[PS]From Extension to Transpression: Drainage Response to the Alhama de Murcia Strike-Slip Fault Growth (Eastern Betics)*

Marta Ferrater[1], Guillermo Booth-Rea[2,3], José Miguel Azañón[2,3], and Eulàlia Masana[1]

Search and Discovery Article #50795 (2013)**
Posted June 21, 2013

*Adapted from poster presentation given at AAPG European Regional Conference & Exhibition, Barcelona, Spain, April 8-10, 2013

[1]RISKNAT Group, Departament de Geodinàmica i Geofísica, Facultat de Geologia,Universitat de Barcelona, c/ Martí i Franquès s/n, 08028 Barcelona, Spain (marta.ferrater@ub.edu)
[2]Departamento de Geodinámica, Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Campus Fuentenueva s/n, 18071, Granada, Spain
[3]Instituto Andaluz de Ciencias de la Tierra UGR-CSIC, Avenida de las Palmeras 4, 18100 Armilla, Granada, Spain

Abstract

Drainage systems adapt to changes in the surface slope and thus have the potential to record the evolution of tectonic structures that produce surface uplift. The development of new mountain fronts can drive the abandonment of earlier drainage networks by way of fluvial captures. Here we analyze the evolution of topographical relief in a transcurrent tectonic setting where a relic drainage network inherited from late Miocene extension is still preserved. The recent drainage network is advancing thanks to tectonic driven rock uplift related to the Alhama de Murcia strike-slip fault and associated structures; overprinting the previous extensional related drainage. For this, we carried out a structural and a qualitative and quantitative relief analysis to understand how the relief has evolved and which are the active structures that currently control the drainage configuration. We identify river capture sites and present a geomorphic index analysis using SLk anomalies, hypsometric curves, mountain front sinuosity, the comparison between longitudinal and projected river profiles with the SLk values and the position of active faults and folds, and a slope analysis of the area. This analysis mainly allows the understanding of the drainage network evolution. The results show 1) the reactivation of the ending part of the main basins by the current uplift of Tercia Range, 2) progressive capture processes related to the growth of the Rambla de Lebor and Totana transverse drainages upon a previous drainage pattern inherited from a late Miocene extensional setting evidenced by the presence of wind gaps, abrupt changes in flow direction, oblique relationship between current river direction and paleosurfaces maximum slope direction and changes in the lithologic composition of terraces, and 3) basin shapes controlled by the interference between a NE-SW-directed drainage network controlled by extensional structures and another NW-SE one controlled by transpressive structures (Alhama de Murcia Fault).

From extension to transpression: drainage response to the Alhama de Murcia strike-slip fault growth (Eastern Betics)

Marta Ferrater (1), Guillermo Booth-Rea (2,3), José Vicente Pérez Peña (2), José Miguel Azañón (2,3), Eulàlia Masana (1)

(1) RISKNAT Group, Departament de Geodinàmica i Geofísica, Facultat de Geologia,Universitat de Barcelona, c/ Martí i Franquès s/n, 08028 Barcelona, Spain (marta.ferrater@ub.edu)
(2) Departamento de Geodinámica, Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Campus Fuentenueva s/n, 18071, Granada, Spain
(3) Instituto Andaluz de Ciencias de la Tierra UGR-CSIC, Avenida de las Palmeras 4, 18100 Armilla, Granada, Spain

ABSTRACT

Drainage systems adapt to changes in the surface slope and thus have the potential to record the evolution of tectonic structures that produce surface uplift. The development of new mountain fronts can drive the abandonment of earlier drainage networks by way of fluvial captures. Here we analyze the evolution of topographical relief in a transcurrent tectonic setting where a relic drainage network inherited from late Miocene extension is still preserved. The recent drainage network is advancing thanks to tectonic driven rock uplift related to the Alhama de Murcia (AMF) strike-slip fault and associated structures; overprinting the previous extensional related drainage. The objective of this study is to understand how the relief has evolved and which are the active structures that currently control the drainage configuration.

In order to analyse the topography of the studied area we carried out a structural analysis of fault segmentation, the identification of fluvial captures, as well as the calculation of several geomorphic indexes for the main drainage basins.

