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Granite geomorphology and its geological controls, Serra da Estrela, Portugal

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ABSTRACT

Serra da Estrela is an elevated granite massif in central Portugal, characterized by extensive plateau surfaces incised by deep valleys affected by Quaternary glaciation, bounded by steep fault-generated escarpments. The presence of seven major textural variants of granite provides an opportunity to study the relationships between lithology and relief, whereas DEM analysis helped to show the relationships between lithology and topography objectively. The higher ground is associated with fine- to medium-grained granites and is typified by planar surfaces of low gradient, with occasional angular tors and rock pedestals. Block fields built by angular material are common in the parts that were not previously glaciated. Less elevated parts of the plateau are supported by medium- to coarse-grained granites and show more varied topography, with an abundance of tors, boulder piles, and depressions. Lithological boundaries locally coincide with slope breaks but this is not the rule. In the northern part of the massif a deep topographic basin has evolved in biotite granite, whereas deeply incised valleys follow major fault lines. Geological controls show a hierarchy, in that gross relief reflects the pattern of tectonic uplift and subsidence, whereas lithology and then fracture patterns become more and more important if one focuses on smaller and smaller landforms.

1. Introduction

Geological factors are amongst the fundamental controls in the evolution of landscapes and are therefore central to geomorphological interpretation. One of the approaches used to assess rock control at a regional scale could be to compare geomorphometric characteristics and landform assemblages of adjacent terrains underlain by different rock types and, if they are different, to use this evidence to argue for an influence of rock properties on the rates and directions of geomorphic change through time (e.g. Kühni and Pfiffner, 2001; Grebby et al., 2010; Zhang et al., 2013). Within this framework differences in altitude are interpreted as either the result of differential rock-controlled erosion or the consequence of spatially varied uplift and subsidence. Among common rock types, granite is often cited as one that supports very distinctive assemblages of landforms (e.g. Thomas, 1974; Godard, 1977; Twidale, 1982; Gerrard, 1988; Godard et al., 2001; Twidale and Vidal Romaní, 2005; Migoń, 2006). Boulders, tors and inselbergs, although not restricted to granite, are characteristic for most granite terrains, whatever the climatic conditions.

Less emphasis has been given to geomorphic variation *within* granite terrains. In many studies it has been demonstrated that jointing patterns guide exogenic processes and hence, exert considerable control on the shape of individual landforms, whether convex (domes, tors, boulder fields) or concave (basins, valleys, channels). Recent reviews are provided by Godard et al. (2001), Twidale and Vidal Romaní (2005), and Migoń (2006), each summarizing a wide range of site-specific publications from different settings and published in different languages. By contrast, the influence of lithological variation has been seldom addressed, although a significant contribution to the understanding of the role of lithology has been made by the French school of structural geomorphology, as summarized by Lagasquie et al. (2001). The granite family in fact includes rocks of varied compositions (Streckeisen, 1976), hence with different proportions of minerals of varied susceptibility to weathering, and an equally wide range of textures. Fracture density also varies considerably. Since both rock composition and fracture patterns influence the intensity of exogenous processes acting upon rock surfaces and rock masses underground via deep weathering, there are good reasons to assume that different lithological variants of granite may be associated with different types of terrain. In a number of studies such relationships have been indicated. For example, Flageollet (1977, cited in Godard et al., 2001) showed that in Limousin, France, higher altitudes correlate with decreasing plagioclase and, especially, biotite content, while Lagasquie (1984) presented evidence that granodiorite ranks as less resistant than monzogranite in the French Pyrenees and preferentially occupies topographic hollows. Pye et al. (1986) have demonstrated that inselbergs in the Kora area of Kenya tend to occur in potassium-rich granites, a finding confirmed in several

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