

CARTOGRAPHY AND GEOMORPHOLOGICAL UNITS OF TETUAN PROVINCE, MOROCCO

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The singularity of the Tetuan province is closely linked to its geological history. The complexity of its landforms and the significant diversity of its sedimentary, igneous, and metamorphic material are at the core of the varied geomorphologic landscape and of the morphogenetic processes found in the region demonstrating an extraordinary parallelism with the Betic Mountain Range.

From a purely physical point of view, the Tetuan province stands out as an area with important natural assets relating to its lithologic, geomorphologic, climatic, and floristic originality that contribute substantially to the geodiversity and biodiversity of the Strait of Gibraltar. The convergence of these diverse factors creates unique and valuable systems, not only for its diversity, but also for the relatively constant degree of conservation not commonly seen in the varied physical world of the Mediterranean region.

It is important to note, however, that humans have had a strong influence on the geoecology of the region modifying the composition and dynamics of the natural elements to meet their needs and acting to form original eco-cultural landscapes of great esthetic and patrimonial worth. The biophysical complexity of the area, the ancientness of its people, and the different moments throughout history of over and under-exploitation are the factors behind the creation of these landscapes and the geomorphological jumble so characteristic of the entire Mediterranean area. Nevertheless, although this dialectic population-territory has existed throughout history, the intense growth in tourism along the Tetuan coastlines in the last years has resulted in a virtual abandonment of many land-use activities that were common up until today and converted many different rock formations, once beautiful landmarks, into extraction sites for construction materials.

The latest transformations stemming from the establishment of quarries in the calcareous Dorsal have deteriorated the beauty and the environment of these valuable rock landscapes as a result of destroying their supporting land foundations. In addition to the deterioration of the rock bases, the mining practices produce mutations in the structure and function of the rock system causing its degradation and destabilization.

In light of these changes, it is important to recognize that the diffusion of geomorphological knowledge about an area such as this needs to be informed by detailed research of high quality so as to add to the partial, and in some cases unknown, geomorphological description of the Strait of Gibraltar.

The following work is a synthesis of the geomorphology of the Tetuan province. The methodology made it possible to differentiate in a wide geomorphological context five large landforms within which exist up to fifteen smaller units that make up the relief of this province and facilitate a collective image of their structural and morphogenetic characteristics. These landforms are the following:

1) Mountains and western hills: This category makes up the first and the largest of the five different landform units. Situated on the western side of the province, it coincides with lithostratigraphic units of Flysch. It is characterized as an undulating low to middle ground level relief of shale marl peppered with sandstone outcroppings that generate more or less delineated topographic projections. This type of landform is divided into two subunits; undulating relief on marl and sandstone mountains and hills.

2) Central mountains: These landforms constitute the second largest geomorphologic unit centered around a border of medium-altitude energetic waters of which Jbel Kelti, (1926 m) stands out as the highest peak. The central mountains present a concentric lithology resulting fundamentally from the erosive action on top of a complex deposit of shifting mantles where the nucleus, more commonly called the chalky Dorsal, is made up of dolomite limestone material. The Dorsal is characterized as a steep relief fragmented by a fluvial network in two large groupings. On the other side, next to the ridge, another geomorphological landform appears with less prominence because of a sandstone piedmont that links it with the Martil river valley.

3) Coastal reliefs: This third largest geomorphological landform which shapes the eastern periphery of the central mountains is composed of a series of materials that are more vulnerable to erosion. It consists of a piedmont made up of small interconnected foothills of metamorphic and sedimentary matter decreasing in size. Within this landform, one can distinguish up to five lesser geomorphological units: (1) a gneissic hill with a steep slope that juts out into the sea and forms the Black Cape (Cabo Negro); (2) a silica line of limestone hills and hillocks with slopes no greater than 30% containing abundant gullies and abrupt taluses at the point where they converge with rivers and streams; (3) hills and hillocks of warped schist that constitutes the largest of the five units; (4) sandstone and marl hills containing traces of solifluction; and finally, (5) a landform unit composed of diverse individual hills. In general, these coastal reliefs conform to the numerous streams and waterways that lead to the Mediterranean Sea and in many instances, join with the sea producing significant cliff units along the coastal strip.

4) Alluvial reliefs: This large heterogeneous landform unit is dispersed around provincial waterways and is, in many cases, connected to the littoral zone. Quarternary material of fluvial deposits predominates as well as an even morphology of fertile and alluvial plains and bordering terraces. The extensive alluvial plain of the Martil River stands out as an example of this landform.

5) Littoral strip: The thin littoral strip comprises the fifth largest landform unit. It is a physical geographic unit made up of a collection of morphologies with one common

denominator: the littoral modeling of its formations. On a regional scale, it can be said that the Rif coastline pertains to the «Pacific» type in that its route runs parallel to and supports the central structure of the region with the mountainous chain forming an almost rectilinear shape with the exception of a few projections. However, the Tetuan coastline presents a more complex configuration. It arrived at its current morphology after experiencing a series of different Pliocene and Quaternary changes with successive stages of erosion and depositing of materials, neotectonic processes, and reorganization resulting from the hydrographic network. As a consequence of this recent geologic activity, either abrasion in the southern half or the accumulation of materials in the northern half, a large part of the coastal strip of the Tetuan region has undergone a regularization. Four geomorphological units have been identified within this littoral strip: cliffs, beaches, dune fields, and tidal marshes and bogs. This division of the relief constitutes the basis of the provincial geomorphological map, which also includes other information related to the tectonics, the structural forms, the karstic forms, and the morphogenetic modeling (fluvial, sloping, eolian and periglacial).

The selected methodology for this investigation of the described relief is based on bibliographic reviews, laboratory work (photo analysis), and fieldwork. In order to contextualize the geomorphology of the province, it was necessary to first study its regional footprint and geological structure. In this initial work, a cursory description of each of the territories, systems, units, and rock formations was done to facilitate the interpretation and knowledge of the geomorphological mapping. Later, a brief paleographic description of the area was performed along with an approximation of the distinct relief landforms that make up the Tetuan province.

Finally, in the conclusions there is a call for information gathering of the region's most relevant geomorphological merits in order to contribute to a balanced approach to land use practices. The Tetuan province depends on its outstanding geomorphological patrimony which is very susceptible to the unfavorable exploitation of its natural resources. One possibility to make the best use of this rich geomorphological landscape is to develop low impact tourism. This can occur in the Oued Laou Gorge, in the depressions and rises of the Dorsal, around the tidal marshes and bogs, and around the extensive beaches and abrupt cliffs that mark the coastline. Low impact tourism is compatible with the conservation of the natural surroundings in that it does not indiscriminately exploit the area's valuable geo-resources.

