Pleistocene calcrete deposits from southern Spain as indicators of climatic conditions and tectonic activity

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1. INTRODUCTION

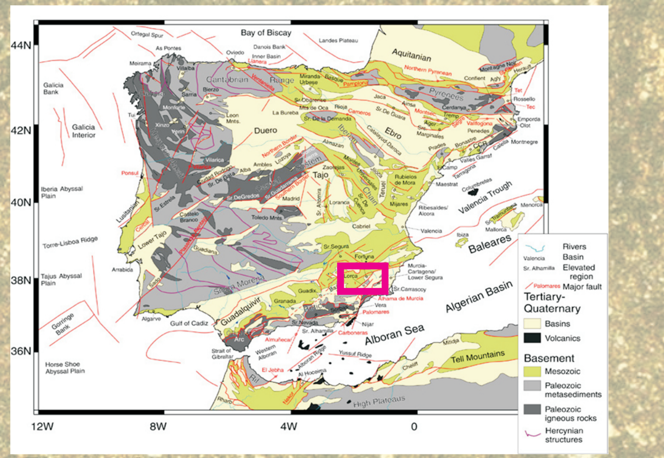

Figure 1: Location of the studied area in the Iberian Peninsula.

The **Cenozoic sedimentary** basins of southeast Spain (Fig. 1) have undergone progressive uplift, inversion and dissection over the **Quaternary Period.**

Pleistocene deposits are characterised by a long-term trend of fluvial incision that has been punctuated by episodes of fluvial aggradation, typically reflecting increased sediment supply during cold and dry glacial stages. Aggradational phases produce extensive gravel bodies that, after the subsequent return to incision, are left in the landscape as vertically distinct terrace surfaces.

In rapidly degrading landscapes the terrace surfaces act as stable platforms on which pedogenic processes can operate. In a **semi-arid region** such as southeast Spain, the terrace surfaces are characterized by **calcrete formation** with the oldest surfaces being cemented by mature forms such as densely cemented hardpans with **laminar crusts.**

2. GEOLOGICAL SETTING

The **Carrascoy Fault** is located in the Internal Zones of the Betic Cordillera, in the Murcia region, Southeastern Spain (Fig. 2A).It is one of the main faults forming the Eastern Betic Shear Zone (Fig. 2B), main structure that serves to accommodate the convergence between Nubian and Eurasian plates.

The Carrascoy Fault splits in two strands. The main relief is bounded by the North Carrascoy Fault, where the Internal Zones forms the hanging wall of a south dipping high angle left-lateral strike slip fault with reverse component. This fault strand affects up to the Tortonian deposits. The other strand of CAF is located to the north, named Casas Nuevas - Fuensanta Fault, which offset the Middle to Late Pleistocene alluvial fans coming from the range. These are the deposits where the studied calcrete horizon developed.

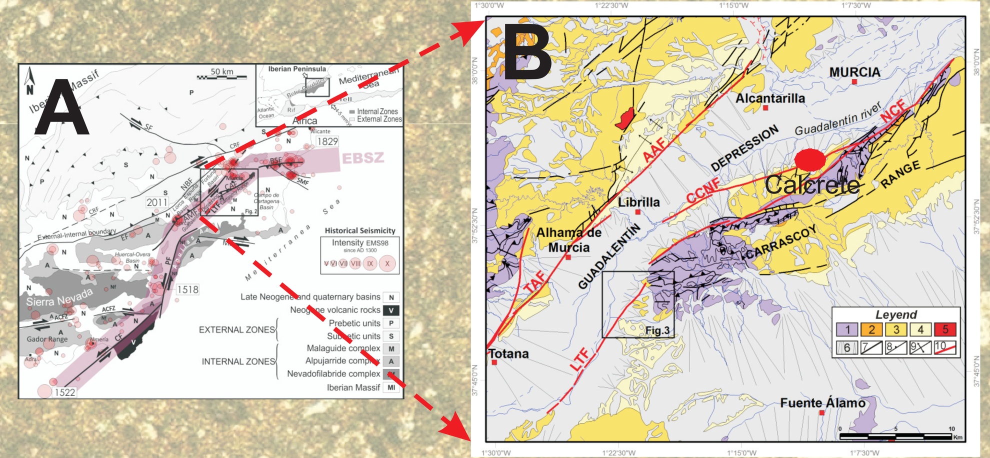

Figure 2: A)General trend of the strike slip fault; B) Detailed map of the location and trend of the Carrascoy Fault and the Carrascoy Range

3. OUTCROP ANALYSIS

Calcrete development

Calcrete development is controlled by different factors: climate, vegetation, carbonate supply, time for formation.

Calcretes within coarse-grained deposits (Fig. 3A) form according to the following stages:

Initially, the **clast are micritised.** The clasts coatings grow, progressively coalesce, and finally form a completely **indurated horizon.**

This indurated horizon promotes **ponding** of downward percolating soil moisture at the **hardpans** upper surface.

