extension of the post-Devonian Drabla-Sidi Smain fault, which is itself a reactivation of a Cambrian rift boundary fault. On the other hand, the Oulad Ziane fault, seems to be inherited from the Cambrian and/or Devonian paleogeography and is reactivated in the Quaternary and probably influenced the Plio-Quaternary transgressions.**

I. INTRODUCTION

The Mazagan Corridor is an elongated depression oriented North-South, 35 km long and 5 km wide (Fig. 1). This morphological discontinuity separates the relatively elevated northeastern part with dune ridges and western part called the Plateau of El Jadida. The altitudes within this corridor vary from 95m in the South, to 5m in the North near the beach of El Jadida.

Gigout (1952) [1] describes five topographic surfaces,so-called platforms, with constant altitude for each. These platforms are distributed from south to north according to the following order: the Platform of Oulad Rafai (POR), the Platform of Sebt Oulad Douib (PSOD), the Platform of Pacha (PPA), the Platform of Douar El Khenadra (PDK), and the Platform of the racetrack (PCC). Several hypotheses have been proposed to explain the origins of this corridor, which are a tectonic origin, since its Cretaceous substratum shows a north-south syncline, a hydrologic origin, based on the assumption that this corridor corresponds to a wide river valley without meander; or simply it is the result of karstification process.

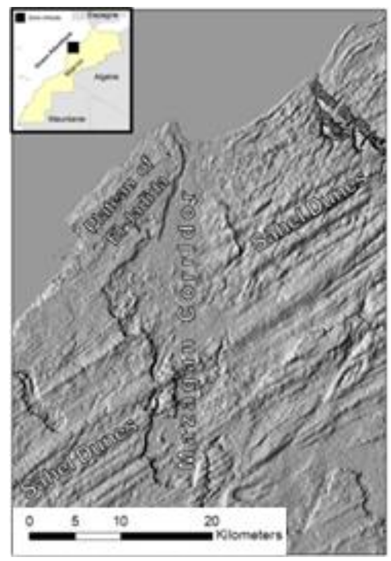

Figure 1. Geomorphological units of the study area.

Since this early platform mapping work, no further studies were performed in that sense and therefore, the resulting map is considered the ultimate map till now. Even though, this map is considered a very important document for geoscientific research, it is one of the most used inputs for conducting civil engineering studies and infrastructure project in this region. However, the map lacks precision and accuracy in terms of spatial distribution of the platforms. Based on this assumption, it was decided to conduct this research in order to produce accurate maps and related documents on the Mazagan Corridor that can be of great help to aforementioned interests. This work is part of a multidisciplinary project aiming to cover all geomorphological, structural and stratigraphic aspect that can give a better understanding of the origin of this corridor.

II. METHODS

Since the platforms are shaped by the geomorphology of the region and have a relatively constant and varying altitude from each one of them, it was decided to use Digital Elevation Model (DEM) as a primary product for further geomorphometric analysis. Habib et al. (2017) have shown that SRTMGL1 suffers from several inconsistencies [2], however it can be a good source for geomorphometric analysis in the region of Sahel-Doukkala, in the case if high resolution DEM is not available. On one hand, the SRTMGL1 was used as the base product to conduct geomorphometric analysis for mapping the different platforms, and on the other hand, it was used to characterize the geometry of faults at the edge of the corridor (Fig. 2).

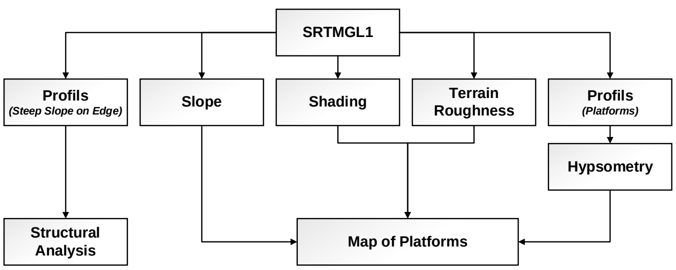

Figure 2. Profiles in the Mazagan corridor.

First, SRTMGL1 was projected into the Lambert conformal conic projection (Zone1), and then a filter based on the algorithm of Sun et al. (2010) [3], was applied under the SAGA software to remove the different errors and artifacts existing in SRTMGL1. Later geomorphometric analysis was carried out to extract geomorphometric parameters that can be related to the platforms, such as shading, slope, hypsometry and terrain roughness (Fig. 3). In addition, several profiles were extracted in different directions in order to investigate the altitudes variation in the different platforms. The combination of these different products as well as the altitudes given by Gigout (1951) allowed to establish new maps of spatial distribution of the platforms. Then, the extracted maps were combined to derive a synthesis map which reflects the new cartographic form for each platform.

