Geomorphology 204 (2014) 21–30

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Late Quaternary catchment evolution and erosion rates in the Tyrrhenian side of central Italy

M. Buccolini [a], M. Materazzi [b,*], D. Aringoli [b], B. Gentili [c], G. Pambianchi [b], F. Scarciglia [d]

[a] Department of Engineering and Geology, University of Chieti, Italy
[b] School of Environmental Sciences, University of Camerino, Italy
[c] School of Architecture and Design "Eduardo Vittoria", University of Camerino, Italy
[d] Department of Earth Sciences, University of Calabria, Italy

ARTICLE INFO

Article history:
Received 1 April 2012
Received in revised form 12 July 2013
Accepted 15 July 2013
Available online 26 July 2013

Keywords:
Erosion
Badlands
Erosion rate
Fluvial incision
Late Quaternary
Central Italy

ABSTRACT

This work assessed the geomorphological evolution and erosion rates in a small clayey catchment of Tyrrhenian central Italy, providing chronological constraints for the fluvial deposits of the area for the first time. The study area is the catchment of the Formone stream, a left tributary of the Orcia River (Tuscany, Italy). A 5 km-long section of the valley, up to its confluence with the Orcia, was studied. It has an area of ca. 12 km^2 and elevations between ca. 300 and 600 m a.s.l. Two soil samples have been radiocarbon dated. One was located at the top of a fluvial terrace (~20 m above the present thalweg), and the other was located near the water divide of a small tributary catchment: they yielded ages of 2780 ± 40 and 14,050 ± 70 yrs B.P., respectively.
These chronological constraints allowed us to reconstruct the geomorphological evolution of the area through topographic and GIS analyses, and to estimate late Quaternary erosion rates. The ages provided a chronological reference for the terraced fluvial deposits of the Formone and the upper Orcia catchments. The resultant erosion rates are consistent with those in the literature both for the Tyrrhenian side of central Italy and for Mediterranean Europe. Moreover, the results confirmed that very intense erosion processes occurred as a consequence of the Pleistocene–Holocene climatic change, as observed in the peri-Adriatic belt of central Italy.

1. Introduction

A hydrographic network is closely related to the transformation of the physical environment, with both erosion and deposition processes. The setting and development of drainage systems are controlled by various factors: climate (Preece and Bridgland, 1999; Brocard et al., 2003), sea level change (Schumm, 1993; Holbrook et al., 2006), tectonic activity (Merritts et al., 1994; Coltorti et al., 1996; Schumm et al., 2000), pre-existing morpho-structural characteristics (Dunne, 1980; Oguchi, 1996; Currado and Fredi, 2000; Pelletier, 2003) and anthropogenic activities (Garcìa-Ruiz and Valero-Garcès, 1998; Buccolini et al., 2007).

In the evolutionary framework of valleys and drainage systems in the Mediterranean countries, erosion rates have been estimated in relation to different morpho-climatic and geo-environmental contexts as well as different time intervals, based on both direct and indirect measurements (Table 1). Direct measurements generally show higher values of current erosion rates, because they often focus on sites severely affected by ongoing erosion processes. On the contrary, indirect measurements based on the reconstruction of landform evolution over long periods and chronostratigraphic markers, tend to show lower erosion rates because they consider wider areas and a longer time span.

This article aims to supply a new knowledge on erosion rates in an area representing the clayey landscape of Tyrrhenian central Italy, in relation to the geomorphological evolution of the last 14,000 years. In the study area, direct measurements of short-term erosion rates have recently been performed (Della Seta et al., 2007, 2009), whereas indirect measurements for a long term had been lacking. However, the chronological constraints of the deposits became available for this area. The topographical location of these deposits indicates that they are highly significant markers for reconstructing landform evolution and determining erosion rates.