Evaporation, together with plant-roots activity and water action, leads to the precipitation of a final carbonate crust that forms the **laminar crust** (Fig. 3B & C).

Calcretes form progressively and a wide range of carbonate phases may occur within a single horizon.

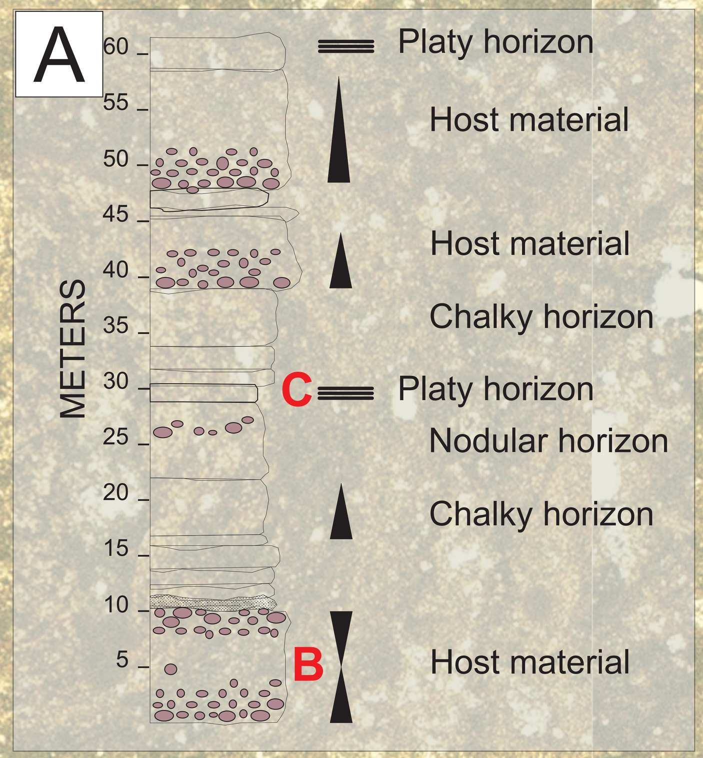

Figure 3: A) Section of the studied outcrop with location of the laminar crust (Location of photographs Fig. 3B and C).

Photographs showing the alluvial fan facies:

B) Polymictic breccia composed of metamorphic and sedimentary rock fragments sourced from the Carrascoy Range; C) Calcrete profile within the alluvial fan facies.