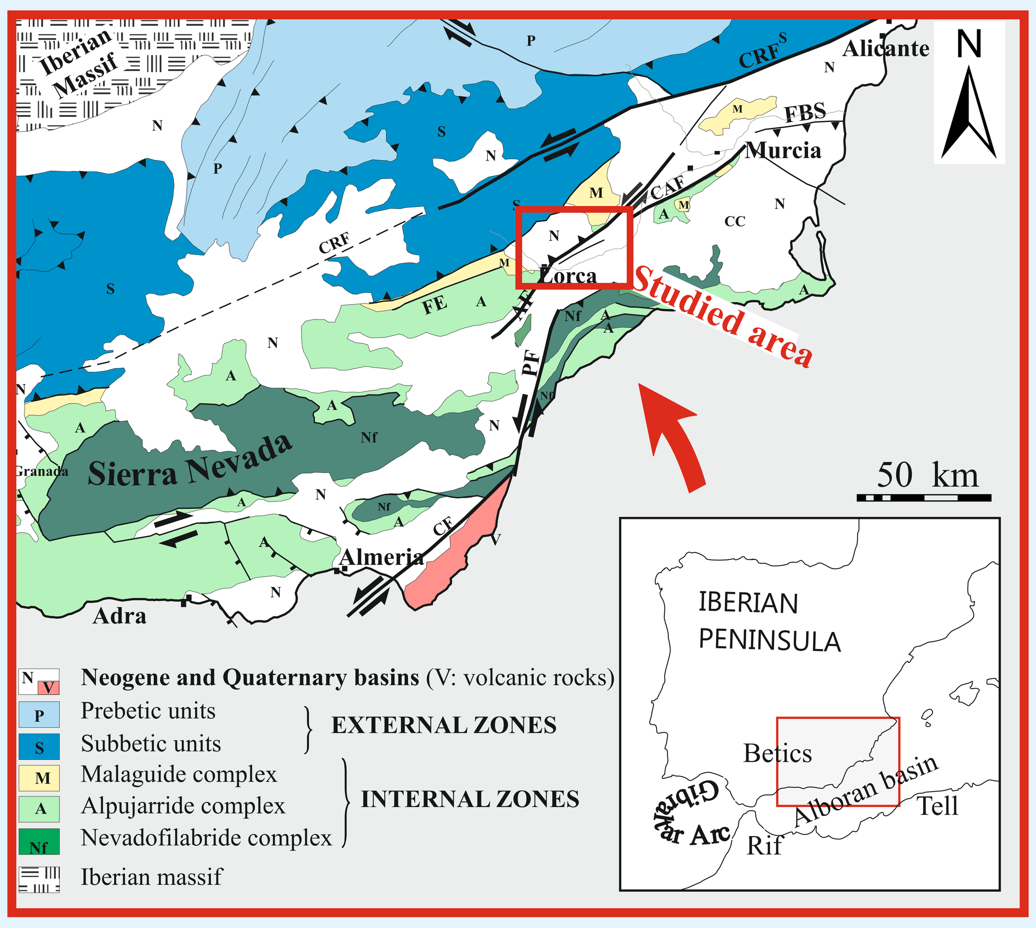


Figure 1. In southeastern Betics NW-SE and NE-SW extensions were active during the Tortonian (Booth-Rea et al., 2004) coeval to early to late Miocene Gibraltar arc formation (Lonergan and White, 1997; Booth-Rea et al., 2007). Strike-slip activity and folding associated to AMF probably initiated in the Pliocene (Bousquet 1979; Meijinger and Vissers, 2006) due to tectonic inversion related to NW-SE convergence between Africa and europe.