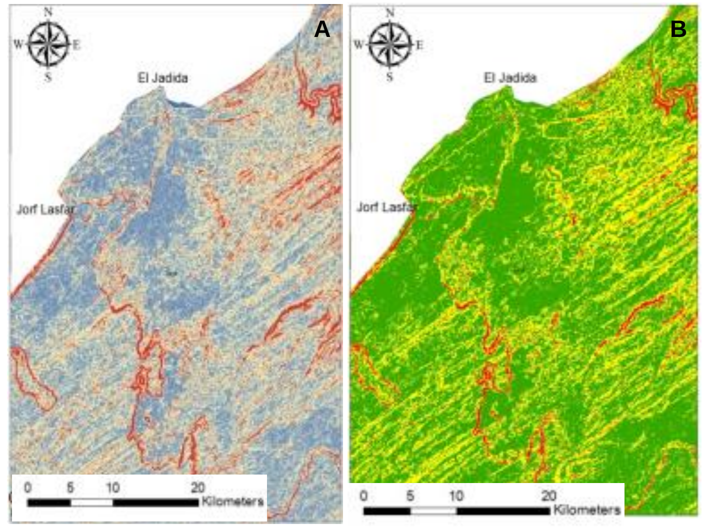

Figure 3. Examples of the extracted geomorphometric parameters. (A) Terrain Roughness (Red illustrates high values and blue illustrates low values). (B) Slope (Red illustrates high values and green illustrates low values).

In the absence of outcrops allowing direct observation of fault offset in the Mazagan Corridor, an indirect method was used to estimate the displacements on its boundaries. Thus, profiles; so-called PRAC, the elevations of the different platforms were made at the level of the El Jadida escarpment but also in its eastern edge (Fig. 4).

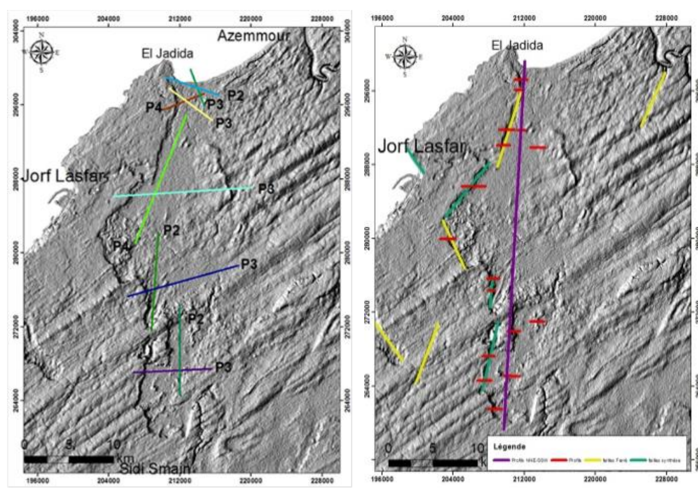

Figure 4. (Left) Profiles used for platforms analysis. (Right) Profiles used for fault offset analysis.

III. RESULTS AND CONCLUSIONS

A. Cartography

Based on the proposed approach, we have been able to extract different kind of information from each product. Using the slope breaks on topographic profiles, a clear idea about the extent of the platform in a given direction was estimated. On the other hand, the combination of different profiles in different directions allows us to delimit the extent of the platforms and consequently its cartographic shape in very precise manner (Fig. 5). The obtained information was used to delineate the lateral extent of the platform using the geomorphometric parameters. The resulted map highlights the presence of five platforms (POR, PSOD, PPA, PDK, PCC) that belong to the Mazagan corridor and has made it possible to propose new cartographic limits to these platforms (Fig. 6).

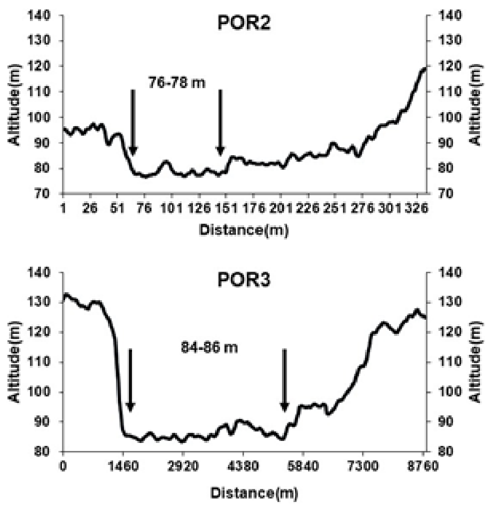

Figure 5. Examples of profiles used to delimit the spatial distribution of the Platform of Oulad Rafai (POR).

