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Discussion

Reply to comment by J.L. Díaz-Hernández and R. Julià on "Quaternary landscape evolution and erosion rates for an intramontane Neogene basin (Guadix-Baza basin, SE Spain)"

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ABSTRACT

We demonstrate that the age of 43 ka obtained for the topmost calcrete layer in the Guadix-Baza remains the only reliable numerical dating of the flat geomorphic surface that marks the end of the sedimentation in the basin. Consequently, the late Pleistocene to Holocene erosion rates derived from the incision of the present-day drainage network into the flat geomorphic surface remain valid. The calcrete radiometric ages reported by Díaz-Hernández and Julià (2012) in their comment are untenable due to the contamination with detrital ^{230}Th (not corrected with the applied U/Th technique) and the possible mix of textural elements with different ages (older inherited grains and newly formed grains). Díaz-Hernández and Julià also quote U/Th ages for travertine terraces formed later than the calcrete layer. These ages lack internal consistency probably due to systematic contamination and/or weathering of the samples. The archaeological ages reported by Díaz-Hernández and Julià are subjected to great uncertainties, but independently of the age assumed as most realistic, they are completely compatible with the age of 43 ka that we obtained for the topmost calcrete layer in the Guadix-Baza basin.

1. Introduction

We acknowledge the opportunity that the comment by Díaz-Hernández and Juliá (2012) offers us to reinforce and clarify the conclusions of our paper (Pérez-Peña et al., 2009). This reply will focus on three main points to answer the criticisms raised, namely (i) reliability and significance of the available calcrete ages, (ii) inconsistency of the travertine ages, and (iii) accuracy of archaeological age constraints.

2. Reliability and significance of the available calcrete ages

Until now, two sets of radiometric ages have been published for the calcrete layer that marks the topmost flat geomorphic surface in the Guadix-Baza basin (Fig. 1). On the one hand, we obtained ages of 68 ka (lower calcrete at the Guadix sub-basin; Fig. 1), 55 ka (uppermost calcrete at the Baza sub-basin) and 43 ka (uppermost calcrete at the Guadix sub-basin) by using the U-series method on four sub-samples in order to correct for the presence of inherited detrital ^{230}Th (Azañón et al., 2006; Pérez-Peña et al., 2009). On the other hand, Díaz-Hernández and Juliá (2006) obtained ages of 323, 316, 293 and 119 ka by using the same method, though on single samples and, therefore, not allowing for the presence of inherited detrital ^{230}Th, as attested by the $^{230}Th/^{232}Th$ ratios (see their Table 1). Consequently, the reliability of the ages reported by Díaz-Hernández and Juliá (2006) is very doubtful and this is why we did not consider them in our incision rate estimations. In Azañón et al. (2006) and Pérez-Peña et al. (2009), each calcrete age was obtained from four coeval sub-samples of the very top laminar horizon, which were dated by the U/Th isochron technique using total sample dissolution (Bischoff and Fitzpatrick, 1991). This method has been successfully applied to calcrete dating from alluvial terraces in the Sorbas basin (Kelly et al., 2000; Candy et al., 2003; 2004; Candy and Black, 2009) and represents the best approach for dating impure carbonates. Pedogenic carbonates might be dated by the U-series technique without the necessity of isochron construction, by simply measuring the U/Th isotopic ratios (Candy et al., 2005). Nevertheless, Candy et al. (2005) stated that this latter technique "it is only applicable to pedogenic carbonates with low levels of detrital contamination (i.e., <10 ppb conc. of ^{232}Th and >25 of $^{230}Th/^{232}Th$)". The U/Th data presented by Díaz-Hernández

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and Juliá (2006) show high levels of detrital contamination with 0.08–0.25 ppm of ^{232}Th concentration and ^{230}Th/^{232}Th ratios lower than 8.3, thus indicating that the calcrete can only be dated with the isochron technique. Therefore, the calcrete ages reported by Díaz-Hernández and Juliá (2006) cannot be considered as reliable data.

Apart from the imperfect dating technique used by Díaz-Hernández and Juliá (2006), the other main concern regarding their ages refers to possible mix of different textural elements in the dated samples. Regarding this point, the petrography and texture of the Guadix-Baza polyphasic calcrete reflect its different degrees of development, but targeted microsampling can isolate material precipitated at a specific time during the formation process, with a unequivocal genetic and chronological meaning (e.g. Sharp et al., 2003). Actually, a calcrete profile consists of different layers, most of them containing inherited grains from the bedrock (Alonso-Zarza, 1999; Candy et al., 2003). These inherited grains can contribute to yield older ages, resulting from the mix with newly formed calcite (Candy et al., 2003; Candy and Black, 2009). In the Guadix-Baza calcrete, the most suitable horizon to be dated is the topmost laminar one (Fig. 2), consisting of calcium carbonate precipitated in situ and representing a unique horizon with a clear and reliable geological significance in the evolution of soil calcretes (Candy et al., 2003; Azañón et al., 2006). The choice of sampling and dating other horizons or facies, such as the pisolitic ones, as presented in Díaz-Hernández and Juliá (2006) can lead to the overestimation of the calcium carbonate precipitation age, because of the possible occurrence of older micrograins of pre-existing material mixed with newly formed micrite coatings or infillings. In comparison, our ages (Azañón et al., 2006; Pérez-Peña et al., 2009) are strictly based on the microsampling of the topmost laminar facies (Fig. 2), with special attention paid to discarding any relict fragments visible at the optically microscopic scale.