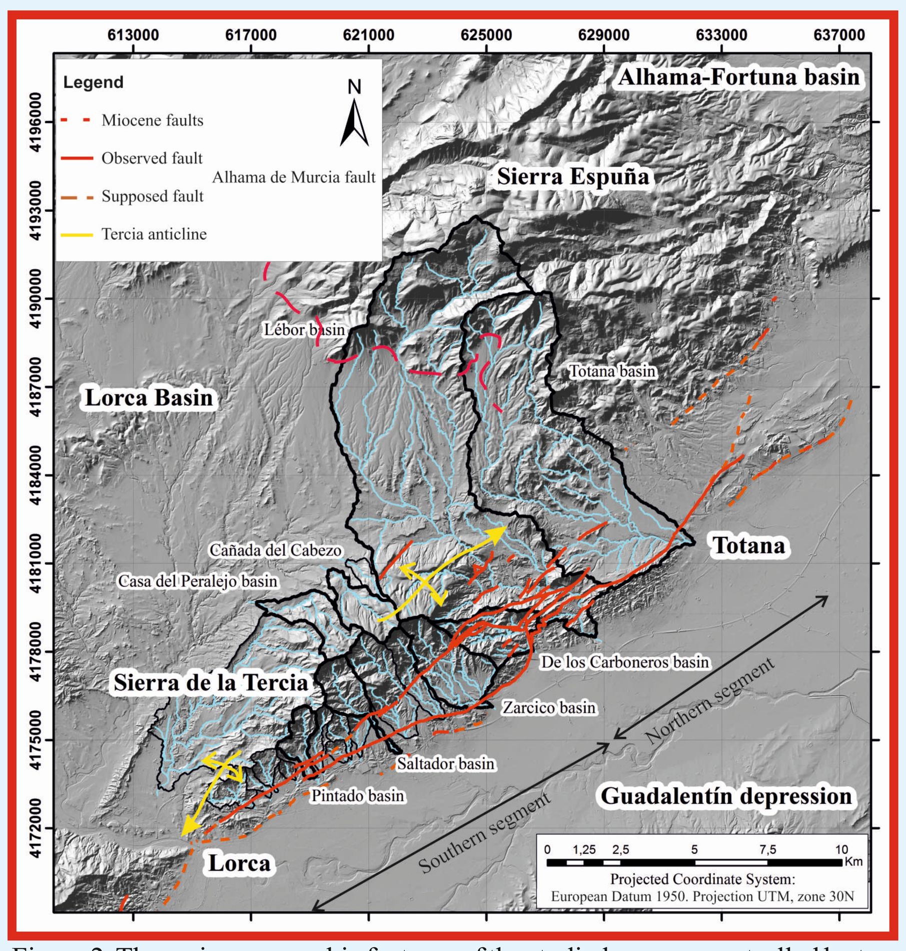


Figure 2. The main geomorphic features of the studied area are controlled by two factors: 1) features (Miocene to Middle Pleistocene alluvial fans and NE-SW drainage system) related to inactive Miocene extensional structures, and 2) features associated with active strike-slip faults.In the second grup: i) a current NW-SE oriented drainage system, ii) fluvial incision into Miocene to Middle Pleistocene alluvial fans, iii) a generation of Middle Pleistocene to present-day alluvial fans and iv) abandoned and diverted fluvial channels.

