Controls on Late Quaternary Landscape development in the Upper Guadalentin Basin, Murcia, SE Spain

J.E.M. Baartman[(1)], A. Veldkamp[(1)]

(1) Wageningen University, Land Dynamics Group, P.O. Box 47, 6700 AA Wageningen, The Netherlands. E-mail: jantiene.baartman@wur.nl

ABSTRACT

Landscapes in South-eastern Spain have developed in response to tectonics, climatic fluctuations and, more recently, to human action. In the valleys, fluvial and colluvial sediments are found in the form of river terraces, pediments and slope deposits. We studied these sediments to evaluate landscape dynamics and the processes of sedimentation and erosion in the semi-arid region of the Guadalentín Basin, Murcia Province, SE Spain.
The objective of the study is to deduce controls on Late Quaternary and Holocene landscape development. Fieldwork was carried out on the reach of the Upper Guadalentin, upstream of the city of Lorca, and two of its tributaries (Rio Velez and Rambla de Torrealvilla). River terrace levels were mapped using GPS and presence of gravel layers in outcrops. For the Rambla de Torrealvilla, more detailed sediment descriptions show their build-up. Charcoal was found and dated (14C) on ten locations, while 15 samples for Optically Stimulated Luminescence (OSL) dating were taken to have an age-control on processes of sedimentation and erosion.
While the OSL dating measurements and analysis are still in process at this time, some preliminary results are given. Several terrace levels are identified along the Rio Guadalentin and the Rio Velez. These have formed in response to regional and/or global changes in climate. However, local mechanisms have played an important role in the area, overruling regional dynamics. From finely layered sediments, it is deduced that a lake existed during some time in the area, caused by a blockage of the valley. This lake was filled in with sediments and a delta was build at its end, interfering with terrace levels. When the blockage was broken through, lake sediments have been removed and after incision, younger terraces have developed.
The Torrealvilla tributary is draining the Lorca Basin, and sediments seem to be younger than those along the Guadalentin and Velez rivers. Infilling of the basin and incomplete removal has shaped this valley. Outcrops in the gully sidewall show stacked layers of large to fine gravels and fine sediments with smaller gravel layers in between.
We will present a conceptual model of landscape development since the Late Quaternary based on the age control (14C and OSL) and field observations. This reconstruction is correlated to climatic fluctuations and rates of sedimentation and erosion are approximated on a millennial timescale. Following this approach of longer-term geomorphological investigation of landscape development, we can ultimately put the relative contribution of human actions in the context of natural erosion and sedimentation processes.

Keywords: Landscape development, Guadalentin Basin, Late Quaternary

INTRODUCTION

Landscapes in southeastern Spain have developed in response to tectonics, climatic fluctuations and, more recently, to human action. In the valleys, fluvial and colluvial sediments are found in the form of river terraces, pediments and slope deposits. We studied these sediments to evaluate landscape dynamics and the controls on sedimentation and erosion processes in the semi-arid region of the Guadalentín Basin, Murcia Province.

Research in this area has focused on recent processes such as gully dynamics as a result of intense rainstorms (Vandekerckhove et al., 2000; Bull et al., 1999; Hooke and Mant, 2000; Hooke et al., 2005), hillslope erosion (Bracken and Kirkby, 2005), scale-threshold effects (Cammeraat, 2004), the impact of land cover and land use change (Kirkby et al., 2002) and land degradation and desertification (Van Wesemael et al., 2006; Oñate and Peco, 2005). These recent processes have not, up till now, been placed in the larger timeframe of landscape dynamics.
Quaternary and Holocene landscape dynamics are relatively sparsely assessed for the Guadalentin Basin. Baumhauer and Schütt (2006) made three augerings in an alluvial fan in the northwestern part of the Guadalentin Basin. Combined with ^{14}C datings on charcoal pieces and chemical analysis of the sediments, they made a reconstruction of environmental conditions from the Late Glacial to recent times. Benito et al. (2006, 2008) applied palaeoflood hydrology to the Rio Guadalentin, upstream of the Valdeinfierno artificial lake. Calmel-Avila (2000) made a reconstruction of the morphological evolution of the lower Guadalentin (near Librilla), with the objective to identify phases of erosion and sedimentation over the past 10,000 years and to analyse the natural and human induced processes that could have taken place. Fuentes et al. (2005) describe an archeological site in Lorca from which four phases of occupation are deduced.

The objective of this study is to understand and develop a conceptual model for Late Quaternary and Holocene landscape development for the Upper Guadalentin Basin. Subsequently, correlation of sedimentation and erosion processes to climatic variations, flood events and/or human activity is possible. Ultimately, the relative contribution of natural and human induced processes could be assessed using this approach.

