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ARE TALUS FLATIRONS FROM CENTRAL SPAIN RELATED WITH HEINRICH EVENTS?

ABSTRACT: GUTIÉRREZ M., GUTIÉRREZ F. & DESIR G., *Are talus flatirons from central Spain related with Heinrich events?* (IT ISSN 1724-4757, 2003).

Talus flatirons generate in slopes of arid and semiarid areas by the alternation of accumulation and incision periods. In the Iberian Peninsula talus flatirons are relatively common in the Duero, Tajo and Ebro Tertiary Basins. In these Tertiary Basins talus flatirons have been found in numerous places and up to five stages of slope evolution have been recognised at some locations. Ashes and charcoal remains from the inside of the slope accumulations were dated with ^{14}C and AMS in order to obtain an absolute chronology of the flatiron stages. The second stage (S_2) dated in several places of the Ebro and Duero Basins by ^{14}C range from 2529 ± 52 BP to 3590 ± 40 BP, corresponding to the Iron and Bronze Cold Stages. The third stage (S_3) has yielded 27862 ± 444 BP in the Ebro Basin and 28550 ± 130 BP in the Duero Basin and can be correlated with Heinrich event H_3 . The fourth stage (S_4) has been dated in the Ebro Basin giving an age of 35570 ± 490 BP, correlative to Heinrich Event H_4 . The obtained temporal data seems to indicate the global cold periods (Heinrich events) control the talus flatirons origin in the studied sector of Spain.

KEY WORDS: Talus flatirons, Heinrich events, Paleoclimatic indicators, Global events, Spain.

INTRODUCTION

Knowledge of slope evolution in arid and semiarid environments is quite scarce. Nevertheless, the understanding of slope processes in these climates has been improved significantly in the last decades by a large number of studies carried out in experimental plots, which in many cases are supported by rainfall simulation experiments. The evolution of slopes in semiarid environments may be easier to study since chronological data can be obtained from charcoal and ashes found inside the slope accumulations. These datable materials are more rare within the slope deposits of arid environments due to the scarce vegetation

cover. In areas with old human occupation the archeological remains found inside the slope deposits can also be used to obtain relative ages.

Incision processes affecting debris slopes developed at the foot of retreating scarps may give place to relict slopes, termed talus flatirons, tripartite slopes and triangular slope facets. Talus flatiron sequences generated by the alternation of accumulation and incision periods are relatively common in arid and semiarid area. These relict slopes generally lie parallel to the present scarp of mesas, buttes or cuestras (fig. 1), being the oldest facets the furthest from the scarp indicating a parallel retreat of the scarp edge. In their distal zones they may grade into mantled pediments.

Talus flatirons are relatively common in the Duero, Tajo and Ebro Tertiary Basins in Spain (fig. 2). These three Tertiary basins are filled with continental sediments and constitute the larger depressions of the inner part of the Iberian Peninsula (figs. 2 and 3). In general, their sedimentary fill is made up of alluvial fan deposits at the basin margins that grade into evaporitic and carbonate lacustrine-palustrine facies towards the center. The Neogene endorheic sedimentation ended with the deposition of relatively thick lacustrine limestones that currently cover a significant portion of the Tertiary basins. Semiarid conditions prevail in studied sedimentary-topographic basins, although the climate becomes more humid towards the mountainous margins.

Talus flatirons have been found in numerous places in the mentioned basins and up to five stages of slope evolution have been recognised at some locations. These relict landforms are not very common at a global scale since their generation is restricted to areas with subhorizontal or slightly tilted stratified formations where scarped caprock overlay more easily erodible materials. (Koons, 1955; Everard, 1963; Büdel, 1970; Blume & Barth, 1972; Gerson, 1982; Gerson & Grossman, 1987; Schmidt, 1989a, 1994; Arauzo & *alii*, 1996). The incision of the slope deposits

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FIG. 1 - Triangular slope facets in Monteagudo de las Vicarías (Eastern sector of the Duero Basin, Soria Province).

and the underlying labile sediments allow the individualization of talus flatirons. In addition, scarps must be formed by a relatively thin caprock, so that debris accumulation does not become excessive (Schmidt, 1987) and the scarp retreat may be fast enough to allow the disconnection of the slope facets. On the other hand, the alternation of resistant and soft strata beneath the caprock inhibits talus flatirons development.

¹⁴C AND AMS RESULTS

Although the prospection of carbonaceous remains in the slope deposits has been most of the times unfruitful, some samples of datable material were collected at different locations. The ages of the different talus flatiron stages obtained by ¹⁴C and AMS and the correlations with climatic sequences are as follow:

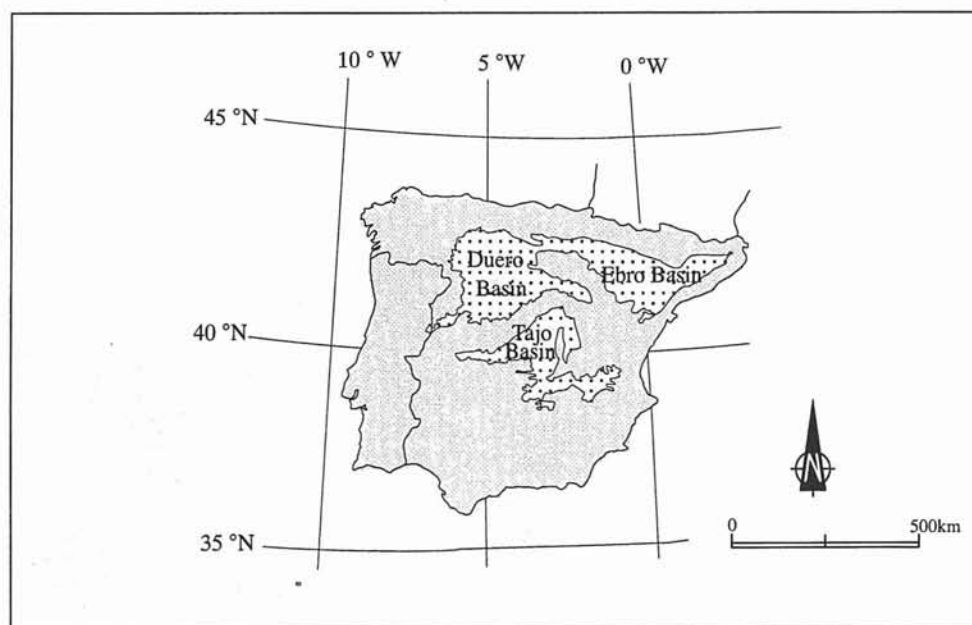


FIG. 2 - Distribution of the continental Tertiary basins.

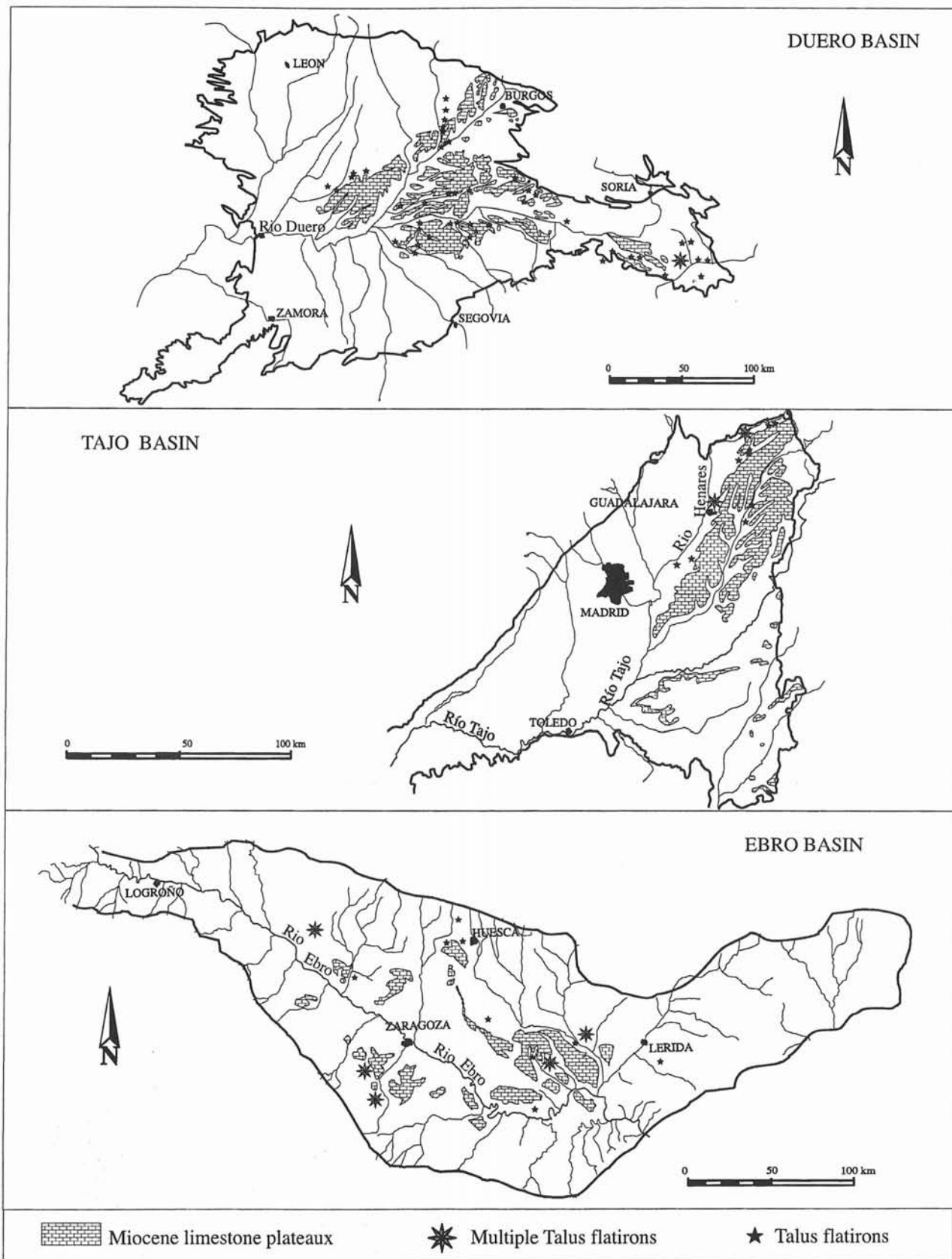


FIG. 3 - Talus flatiron areas in the main Tertiary basins in central Spain.

