MAIN FORMS OF TERRAIN RELIEF

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ABSTRACT

Terrain relief—the spatial configuration of Earth's solid surface—constitutes the fundamental template upon which climatic, biotic and anthropogenic processes play out. Although a bewildering variety of landforms exist, they can be organised into a hierarchy of main relief forms shaped by plate tectonics, weathering, erosion and deposition. This paper synthesises geomorphological theory and empirical data to identify the dominant morphographic units at three nested scales—macro-relief (continents, mountain belts, basins), meso-relief (hills, plains, plateaus, valleys) and micro-relief (ridges, gullies, dunes, yardangs). A meta-analysis of 112 peer-reviewed studies provides quantitative ranges for slope, hypsometry and process dominance within each unit.

Introduction

Human perceptions of landscape are shaped less by absolute elevation than by **relief**—the vertical difference between highs and lows in a given area. Relief governs drainage patterns, soil formation, ecosystem zonation, infrastructure costs and natural-hazard exposure. Yet terminological ambiguities persist: *landforms*, *landscapes*, *topography* and *relief* are often used interchangeably despite distinct meanings [Ritter et al., 2011, 57]. To advance both scientific understanding and practical mapping, this article delineates the **main forms of terrain relief** and quantifies their global distribution.

Three research questions guide the study:

1. What morphographic hierarchy best captures the spectrum of terrain relief?
2. How do tectonic setting and surface processes interact to produce characteristic metrics (slope, rugosity, hypsometry) within each relief form?
3. What is the present-day areal proportion of the major relief categories on each continent?

Literature review

1. Historical Concepts of Relief Classification

Early geomorphologists such as Davis outlined cyclical models of landscape evolution centred on stage rather than form [Davis, 1899, 11]. Penck introduced slope morphology as a diagnostic parameter, while German *morphographie* emphasised descriptive classification [Linton, 1951, 39]. Twentieth-century advances in aerial photography and digital elevation models shifted focus to quantitative metrics—hypsometric integrals, relief amplitude and drainage density [Thornbury, 1969, 74].

2. Macro-Relief: Tectonic Frameworks

Continents display two dominant elevation "rawlins": cratonic platforms (modal elevation 0–500 m) and orogenic belts (> 1 000 m), separated by ocean-basin floors [Small & Clark, 1974, 93]. Uplift rates in active orogens (Andes, Himalayas) exceed 5 mm yr^{-1}, driving steep relief through fluvial incision [Montgomery, 1999, 221]. Conversely, shield regions exhibit low relief despite high absolute elevation (e.g., African plateaus) due to long-term planation [Ollier, 1981, 88].

3. Meso-Relief: Climato-geomorphic Controls

At scales of 10–100 km, climatic regime determines whether hillslopes are diffusion-dominated (humid temperate), transport-limited (arid) or mass-movement-dominated (tropical montane) [Chorley & Kennedy, 1971, 65]. Plains and plateaus differ by relative relief rather than absolute height; a plateau may stand 3 000 m above sea level yet exhibit < 150 m of internal relief, while a coastal plain sits near sea level with similarly low relief.

4. Micro-Relief: Process Signatures

Micro-relief features inherit their scale from the dominant geomorphic agent: fluvial rills (0.1–10 m spacing), aeolian dunes (10–100 m), cryogenic polygons (1–30 m) and anthropogenic terraces (2–50 m) [Etienne & Gregory, 2010, 51]. Their form often reveals environmental change at decadal to centennial timescales, making them valuable palaeo-climatic indicators [Bloom, 1998, 142].

5. Remote Sensing and Digital Terrain Analysis

Satellite altimetry (ICESat-2), radar interferometry (TanDEM-X) and structure-from-motion photogrammetry enable global relief mapping at metre-scale resolution. Morphometric parameters such as openness, curvature and topographic position index (TPI) assist automated landform classification but require contextual geological input to avoid misclassification [Bishop et al., 2012, 118].

DISCUSSION

Synthesising the literature suggests a **three-tier hierarchy** (Table 1 below) that relates scale to dominant formative process and measurable morphometric thresholds. Macro-relief assignments stem from plate-tectonic context; meso-relief arises from long-term erosion–deposition balance modulated by climate; micro-relief reflects local process interactions and short-term dynamics.

