Geomorphic restoration

Brief description

Geomorphic Restoration includes a set of techniques, procedures and software capable of designing and building landforms and soils that replicate the shape and dynamics of natural landscapes. All that in lands and terrains either already transformed and degraded (brownfields sites) —or new projects (greenfield sites)— by human activities that move earth, such as mining, civil works, all type of landfill and waste repositories or urban developments. Geomorphic Restoration belongs to terrain engineering and landscape architecture.

Figure 1. Geomorphic Restoration of the external waste rock dumps of the Santa Engracia mine (Peñalén, Guadalajara, Spain), carried out with the GeoFluv – Natural Regrade method. Left, pre-restoration situation, March of 2020 (photo by Diedro). Right, post-restoration situation, May of 2021 (photo by M.A. Langa).

How does it work?

A Geomorphic Restoration solution consists of: (1) Identifying natural, steady state landforms and landscapes, developed within similar environmental conditions than those of the project. (2) Analyzing the topographical and hydrological conditions of the site to be restored. (3) Making a geomorphic landform design in CAD format. (4) If needed, the erosive and hydraulic stability of the design is evaluated, with tools such as landscape evolution modelling (SIBERIA type) or hydrodynamic models (IBER type). (5) If required, geotechnical, geochemical or revegetation reports are integrated, in collaboration with expert colleagues. (5) Writing the reports of projects of land restoration. (6) Guiding the construction of the geomorphic restoration, with previous training of machinery operators and construction managers. (7) Monitoring the performance and evolution of the scenarios in which Geomorphic Restoration has been applied.

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What problem does it solve?

Geomorphic Restoration solves problems related with high land instability by water erosion, mass movements and action of other geomorphic agents (such as wind), environmental impact and social conflicts related with earth movements, providing stable, ecologic, holistic, durable and efficient solutions. Therefore, reducing restoration maintenance and social confrontation. All that in contrast with the limitations of the usual approaches of landform design by conventional engineering, which too often are highly vulnerable to water erosion and have a very low ecological, hydrological and visual integration and connection with the surrounding landscape, which is starting to causing a broad social and regulators rejection.

Figure 2. Geomorphic Restoration of a sector of the Riotinto mine (Atalaya Mining, Huelva, Spain). Left, pre-restoration scenario in 2021. Right, post-restoration result, in 2024 (photo by Atalaya Mining).

What future products will it develop?

Geomorphic Restoration creates new functional, dynamically stable landscapes, which maximize biodiversity, but the land use potential by current and future generations. Geomorphic Restoration is applied, mostly, in mining, civil works, all type of waste landfills and repositories, and urban development projects.

Competitive advantages compared to other research.

In contrast with the conventional approaches of landform design, the sites that are subject of Geomorphic Restoration:

1. Achieve a much higher stability against any type of erosion, mostly water erosion, reducing maintenance costs, such as gully repairing or revegetation failures
2. Maximize the ecological, hydrological and visual integration of the intervened sites, blending and connecting them with the topography and drainage network of the surrounding terrain
3. Accomplish a broad social and regulatory acceptance, so that, for example, many new mining projects which are rejected with conventional landform design, achieve permit approvals and a broad community acceptance, on the basis of Geomorphic Restoration

Geomorphic Restoration solutions were born in Canada and United States at the 1990 decade. Since then, they were transferred, thanks to our group, to Europe. They were also transmitted to Australia. Recently, our group is spreading them to Iberoamerica. So far, the results are successful, and they are supported by a growing scientific literature, which can be found at www.restauraciongeomorfologica.es.

Where has it been developed?

Restauración Geomorfológica® (www.restauraciongeomorfologica.es) is a research and transference group of the Complutense University of Madrid, created and lead by José F. Martín Duque, Professor of Geomorphology at the Faculty of Geology and Geosciences Institute (CSIC-UCM). Although the group was born in 2010, J. F. Martín Duque, always in collaboration with other people, has lead geomorphic restoration projects in areas degraded by earth movements (mostly mining) since 1995. This group has developed Geomorphic Restoration solutions in 23 built projects in Spain, and more than 20 designed, distributed in nine Autonomous Regions. In addition, we have participated in projects, or lectured, about Geomorphic Restoration in Australia, Belgium, Canada, Colombia, Chile, Germany, Israel, Paraguay, Portugal, United States, Saudi Arabia and Sweden.

And moreover…

We are the leader group, worldwide, in Geomorphic Restoration. Specifically, we are the only group in the world: (a) capable of providing Geomorphic Restoration solutions for different geologic settings (GeoFluv – Natural Regrade for non-consolidated materials) and Talus Royal for hard-rock settings; all that with the inventors of those methods, Nicholas Bugosh and Paul Royal, respectively. (b) teaching those techniques in a University, worldwide. Additionally, we are the group: (c) with a higher number of geomorphic restoration projects designed and built, at a global scale. (d) with the largest number of scientific publications (papers) on geomorphic restoration at a global scale. (e) with the higher degree of internationalization in the discipline of Geomorphic Restoration, both in terms of number countries in which we have worked or lectured or number of international experts with which we collaborate. More information at www.restauraciongeomorfologica.es.

Figure 3. Geomorphic restoration of the former highwall of the Santa Engracia mine (Peñalén, Guadalajara), carried out following the Talus Royal method. Left, pre-restoration condition, in 2020 (photo by Diedro). Right, post-restoration situation, in 2024 (photo by M.A. Langa).

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