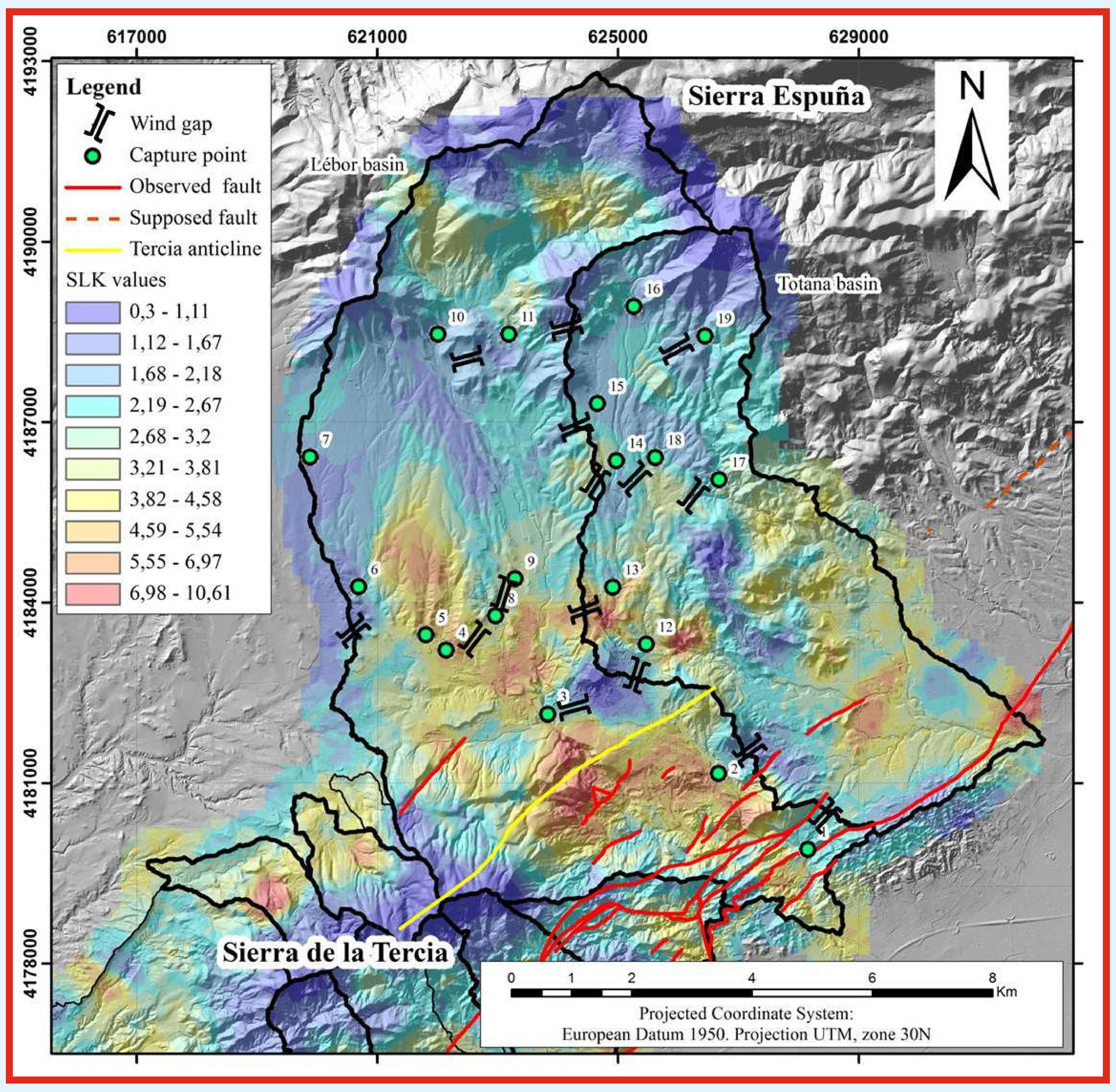


Figure 7. Relief analysis in the Totana and Lébor basins. Captures (most of them associated with wind gaps and abrupt changes in river direction) are related to SLk anomalies and structural features (Alhama de Murcia fault and Tercia anticline).