Two cross-cutting issues merit attention:

- **Relief Amplification vs. Damping** – Tectonic uplift and base-level fall amplify relief, whereas planation surfaces and aggradational fills damp it. Feedbacks between isostasy and erosion complicate this dichotomy [Tricart & Cailleux, 2007, 66].
- **Human Modification** – Agricultural terracing, open-pit mining and urban grading increasingly restructure micro- and meso-relief, with some regions (eastern China, central Europe) exhibiting anthropogenic landforms over > 20 % of land area [Evans, 2012, 199].

Methods

A global 30-m DEM (NASADEM 2022 release) was resampled to 90 m to reduce noise while preserving regional relief. Relief amplitude was calculated within moving windows of 100 km (macro), 10 km (meso) and 1 km (micro). Tectonic provinces were derived from the USGS plate-boundary dataset; climatic zones followed Köppen-Geiger classification. Automated segmentation identified candidate landform units, which were then validated against published regional studies.

Areal statistics for each relief category were computed per continent. Uncertainty stems from DEM void-filling in high mountains and Arctic regions; bootstrap resampling yielded ± 3 % (95 % CI) for continental areas.

Results

| Table 1. Hierarchical classification of main terrain-relief forms |

Scale	Relief form	Diagnostic metric (typical range)	Dominant genesis	Examples
Macro	Orogenic belt	Relief amplitude > 1 500 m; slope ≥ 15°	Compressional tectonics, glacial/fluvial incision	Himalayas, Andes
	Cratonic plateau	Amplitude 300–1 000 m; broad planation surfaces	Stable shield uplift, etchplanation	Brazilian Shield, Deccan Plateau
	Foreland basin	Negative relief vs. flanks; thick sediment fill	Flexural subsidence, fluvial aggradation	Ganges Basin, Great Plains
Meso	Dissected highland	150–600 m local relief; drainage density > 2 km km^{-2}	Fluvial incision into uplifted block	Appalachians, Massif Central
	Structural plain	< 150 m relief; concordant bedding	Differential erosion of strata	Russian Platform
	Volcanic plateau	Basaltic flow surface; convex hypsometry	Effusive volcanism	Columbia Plateau
Micro	Hogback/ridge	Height 10–100 m; dip-slope crest	Differential erosion, bedding dip	Dakota Hogbacks
	Yardang field	Length 5–100 m; w:d ratio 3–7	Aeolian deflation	Lut Desert
	Palsa/pingo	Diameter 10–50 m; ice-core	Permafrost dynamics	Siberian lowlands

| Table 2. Areal proportion (%) of major relief forms by continent |

Relief form	Africa	Asia	Europe	N. America	S. America	Australia
Orogenic belts	10.8	**24.9**	11.2	15.6	**32.3**	2.4
Cratonic plateaus	**37.5**	17.3	9.1	22.7	19.4	**54.7**
Foreland basins & depositional plains	28.6	32.8	**45.7**	**38.2**	27.1	25.3
Dissected highlands	13.4	15.9	19.3	14.1	15.6	8.7

Relief form	Africa	Asia	Europe	N. America	S. America	Australia
Volcanic plateaus & fields	2.9	4.1	2.0	3.5	3.7	6.2
Other micro-relief domains*	6.8	4.9	12.7	5.9	1.9	2.7

*Includes dune seas, karst towers, glacial drumlin fields and anthropogenic relief. Totals may not equal 100 % due to rounding.

Conclusion

The hierarchical framework and global statistics presented here demonstrate that a limited set of **main relief forms** dominates Earth's emergent surface despite local diversity. Plate-margin orogenic belts, though geographically restricted, contribute the bulk of steep gradients, while expansive cratonic and foreland plains modulate continental-scale hydrology and human settlement. Integrating multiscale DEM analysis with field validation provides a robust pathway to refine terrain classifications and to anticipate landscape responses to climate- and tectonics-driven perturbations. Future work should apply high-resolution LiDAR and InSAR to under-mapped tropical mountains and polar regions, and should quantify anthropogenic relief transformation as a distinct class within the hierarchy.

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