- *Second stage (S₂):*
 - San Pablo and Las Coronas (Ebro Basin) - Iron Cold Epoch (2900-2300 years BP) (Lamb, 1977; Gribbin & Lamb, 1978; Grove, 1979; Harding, 1982).
 - Monteagudo (Duero Basin) - Middle-Final Bronze Age (3500-3100 years BP) (Harding, 1982; Lamb, 1982).
 - Event 2 (2800 years BP) (Bond & *alii*, 1997).
 - These periods are called by Goudie (1995) «Upper Holocene Neoglaciations»
- *Third stage (S₃):*
 - Monteagudo (Duero Basin) (28350 years BP) H₃ (Heinrich event)
 - Las Coronas (Ebro Basin) (27862 years BP) H₃ (Heinrich event)
- *Fourth stage (S₄):*
 - San Pablo (Ebro Basin) (35570±490 years BP) H₄ (Heinrich event)

In the Tajo Basin, although five slope facets have been recognised, the prospection of charcoal and ashes has been unsuccessful.

DISCUSSION AND CONCLUSIONS

The generation of talus flatirons generation requires the alternation of periods with prevalence of accumulation processes followed by periods with preponderance of erosion processes in the slopes. The change from an accumulation stage to an incision stage involves a substantial modification of the morphogenetic processes. These changes can be related to climatic variations and reflect the sensibility to erosion/deposition thresholds (Schumm, 1973, 1979) of the slopes. The thresholds could be related with a critical point of vegetation cover, which may be around 70% corresponding to a mean annual precipitation of 400-500 mm (Knox, 1984).

There is a generalised consensus about the climatic origin of incision-accumulation periods (Everard, 1963; Gerson, 1982; Gerson & Grossman, 1987; Sancho & *alii*, 1988; Gutiérrez-Elorza & *alii*, 1998a, b; Schmidt, 1989 a,b, 1994, 1996; Gutiérrez-Elorza & Sesé, 2001). Nevertheless, it is necessary to know the absolute age of the talus flatirons and to identify their morphologic evolution during the different climatic periods. This information could help to make correlations between climatic sequences of distant arid and semiarid zones of our planet. It is also important to consider that in the recent past anthropogenic activities may have influence these evolutionary stages (Everard, 1963; Gutiérrez-Elorza & Peña, 1989, 1992, 1998). Precipitation and temperature temporal variations give place to modifications in the percentage of vegetation cover affecting the hydric and aeolian erosion processes.

Heinrich events (Heinrich, 1988) are related with extreme cooling periods (Bond & *alii*, 1993). The North Atlantic deep sea cores study for the last 80000 years allowed the identification of 6 Heinrich events (Bond & *alii*, 1992; 1993). The obtained datations from different locations of

our study area show a good correlation with Heinrich events. Despite the scarce number of available absolute ages, it seems that the development of the talus flatirons in central-northern Spain has been controlled by large scale cold periods coincident with the Heinrich events

According to Heinrich (1988) and Bond & *alii* (1992, 1993), icebergs are supposed to spread from the North Atlantic to low latitudes (46 °N). Bond & *alii* (1993) suggest that Heinrich events are related with extreme cooling periods. Greenland ices cores indicate a temperature fall between 3 °C and 6 °C in relation to surges of icebergs (Bond & *alii*, 1993; Mayewski & *alii*, 1997). The cooling of the North Atlantic sea waters and air masses related to the presence of icebergs at low latitudes may have influence the climate of the Spanish Tertiary basins, causing an abrupt drop in temperature. The decrease in evapotranspiration and the consequent increase in the hydric availability of the soils favours the development of a denser vegetation cover. Under these conditions debris accumulation prevails over incision processes. Upper Holocene Neoglaciations also correspond to periods of glacial advance and cooling of North Atlantic waters.

Heinrich events have also been correlated with pollen records in Europe and North America, glacial deposits in the western of United States, loess deposits in China and with sediments in Arabian Sea suggesting the global incidence of these events. Our study suggests that the alternating accumulation and incision periods recorded in the talus flatirons sequences may be correlative to Heinrich events and warm interstadials and that the slope facets may be good paleoclimate indicators. The corroboration of this hypothesis is limited by the scarce amount of absolute datations. However, we hope that further research on this topic will support the proposed correlation. If future investigations demonstrate the climatic genesis of the talus flatirons, a curve for the Upper Pleistocene and Holocene climate of the studied region could be obtained. Due to the situation of the Iberian Peninsula between Europe and Africa, this climatic curve could be very useful for a possible correlation with the pluvial periods of northern Africa and the climatic fluctuations recognized in central and southern Europe.

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