EARTH SURFACE PROCESSES AND LANDFORMS
Earth Surf. Process. Landforms **35**, 531–548 (2010)

Published online 13 January 2010 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/esp.1950

Restoring earth surface processes through landform design. A 13-year monitoring of a geomorphic reclamation model for quarries on slopes

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Received 10 March 2009; Revised 27 August 2009; Accepted 5 October 2009

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ESPL
Earth Surface Processes and Landforms

ABSTRACT: The application of geomorphic principles to land reclamation after surface mining has been reported in the literature since the mid-1990s, mostly from Australia, Canada and the USA. This paper discusses the reclamation problems of contour mining and quarries on slopes, where steep gradients are prone to both mass movement and water erosion. To address these problems simultaneously, a geomorphic model for reclaiming surface mined slopes is described. Called the 'highwall–trench–concave slope' model, it was first applied in the 1995 reclamation of a quarry on a slope (La Revilla) in Central Spain.

The geomorphic model does not reproduce the original topography, but has two very different sectors and objectives: (i) the highwall–trench sector allows the former quarry face to evolve naturally by erosion, accommodating fallen debris by means of a trench constructed at the toe of the highwall; (ii) the concave-slope base sector, mimicking the landforms of the surrounding undisturbed landscape, promotes soil formation and the establishment of self-sustaining, functional ecosystems in the area protected from sedimentation by the trench. The model improves upon simple topographic reconstruction, because it rebuilds the surficial geology architecture and facilitates re-establishment of equilibrium slopes through the management and control of geomorphic processes.

Thirteen years of monitoring of the geomorphic and edaphic evolution of La Revilla reclaimed quarry confirms that the area is functioning as intended: the highwall is backwasting and material is accumulating at the trench, permitting the recovery of soils and vegetation on the concave slope. However, the trench is filling faster than planned, which may lead to run-off and sedimentation on the concave slope once the trench is full. The lesson learned for other scenarios is that the model works well in a two-dimensional scheme, but requires a three-dimensional drainage management, breaking the reclaimed area into several watersheds with stream channels. Copyright © 2010 John Wiley & Sons, Ltd.

KEYWORDS: geomorphic reclamation; landform design; quarry reclamation; hillslope evolution of reclaimed mines; Segovia province (Central Spain)

Introduction

This paper discusses a geomorphic model for the reclamation of an abandoned silica sand quarry on a slope of Central Spain (La Revilla), and documents its 13-year geomorphic and edaphic maturation. Reclamation was planned and executed using geomorphic principles, and it involved local landform-based topographic reconstruction, replacement of original surficial deposits and management of the long-term geomorphic dynamics. The logic behind this study requires an understanding of the role of geomorphic processes in mining reclamation with attention to the specific rehabilitation problems of quarries on slopes, so this background is presented before discussing the study in detail.

Mining moves earth and shapes new landscapes

Cumulative effects of human-induced earth movements have a profound effect on global change (Osterkamp and Morton, 1996): 'humans are arguably the most important geomorphic agent currently shaping the surface of Earth' (Hooke, 1994, p. 217; Hooke, 1999). In particular, surface mining is most efficient at moving earth (Hooke, 1994).

Surface mining imposes severe ecological effects on the land because alteration affects vegetation, soils, bedrock and landforms. Surface hydrology and groundwater levels and flow paths are also changed (Osterkamp and Joseph, 2000; Nicolau and Asensio, 2000).