Research area
The Guadalentin Basin (~3300 km^2) is located in Murcia Province, southeastern Spain. Our research area is restricted to the upper part of the Rio Guadalentin, upstream of the city of Lorca (Fig. 1). We focussed on the Rio Guadalentin upstream of Lorca and two tributaries; the Rambla de Torrealvilla and the Rio Velez (Fig. 1). Altitude ranges from 300 – 1500 masl.
Current climate is semi-arid Mediterranean. Average annual precipitation is about 300 mm, with 75% of rainfall in spring (mainly April) and autumn (mainly October) and high annual variability (Navarro Hervás, 1991). Semi-natural vegetation in the research area consists mainly of natural shrubs and forest. Land use is mainly dryland farming and irrigated crops.
Geologically, the research area is located in the Betic Cordillera, a west-east oriented alpine orogenic belt that can be subdivided into an Internal and External Zone. The External Zone consists dominantly of non-metamorphic sedimentary rocks deposited during the Mesozoic (limestones, dolomites and marls) and Cenozoic (sandstones, (sandy) marls and conglomerates). The Internal Zone is formed by nappe complexes with lithologies ranging from highly metamorphic schists and phyllites to non-metamorphosed calcarenites, conglomerates and marls (Geel and Roep, 1998; IGME, 1981). The Lorca-Alhama Fault forms the graben of the active Guadalentin Depression.

METHODS

During fieldwork, an inventory of sediments was made along the three parts of the river. Presence of gravel, imbrication and stratification, deposits on top of the gravel layer and thickness of the gravel layer was investigated and their location recorded using a GPS (Garmin eTrex Legend). Relative height above the river was calculated.
Charcoal pieces were found on ten locations (Fig. 1). These were radiocarbon dated using the Accelarator Mass Spectometer (AMS) at the Center for Isotope Research, University of Groningen, the Netherlands (Gottdang et al., 1995).

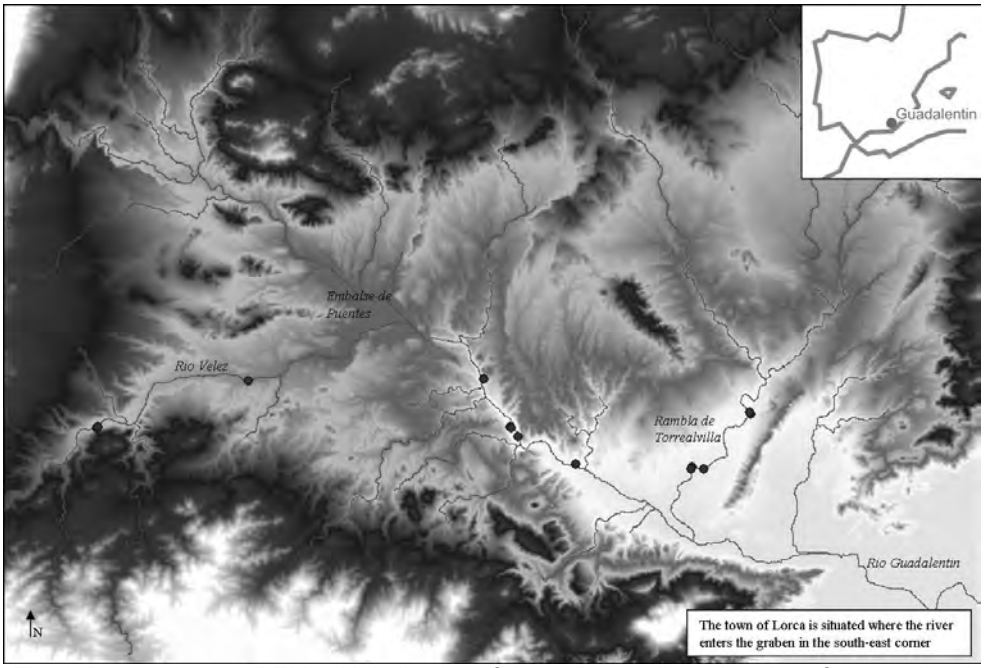

Fig. 1: Research area (DEM) with indication of rivers. Dots indicate location of charcoal and OSL samples.

To determine the timing and deduce rates of sediment deposition, OSL dating was used. This method determines the last time sand grains were exposed to sunlight, i.e. burial of the sediment. Samples were taken on 15 locations; 8 in the Rambla de Torrealvilla, three along the Rio Guadalentin and three in the Rio Velez. Samples were taken in the courser parts of the sediments, to ensure that sufficient large-sized quartz grains were present. Metal cores (diameter ~10cm; length ~50cm) were hammered into the sediment; sealed and transported to the laboratory. Analysis is at the moment of writing being carried out at the Netherlands Centre for Luminescence Dating (NCL) in Delft.