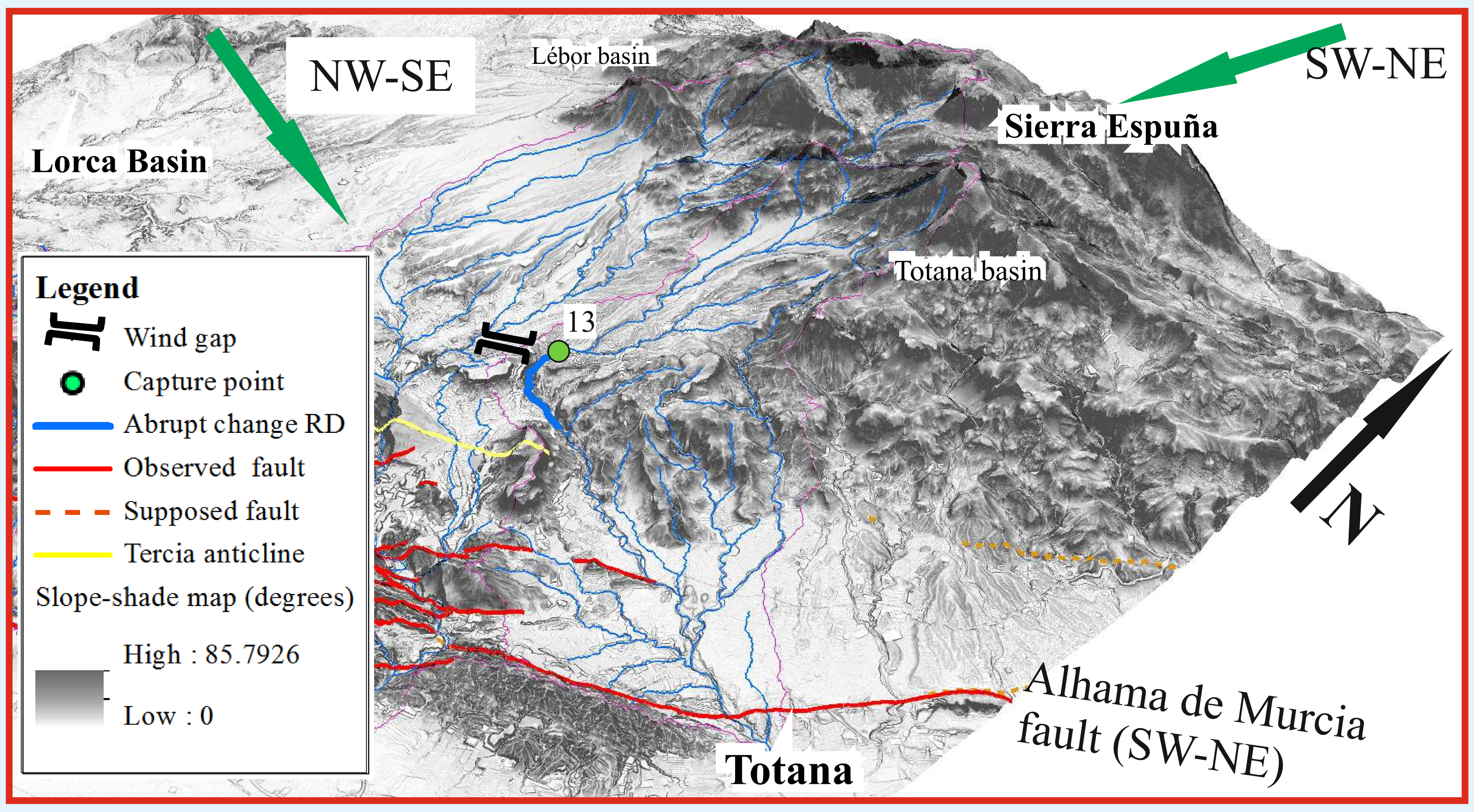


Figure 8. 3D image with the two main river directions (NE-SW, inherited from Miocene, and NW-SE, recent and related to Alhama de Murcia active