Available online at www.sciencedirect.com
ScienceDirect
Geomorphology 97 (2008) 190–207
GEOMORPHOLOGY
www.elsevier.com/locate/geomorph

Combined numerical and geomorphological reconstruction of the Serra da Estrela plateau icefield, Portugal

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Received 3 October 2006; received in revised form 5 December 2006; accepted 26 February 2007
Available online 23 June 2007

Abstract

The paper focuses on reconstructing a plateau icefield surface from field geomorphological data and a physical-based glacier model. The results allow the analysis of the patterns of glacial erosion and the estimation of the palaeo-Equilibrium Line Altitudes (ELA). The study area is the Serra da Estrela, a plateau in Central Portugal rising to ~2000 m ASL. The glaciated area during the Last Maximum of the Serra da Estrela Glaciation (LMGSE) was ~66 km^2. The reconstruction of the topography of the icefield and valley glaciers in the LMGSE is based on the Schilling and Hollin model. It iterates along the valley longitudinal profile and is based on the gradient, on valley-shape indices and on yield basal shear stresses. These variables influence ice thickness and therefore, also the slope of the ice surface allowing for its reconstruction. The key variable is basal yield shear stress and its value was included in the model manually starting from the points of maximum extent of the valley glaciers and following a range known to occur in contemporary conditions. The input values are validated by matching the resulting ice surface to geomorphological features. Where these are absent, a constant value of 100 kPa was used. The icefield was reconstructed from a radiating set of long-sections, along which ice thicknesses were calculated. A DEM of the ice surface was constructed, allowing the estimation of the hypsometric curves of the distinct glacier catchments and the calculation of the palaeo-ELAs. The results show a regional ELA at 1650 m ASL with spatial variations across the icefield reflecting mainly the effect of eastward snow drift. The LMGSE glaciers were very sensitive to minor climatic changes, especially due to the large area of the plateau icefield, and to the positioning of the ELAs, close to, or in the, flat part of the hypsometric curve. The model of the ice surface is of significant value for the analysis of the patterns of glacial erosion at the landscape level. In the Serra da Estrela most of the glacial erosion occurred near the plateau margins and in valley heads, where glacier surface slope was steeper allowing for a faster ice flow and where ice flow concentrated. Strong glacier erosion in the Zêzere valley is linked to the tectonic setting, but also to the confluence of glaciers and to the overfeeding of snow from the plateau.

Keywords: Plateau icefield landsystem; Glacial erosion; Glacier model; ELA; Balance ratio; Portugal

1. Introduction

Equilibrium Line Altitudes (ELA) of glaciers are particularly sensitive to changes in summer temperature and winter precipitation (Ohmura et al., 1992; Paterson, 1994; Nesje and Dahl, 2000). The accurate estimation of the ELA is therefore of major importance for

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0169-555X/$ - see front matter © 2007 Published by Elsevier B.V.
doi:10.1016/j.geomorph.2007.02.042