RESULTS AND DISCUSSION

Preliminary results are given here, as OSL dating results are not yet available at the time of writing. Several terrace levels are found ranging in height above the river from 2 to more than 30m. Finely layered sediments are found, indicating that a lake existed during some time. This is being investigated at the moment. After breakthrough of the blockage, lake-sediments were (partly) removed by erosion and the last two terrace levels were formed afterwards. The existence of the lake influenced erosion and deposition upstream, as local base level changed abruptly. Gravel found upstream is possibly from a delta that formed at the far end of the lake. In this case, local processes are clearly more important than regional (climatic) controls on landscape formation.
Results from charcoal dating give ages between 140 yr BP for the most recent sediments to about 5000 yr BP for the lowest (exposed) sediments in the Rambla de Torrealvilla. For charcoal found along the Rio Velez ages of about 11 and 14 ka BP were found. This implies that sediments in the Lorca Basin, where the Rambla de Torrealvilla is located, are relatively young compared to the sediments along the Rio Velez.

A complete reconstruction of landscape forming processes and their relative importance in the area is being made. Results will be presented when available.

REFERENCES

- Benito, G. 2006. Riesgos de inundaciones: tendencias históricas y perspectivas de acuerdo con el cambio climatico. *Rev. C. & G.* 20, 29-44.
- Benito, G., Thorndycraft, V.R., Rico, M., Sánchez-Moya, Y., Sopeña, A. 2008. Palaeoflood and floodplain records from Spain: Evidence for long-term climate variability and environmental changes. *Geomorphology* 101, 68-77.
- Bracken, L.J., Kirkby, M.J. 2005. Differences in hillslope runoff and sediment transport rates within two semi-arid catchments in southeast Spain. *Geomorphology* 68, 183-200.
- Bull, L.J., Kirkby, M.J., Shannon, J., Hooke, J.M. 1999. The impact of rainstorms on floods in ephemeral channels in southeast Spain. *Catena* 38, 191-209.
- Calmel-Avila, M. Procesos hídricos holocenos en el Bajo Guadalentín (Murcia, SE España). *Rev. C. & G.* 14, 65-78.
- Cammeraat, L.H. 2004. Scale dependent thresholds in hydrological and erosion response of a semi-arid catchment in southeast Spain. *Agriculture, Ecosystems and Environment* 104, 317-332.
- Fuentes, N., García-Martínez, M.S., González-Sampériz, P., Fernández, S., Carrión, J.S., López-Campuzano, M., Medina, J. 2005. Degradación ecológica y cambio cultural durante los últimos cuatro mil años en el sureste ibérico semiárido. *Anales de Biología* 27, 69-84.
- Geel, T., Roep, T.B. 1998. Oligocene to middle Miocene basin development in the Eastern Betic Cordilleras, SE Spain (Velez Rubio Corridor – Espuña): reflections of West Mediterranean plate-tectonic reorganizations. *Basin Research* 10, 325-343.
- Gottdang, A., Mous, D.J.W., Van der Plicht, J. 1995. The HVEE ^{14}C system at Groningen. In: Cook, G.T., Harkness, D.D., Miller, B.F., Scott, E.M. (Eds) *Proceedings of the 15th International ^{14}C Conference* 37, 649-656.
- Hooke, J.M., Brookes, C.J., Duane, W., Mant, J.M. 2005. A simulation model of morphological, vegetation and sediment changes in ephemeral streams. *Earth Surface Processes and Landforms* 30, 845-866.
- Hooke, J.M., Mant, J.M. 2000. Geomorphological impacts of a flood event on ephemeral channels in SE Spain. *Geomorphology* 34, 163-180.
- IGME, 1981. Mapa Geologico de España, 1:50.000; Hoja 953 (Lorca). Servicio de Publicaciones, Ministerio de Industria.
- Kirkby, M., Bracken, L., Reaney, S. 2002. The influence of land use, soils and topography on the delivery of hillslope runoff to channels in SE Spain. *Earth Surface Processes and Landforms* 27, 1459-1473.
- Navarro-Hervas, F. 1991. El Sistema Hidrografico del Guadalentin. Cuadernos Technicos 6, Consejeria de Politica Territorial, Obras Publicas y Medio Ambiente de la Region de Murcia.
- Oñate, J.J., Peco, B. 2005. Policy impact on desertification: stakeholders' perceptions in southeast Spain. *Land Use Policy* 22, 103-114.
- Schütt, B., Baumhauer, R. 2000. Subrezente Morphodynamik im Bereich der Cañada Hermosa, SE Spanien. *Trierer Geographische Studien*, Heft 23, 99-112.
- Van Wesemael, B., Rambaud, X., Poesen, J., Muligan, M., Cammeraat, E., Stevens, A. 2006. Spatial patterns of land degradation and their impacts on the water balance of rainfed treecrops: A case study in South East Spain. *Geoderma* 133, 43-56.
- Vandekerckhove, L., Poesen, J., Oostwoud Wijdens, D., Nachtergaele, J., Kosmas, C., Roxo, M.J., De Figueiredo, T. 2000. Thresholds for gully initiation and sedimentation in Mediterranean Europe. *Earth Surface Processes and Landforms* 25, 1201-1220.