fault); position of capture point 13, used to calculate the retreat rate since Middle Pleistocene.

METHODOLOGY

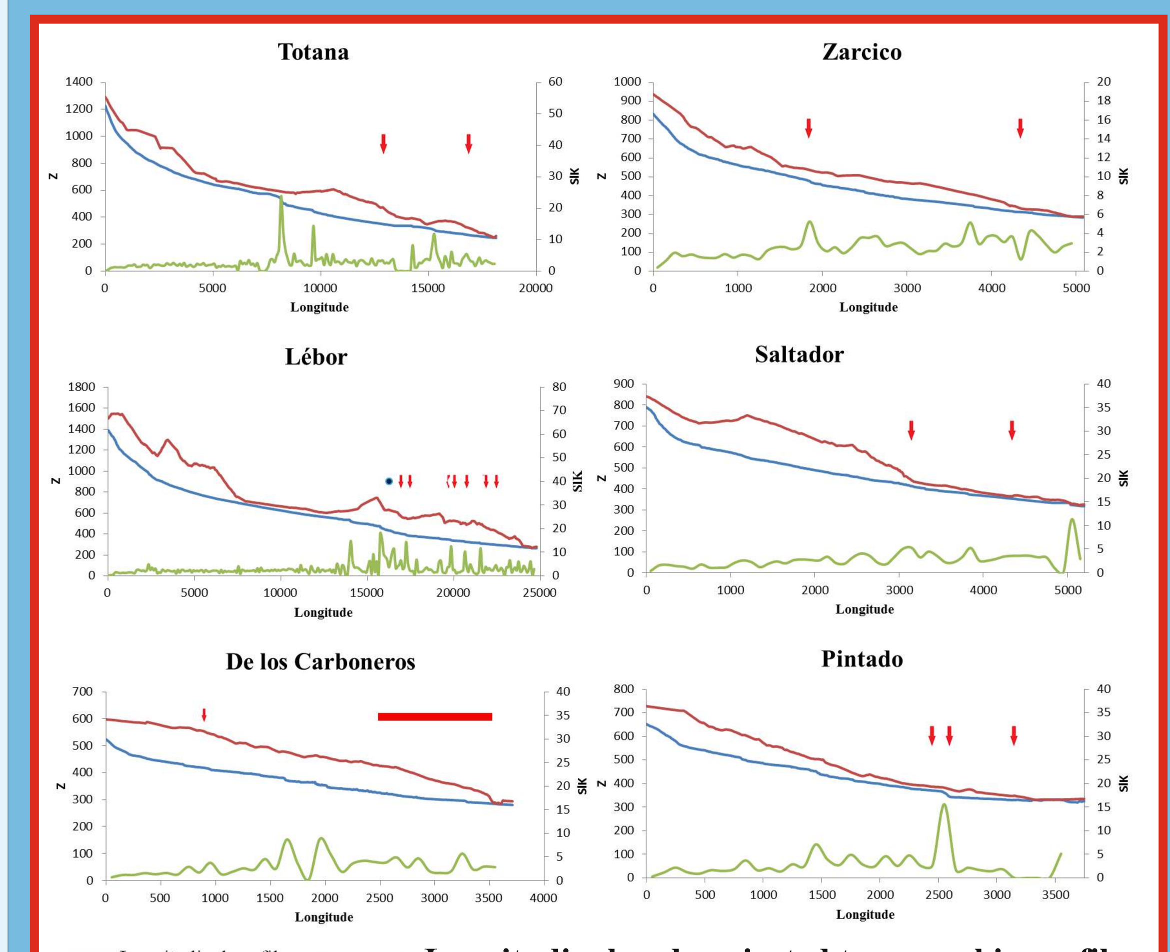
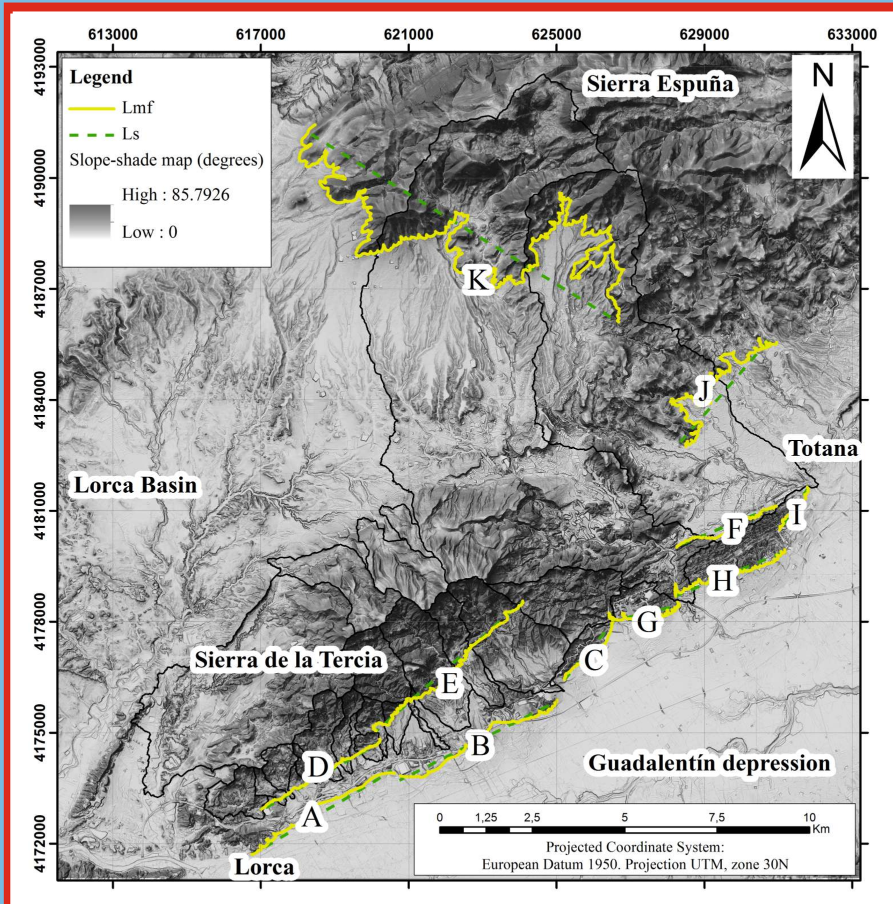


