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The role of mass wasting in the evolution of valley systems: an example from the Molise region (Southern Italy)

Aucelli Pietro (1), Rosskopf Carmen (2), and Di Paola Gianluigi (2)

(1) University of Naples Parthenope, Department of Environmental Sciences, 80143 Naples, Italy (pietro.aucelli@uniparthenope.it)., (2) Molise University, Department S.T.A.T., 86090 Pesche (IS), Italy (rosskopf@unimol.it; gianluigi.dipaola@unimol.it)

The Adriatic flank of Apennine chain in the Molise Region (Italy) is a typically hilly to mountainous landscape built from prevailingly weak rocks. In fact, the Molise region is characterised by a high susceptibility to mass wasting and, according to a recent region-wide landslide inventory (2007), is affected by ca. 23,000 landslides which are considerably more frequent along the Adriatic flank where about 15,000 active and dormant landslides have been censured. Main types of movements are slides, flows (far the most frequent type) and complex and/or composite phenomena, mainly slide-flows. Such major frequency clearly depends, besides the major presence of weaker rocks such as the Varicoloured scaly clays and marls (characterised by a landslide index of 42 %), on the frequent juxtaposition of stratigraphic successions of markedly different mechanical behaviour and also on the strong interaction between rivers and slope systems.
The Adriatic sector of Molise region is drained by three major catchments (Trigno, Biferno and Fortore valleys), which are elongated from south-west to north-east and cut transversally the trusted and folded terrains of the Molise Apennine. The evolution of these catchments, mainly carved into calcareous-marly to clayey Tertiary successions and less deformed sandy-clayey foredeep sequences of Pliocene-Pleistocene age, is strongly controlled by a more or less continuous tendency to downcutting, mainly driven by climate fluctuations and Quaternary regional uplift. Mass movements represent one of the main denudation processes, and are greatly favoured by the intense interaction between fluvial and slope systems.
Aim of the present study was to investigate on the distribution in space and time of landslides present in this sector in relation to their possible poly-cyclical origin and their role in the valley evolution due to distinct phases of valley downcutting.
Down-cutting rate, on general, strictly depends on the stream's capacity to remove the sediments (hereinafter removals) supplied to the valley bottom (hereinafter arrivals): if the removals exceed the arrivals, down cutting and consequent valley side over-steepening will occur, generating unstable, failure-prone fluvial scarps; if arrivals, instead, equal or weakly prevail on removals, down cutting will not occur and a dynamic equilibrium will be reached in certain valley sections, allowing fluvial scarps to evolve by slope replacement, the progressive widening of the valley and the formation of stable gentle slopes, the so-called valley side glacis. Mass wasting contributes significantly to slope replacement and progressive reduction in height of the original fluvial scarp, while fluvial dynamics results strongly influenced by continuous arrivals from fluvial scarps.
If down cutting is re-activated by climate and/or tectonic influences, the valley profile developed previously in dynamic equilibrium will be rejuvenated and a new cycle of valley evolution starts.
Detailed geomorphological mapping of the landslides allowed to refer them to different generations on the basis of (i) characteristics, (ii) distribution and relative position on the same slope, (iii) proximity to the present thalweg and (iv) relationships to hanging valley side glacis. In particular, three orders of landslides were distinguished which can be related to three different base levels and phases of valley evolution starting from a palaeo-landscape dating ca. 400 ky. Diachronic analysis showed that during phases of dynamic equilibrium some landslides, by a retrogressive behaviour, "migrate" upslope giving rise to a superimposition (union) of landslides referring to distinct orders (poly-cyclic landslide).
In synthesis, the performed study highlights the fundamental role of landslides in the valley evolution following distinct cycles of river down cutting, which may, thus, contribute to a better identification of past erosion levels in the long term geomorphologic analysis.