2. Study area

2.1. Regional setting

The tectonic–sedimentary evolution and the characteristics of the landscape in the study area have been the subject of scientific studies particularly since the 1990s including systematic studies on hillslope erosion processes (Marini, 1995; Del Monte et al., 2002). The evolution of the landscape in the Tyrrhenian hillside of the central Apennine started at the transition from the Upper Pliocene to the Pleistocene. In this period, a rapid tectonic uplift lasting for the entire Quaternary, in conjunction with intense volcanic activities (Acocella and Rossetti, 2002), raised the Pliocene–Pleistocene sandy–clayey–conglomeratic

* Corresponding author. Tel.: +39 0737402603; fax: +39 0737402644.
E-mail address: marco.materazzi@unicam.it (M. Materazzi).

0169-555X/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.geomorph.2013.07.023

Table 1
Known erosion rates in the Mediterranean area and surroundings.
Modified after Buccolini et al., 2010.

ID	Locality	Environment	Lithology	Method	Denudation rate	Period	Reference
1	Southern Apennine Chain	Mountain belt	Limestones and marly limestones	GIS analysis on summital palaeosurfaces	0.22–0.30 mm yr^{-1}	Middle Pleistocene–present	Amato et al. (2003)
2	Alps	Mountain chain	Various	Sediment volume trapped in valleys and lake basin	1.77 mm yr^{-1}	Late Glacial	Hinderer (2001)
3	Alps	Mountain chain	Various	Sediment volume trapped in valleys and lake basin	0.6 mm yr^{-1}	Last 17,000 yrs	Hinderer (2001)
4	Central Spain	Mountain chain	Granites and gneisses	Dendrogeomorphological methods	1.7–2.6 mm yr^{-1} 1.1–1.8 mm yr^{-1}	Last 101 yrs Last 42 yrs	Bodoque et al. (2005)
5	Black Sea source area	Mountain chains, hills and plains	Various	Sediment volume in Black Sea	0.063 mm yr^{-1}	Holocene	Degens et al. (1976)
6	Adriatic Central Italy	Main fluvial basins	Alluvial deposits	Thermochronometry	0.7–1.5 mm yr^{-1}	Last 20,000 yrs	Coltorti et al. (1991)
7	Lac Chambon (Massif central, France)	Mountain basin	Lacustrine deposits	Qualitative estimation	0.12 mm yr^{-1}	Last deglaciation	Gay et al. (1998)
8	Lac Chambon (Massif central, France)	Mountain basin	Lacustrine deposits	Qualitative estimation	0.05–0.1 mm yr^{-1}	Holocene	Gay et al. (1998)
9	Ebro Basin (NE-Spain)	Badlands on hilly area	Clayey bedrock	Direct measures on erosion plots in badland areas	5.6–11.2 mm yr^{-1}	Present (1991–1993)	Sirvent et al. (1997)
10	Southern Tuscany	Hilly area	Clayey bedrock	Direct measures	15–30 mm yr^{-1} (badlands) 60–70 mm yr^{-1} (landslides)	Present	Ciccacci et al. (2006)
11	Central Italy	Hilly areas	Clayey bedrock	Direct measures compared with indirect estimation from quantitative geomorphology on drainage network	10–25 mm yr^{-1} (badlands) 30–40 mm yr^{-1} (landslides)	Present	Della Seta et al. (2007)
12	Europe	Various	Soil	Various	10–20 t ha^{-1} yr^{-1} (overall) 455 t ha^{-1} yr^{-1} (gully erosion-maximum value)	Present	Verheijen et al. (2009)
13	Mt. Ascensione (Adriatic central Italy)	High hills	Slope deposits and clayey bedrock	Radiometric datings and GIS analysis	7.8 mm yr^{-1} (156 t ha^{-1} yr^{-1}) 15.6 mm yr^{-1} (312 t ha^{-1} yr^{-1})	Last 20,000 yrs Holocene	Buccolini et al. (2010)
14	Atri (Adriatic central Italy)	Coastal hills	Colluvial deposits and clayey bedrock	Radiometric datings and GIS analysis	2.4–3.0 mm yr^{-1} (48–60 t ha^{-1} yr^{-1}) 4.8–6.0 mm yr^{-1} (96–120 t ha^{-1} yr^{-1})	Last 20,000 yrs Holocene	Buccolini et al. (2010)