Figure 3. **Longitudinal and projected topographic profiles** of selected rivers (units in meters). SLk values and fault traces are indicated. Except in de los Carboneros basin where the fault is parallel to the basin, knick points in the topographic longitudinal profile coincide with SLK anomalies and/or fault trace location.

Geomorphic indexes are useful to characterize recent tectonic activity (Pérez-Peña et al., 2009b; Giaconia et al., 2011). Relief analysis based on a 4m DEM obtained from the NatMur-08 project.



Name	Sinuosity (Smf)
A	1,19
B	1,21
C	1,24
D	1,27
E	1,45
F	1,25
G	2,04
H	1,56
I	1,47
J	3,07
K	3,75

Table 1. Sinuosity values for A to K mountain fronts. Smf=1.4 took as corresponding to active fronts (silva et al., 2003)

Figure 4. **Mountain front Sinuosity**. Legend: Lmf: length of the mountain front along the foot of the mountain, Ls: length of the mountain front measured along a straight line.

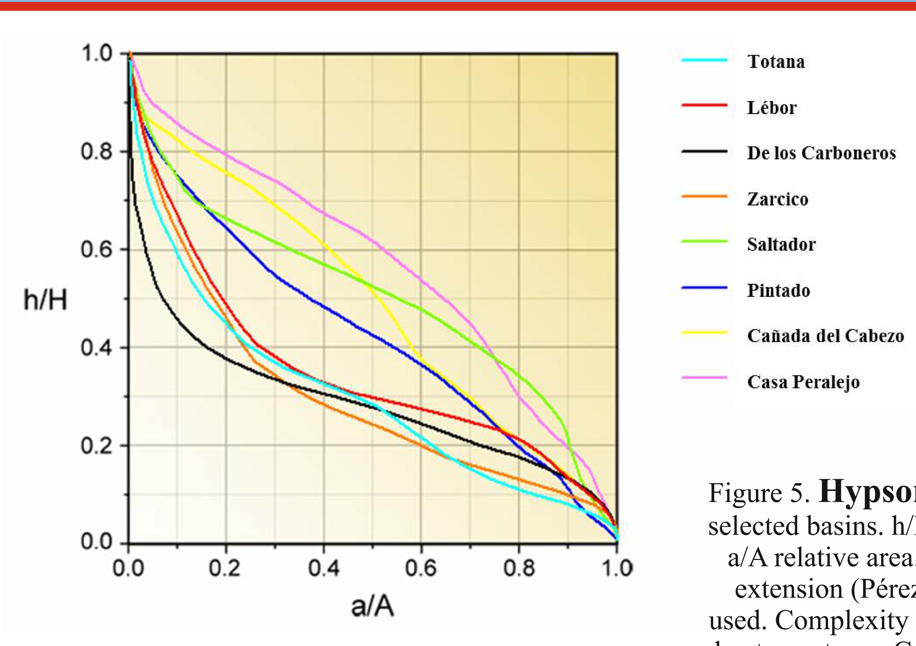


Figure 5. **Hypsometric curves** of selected basins. h/H relative elevation, a/A relative area. CalHypso ArcGIS-extension (Pérez-Peña et al., 2009b) used. Complexity in Lébor and Totana due to captures. Convex lower part for all basins.