The comparison of the Guadix-Baza calcretes with other dated calcretes on a regional scale could offer some additional data on the age of calcrete formation. Candy et al. (2003) reported a set of 24 U/Th calcrete ages in the neighbouring Sorbas basin (Fig. 1) in order to correlate calcrete formation with specific past climate conditions. They concluded that in the Sorbas basin the majority of the calcrete ages correspond to warm isotope stages (MIS 1 and 5), with only a few of them formed during cold stages (MIS 2–4) (Candy and Black, 2009). In order to establish the climatic conditions during the formation of the topmost Guadix-Baza calcrete, Azañón et al. (2006) performed a stable isotope study of 17 samples drilled from the uppermost centimetres of the laminar horizon (Fig. 2). The values obtained range from −9.17‰ to −6.28‰ for δ^{18}O and from −11.18‰ to −6.36‰ for δ^{13}C (Fig. 2), using the Vienna Peedee Belemnite as standard. Despite some quite obvious cyclicity, the stable isotope values as a whole suggest arid and cold climatic conditions during formation of the laminar calcrete (Azañón et al., 2006). Therefore, these data indicate that the Guadix-Baza topmost calcrete was not formed during a warm isotope stage as in the case of most of the Sorbas basin calcretes (Candy and Black, 2009), but during a glacial stage. Actually, the combined consideration of our U/Th ages for the topmost calcrete and the stable isotope data allow us to relate the formation of the Guadix-Baza topmost calcrete to the glacial stages MIS 2–4.

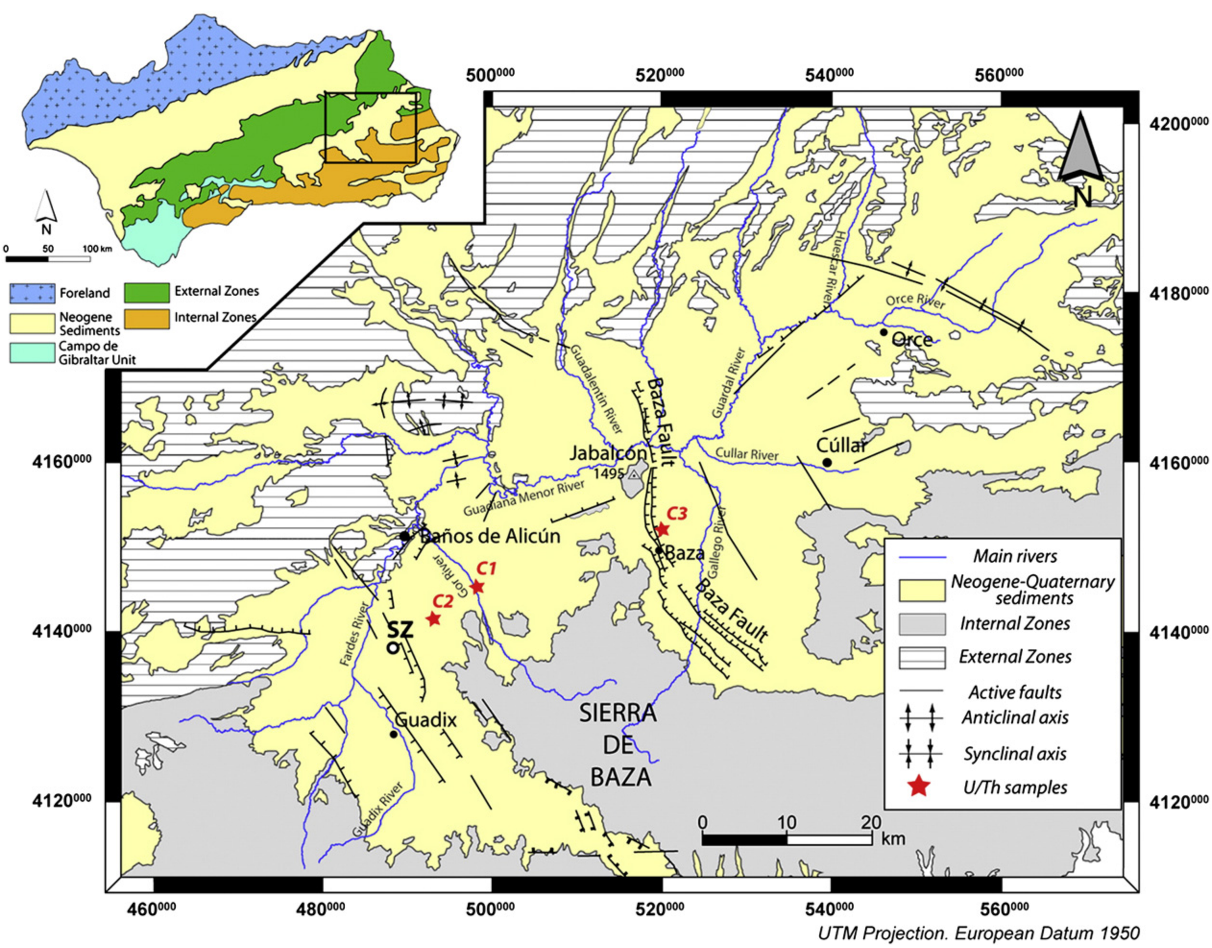

Fig. 1. Geologic map of the Neogene–Quaternary Guadix-Baza basin (modified from Pérez-Peña et al., 2009). Inset shows the location of the Guadix-Baza (GBB) and the Sorbas (SB) basins within the Betics. The location of the samples dated by Azañón et al. (2006) and Pérez-Peña et al. (2009) is shown (C1: 43 ka, C2: 68 ka, C3: 55 ka). SZ refers to La Solana del Zamborino archaeological site.