For the first platform which is the platform of Oulad Rafai (POR), it can be seen the presence of three terraces (POR1, POR2, POR3) that belong to the same platform. Their shapes differ from the delimitations made by Gigout (1951) towards the SE. On the Sebt Douib platform (PSOD), we have been able to map two depressions, separated by a low hill, one is at 54-60 m and the other at 54-68 m. On the Pacha Platform (PPA), the two profiles show a very clear depression, limited by steep slopes. This suggests a collapsed zone of tectonic origin, especially on its western edge. This edge corresponds to a Cretaceous cliff with a straight NNE line. On the other hand, the Platform of El Khenadra (PDK) shows an altitude of 12 to 23 m for the PDK2 and 11 to 20 m for the PDK3. The digital mapping allows detecting the presence of two terraces PDK1 and PDK2. Finally, the platform of the Racetrack (PCC), shows an altitude of 4 to 11 m for the PCC3 and 3 to 9 m for the PCC1.

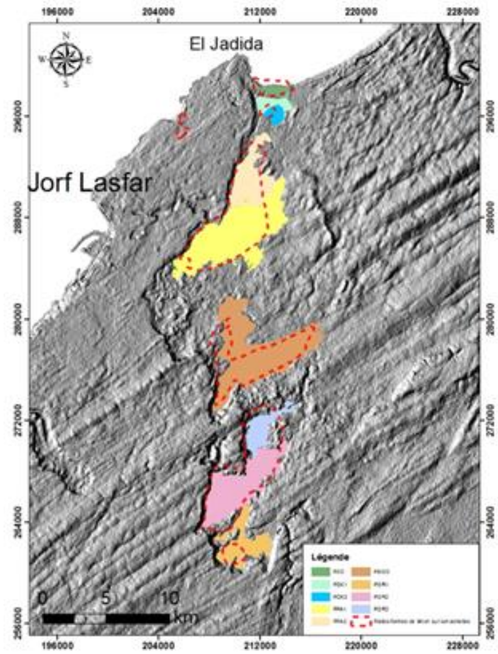

Figure 6. (Left) Profiles used for platforms analysis. (Right) Profiles used for fault offset analysis.

The new cartographic limits of the mapped platforms match perfectly with those already proposed by Gigout (1951), specifically the west limits, and therefore it supports the hypothesis of a tectonic origin. On the other hand, our findings show that the platforms have the same pattern in the northeastern direction, however, the new proposed limits are larger with more details.

B. Tectonics

The Sahel-Doukkala is subject to neotectonic activity [4]–[6], which may be sufficient for the reactivation and apparition of fractures. The edges of the Mazagan corridor show remarkable slopes and scarps especially on the western side where several authors have mentioned the presence of flexures and/or faults [1], [7]–[10].

This, led us to carry out several E-W profiles across this escarpment and along the western edges at the level of the different platforms of the Mazagan corridor (Fig. 7). The results obtained are represented in the following table (Table 1). From these results, the calculated normal fault vertical offsets vary between 10 and 47 m, with an average of 25.5 m. On the western edge, the NNE accident shows offsets that increase from north to south. They measure 20 m at the El Jadida flexure (PRAC3 and PRAC5), 25 m on the eastern fault of Sebt Douib and 36 to 45 m east of Oulad Rafai.

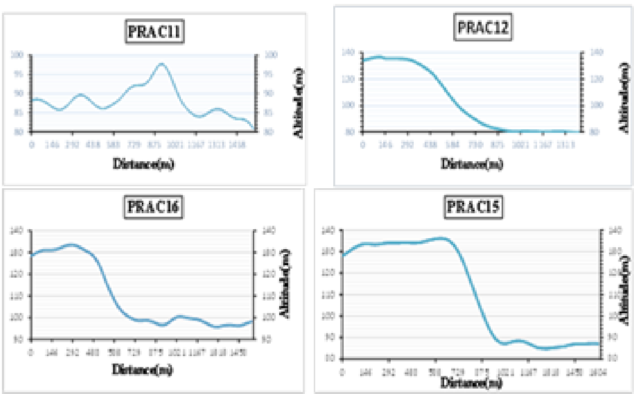

Figure 7. Example of profiles for faut offset analysis.

On the oriental edge, the values are relatively lower and are between 10 and 20m. To the east of the Pacha Platform, the offset is about 10m compared to 20m on the flexure to the west of the same platform. Similarly, the offsets on the west side of the Oulad Rafai Platform (36 to 47m) are higher than those on the east side (13 to 16m). We deduce that the offsets of the NNE faults bordering the Mazagan corridor are stronger on the west side than on the east side.

Table1: Calculated fault vertical offsets.

Profile	Offset (m)
PRAC1	31
PRAC2	11
PRAC3	20
PRAC4	10
PRAC5	20
PRAC6	23
PRAC7	24
PRAC8	25
PRAC9	18
PRAC10	33
PRAC11	13
PRAC12	43
PRAC13	36
PRAC15	47
PRAC16	32

This variation in fault vertical offsets is related to the Jorf Lasfar fault which divides the Mazagan corridor in two parts. In the uplifted northern part, the low values of the offsets bring the Upper Cretaceous substratum into contact with these platforms (PCC, PPA, PDK). In the subsided southern part, the Plio-Quaternary substratum is shifted from the platforms by strong values of fault vertical offsets (POR, PSOD).

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