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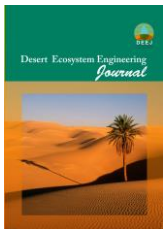

Identification of Morphogenesis Regions and Rock Weathering Regimes Based on the Peltier Model (Case Study: Tajan Watershed)

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Extended Abstract

Introduction: The Quaternary period stands out for its pronounced climatic fluctuations, which have profoundly impacted geological morphogenesis systems and landforms. These highly variable climatic shifts are of significant interest to geomorphologists, particularly for understanding morphoclimatic and morphodynamic transformations. Earth's surface environments are continuously sculpted by the complex interplay of climate, biological activity, and geological processes. Despite their common perception as symbols of stability, rocks progressively lose their structural integrity over time through weathering processes, whether physical, chemical, or biological. Recent research has increasingly concentrated on the influence of climate change on erosional systems and landform development. A prominent framework in this domain is Louis Peltier's model, which systematically investigates the effects of temperature and precipitation on geomorphic processes. Peltier's work notably identified seven distinct weathering regimes, incorporating both chemical weathering and frost activity. A deeper comprehension of the drivers behind landform evolution is crucial, as it enhances our capacity to assess geomorphic hazards and environmental potentials, thus playing a vital role in both infrastructure planning and land management.

Materials and methods: This study aimed to zone rock weathering regimes within the Tajan watershed based on Peltier's model. To assess the weathering conditions and associated morphogenesis forms across the basin, we acquired climatic variables, specifically annual average temperature and precipitation data, from synoptic stations provided by the Mazandaran Meteorological Department. After addressing statistical deficiencies, including the removal of outliers and the estimation of missing data using regression methods, four synoptic stations with reliable long-term records (1983–2023) were selected for analysis. A geospatial database was subsequently developed in ArcGIS, integrating topographic maps (specifically, elevation classes and slope gradients) and fluvial erosion data. Following the analysis of temperature and precipitation trends at the selected stations, the corresponding weathering regimes were identified using Peltier's model. These regimes were then assigned weighted values, and their spatial distribution maps were generated using the Inverse Distance Weighting (IDW) interpolation method. Finally, leveraging this comprehensive database, we produced morphogenesis maps and maps illustrating the intensity and type of weathering throughout the Tajan watershed, all based on Peltier's classification system.

Result: The physical characteristics of the Tajan watershed, including elevation classes, aspect, and erosion, are pivotal in influencing the type and intensity of rock weathering. To facilitate this analysis, relevant maps depicting these variables were prepared. Climate is a central driver of geomorphic processes, hydrological conditions, vegetation cover, wildlife distribution, and human activities. Based on the patterns of temperature and precipitation, the study area

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is primarily divided into two main climatic types: The Caspian temperate climate and the mountainous climate. The latter further encompasses both temperate and cold subtypes.

Our findings indicate that the highest temperatures are recorded in the northwestern part of the region, correlating with lower elevations. Conversely, the lowest temperatures are observed at the Pol Sefid station, which is situated at higher altitudes. Precipitation exhibits a clear south-to-north gradient, with the highest rainfall occurring in the western part of the region during spring. The Amirabad station records the highest annual precipitation (1,025 mm), whereas the Pol Sefid station receives the lowest (210 mm). Climatically and geomorphologically, the watershed is categorized into three distinct zones: semi-arid, temperate, and savanna. Among these, the temperate zone covers the largest area, spanning 1,599 km², while the savanna zone has the smallest extent at 1,269 km². Applying Peltier's model, three primary types of weathering regimes were identified within the region. Low mechanical weathering is the most extensive, covering an area of 2,630 km². In contrast, very low-intensity weathering is the least extensive, occupying 595 km².

Discussion and Conclusion: Weathering processes lead to the disintegration of hard, compacted rocks into fragments of varying sizes, driven by physical, chemical, or biological factors. On steep slopes, these unstable fragments rarely remain in situ; instead, they are mobilized downslope by gravity, mass weight, or transport mechanisms such as sliding, falling, and flowing, ultimately accumulating at the base of slopes. The study of weathering is critical due to its role in rock breakdown and decomposition near the Earth's surface, its intensification of erosion, its contribution to gravitational collapses, its facilitation of landform development, and its influence on mineral deposit concentration and soil formation. The Tajan watershed, our study area, is characterized as a high-rainfall basin with diverse topography, encompassing both lowland and mountainous zones. In the lowlands, minimal temperature fluctuations enhance susceptibility to chemical weathering, a finding consistent with our results. Weathering processes are influenced by a range of environmental parameters, with annual average temperature and precipitation recognized as primary drivers. Peltier's models, which formed the basis of this study, also rely on these two fundamental climatic indicators. Our research findings indicate that the region's temperature and precipitation patterns are largely governed by its geographic location (latitude) and topographic structure, including the orientation and alignment of mountain ranges. These factors significantly shape the spatial variability of weathering patterns across the basin. Overall, elevation and slope orientation emerge as key determinants in the formation of weathering regimes and their associated geomorphological features.

Keywords: Tajan Watershed, Geographic Information System, Morphogenesis Regions, Rocks Weathering.