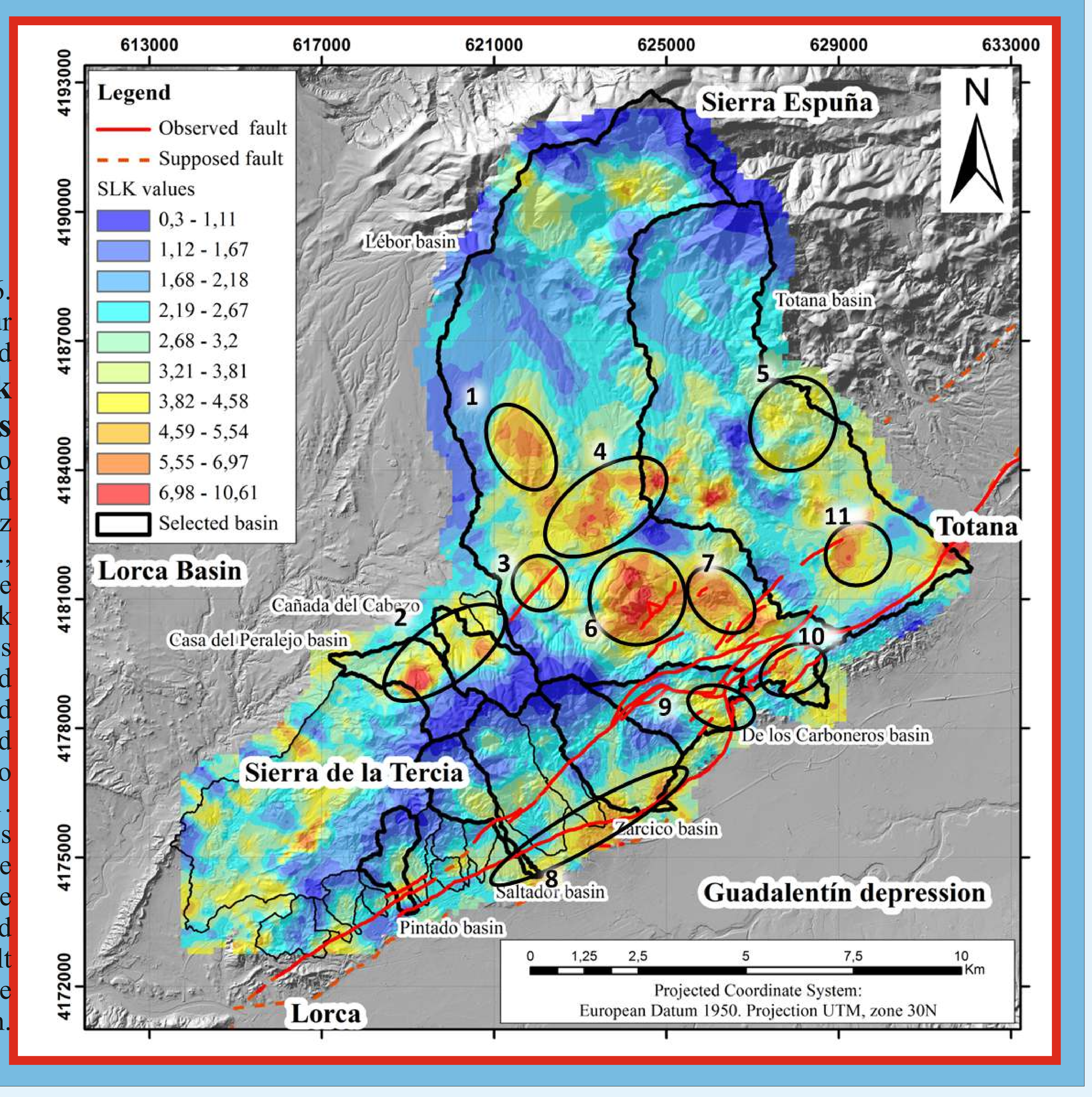


Figure 6. Contour map and **SLk values** (methodology proposed by Pérez Peña et al., 2009a). The SLk anomalies highlighted and numbered from 1 to 11. Anomalies coincide with capture point and with fault trace position.

CONCLUSIONS

The geomorphic indexes are consistent with a **relief reactivation due to Alhama de Murcia fault** activity: 1) **Smf** values **lower than 1.4** in the mountain fronts controlled by the fault (figure 6 and table 1); 2) **positive SLk anomalies** (figure 5, anomalies 8, 9 and 10); 3) the **reactivation of the ending part of the main basins** evidenced by convex shaped hypsometric curves (figure 3); and 4) **knick points** in the river topographic profiles that **coincide with the position of the tip fault line and SLk anomalies** (figure 4, Pintado). The southern segment is more active than the northern one according to the mountain front sinuosity values.

The development of **new mountain fronts related to** sinistral-reverse **Alhama de Murcia fault** segments in the Eastern Betics since the middle Pleistocene has **promoted the growth of transverse drainage systems** like the Rambla de Lébor and Totana. These ramblas are **capturing a previous NE-SW oriented drainage network inherited from Late Miocene extension**.

The **interference** between the old NE-SW oriented basin and the more recent NW-SE directed ones has resulted in the formation of **basins with L-shape**.

The **capture processes** are evidenced by the presence of **wind gaps, abrupt changes in flow direction and SLk anomalies**. The minimum linear long-term **retreat rate** of the newly developed drainage is **10mm/yr**.

ACKNOWLEDGEMENTS

The authors were supported by research projects CGL2011-29920, CSD2006-00041 TOPOIBERIA CONSOLIDER-INGENIO2010, CTM2007-66179-C02-01/MAR, CGL2011-30005-C02-02 SHAKE, and the CTM2011-30400-C02-01 HADES Projects from the Spanish Ministry of Science and Innovation. Funding for the doctoral fellowship of M. Ferrater was provided by the University of Barcelona (APIF fellowship) and Spanish Ministry of Education, Culture and Sport (FPU fellowship).

REFERENCES

Booth-Rea, G., Azañón, J.M., Azor, A., García-Dueñas, V., 2004. Journal of Structural Geology 26, 1615–1632.
Booth-Rea, G., Ranero, C., Martínez-Martínez, J.M., Grevemeyer, I., 2007. G-Cubed 8, Q10004, doi:10.1029/2007GC001661.
Bousquet, J.C. 1979. Tectonophysics 52, 277-286.
Giaconia, F., Booth-Rea, G., Martínez-Martínez, J.M., Azañón, J.M., Pérez-Peña, J.V., Pérez-Romero, J. Irene Villegas, I., 2012. Geomorphology 145-146, 90-106.
Lonergan, L., White, N., 1997. Tectonics 16, 504-522.
Meijninger, B.M.L., Vissers, R.594 L.M., 2006. Basin Research 18, 547-571, doi: 10.1111/j.1365-2117.2006.00308.x
Pérez-Peña, J.V., Azañón, J.M., Azor, A., Delgado, J., González-Lodeiro, F., 2009a. Earth Surface Processes and Landforms 34, 16-25.
Pérez-Peña, J.V., Azañón, J.M., Azor, A., 2009b. Computers & Geosciences 35, 1214-1223.
Silva, P.G., Goy, J.L., Zazo, C., Bardaji, T., 2003. Geomorphology 50, 203-225.