4. PETROLOGY AND XRD ANALYSES

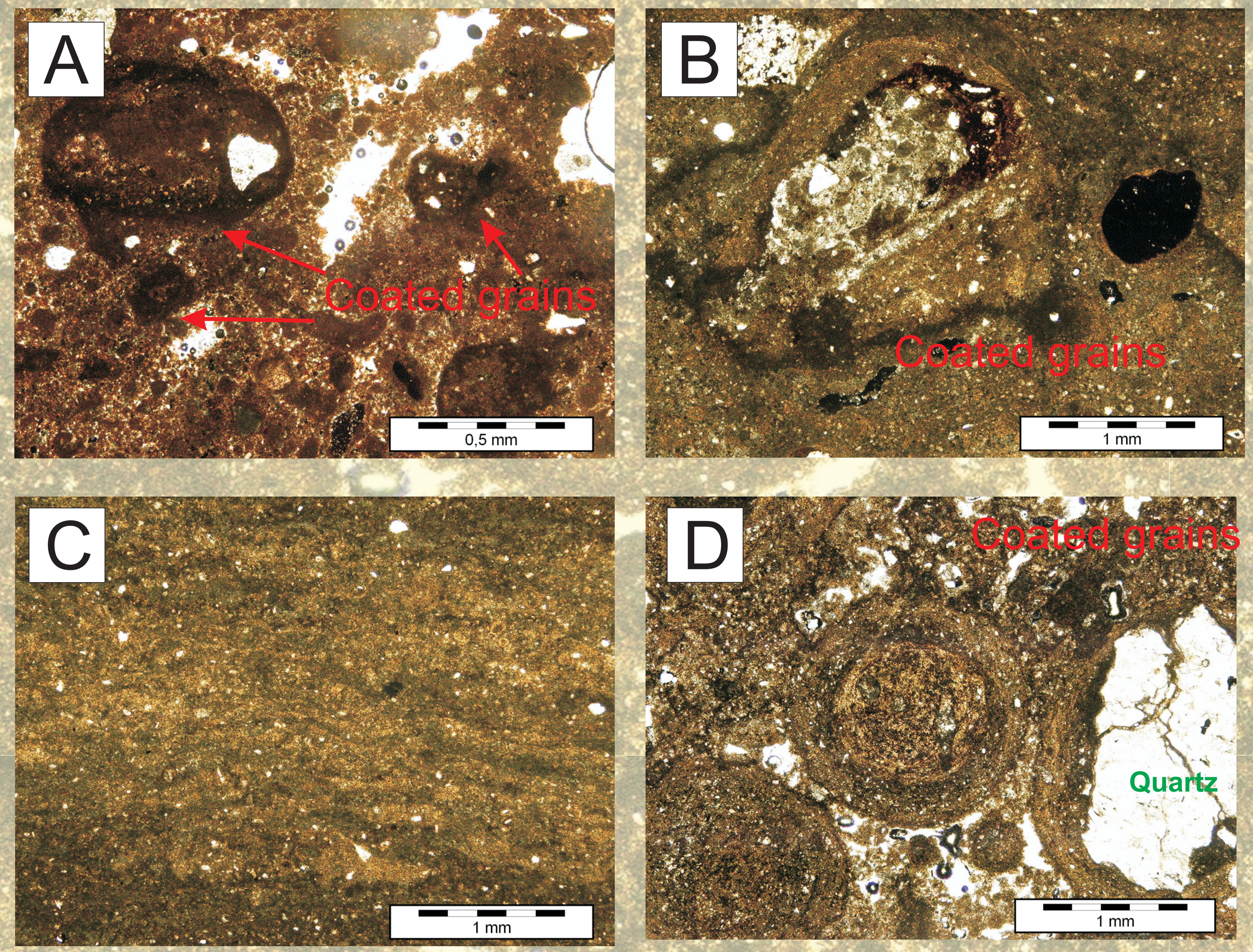

Figure 4: Photographs showing representative micromorphologies from thin sections of the studied carbonates. A) Calcrete fabric; B) Coated grain; The envelops are dark and irregular and include silt-size detrital grains; C) Laminar calcrete, with a thinly bedded habit, with variable microfabrics that include micritic layers, laminae with alveolar pores and laminae with micrite coated grains. D) Peloidal and/or intraclastic limestone formed by coated micritic grains.

The location of the **latest cement phase of the calcrete deposit** has been estimated by microscopic observations (to establish their suitability for dating) together with a detailed sedimentological analysis of the calcrete profile in the field.

The laminar crust consists of less than 1 mm thick laminae characterized by the alternation of layers of micrite and layers of micrite with ooids (Fig. 4A,B) detrital grains (fig. 4D) and clays indicating environmental conditions in which sedimentation rates were low and episodic.

These laminar calcrete (Fig. 4C) is very densely cemented, nonporous and, therefore **relatively resistant to diagenesis.**
It is composed of 98% of calcite and minor quartz ammounts (2%) that corresponds to detrital contamination (Fig 5A). It is the last carbonate phase formed in the calcrete profile, and we have sampled it (Fig. 5B) in order to obtain the last time at what the calcrete was active.

This study has lead to reliably asses the **timing of changes in alluvial processes**, to **characterize this part of the stratigraphic succession as corresponding to an arid to semi-arid environment.**

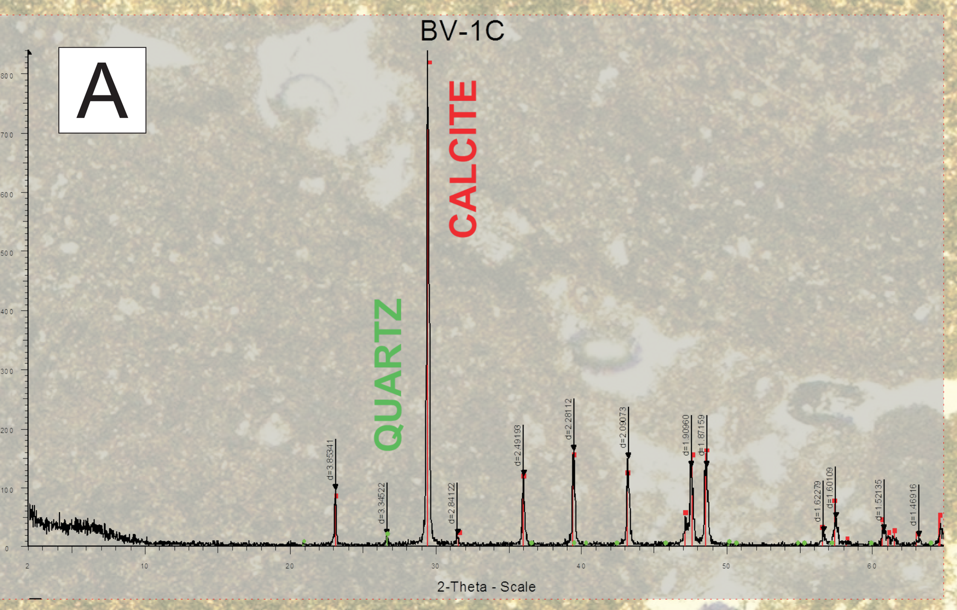

Figure 5: A) XRD Difractogram of the laminar calcrete, showing the calcite and quartz peaks.

Figure 5: B) Hand specimen of the laminar calcrete and points sampled for U/Th analysis.

5. GEOCHRONOLOGY

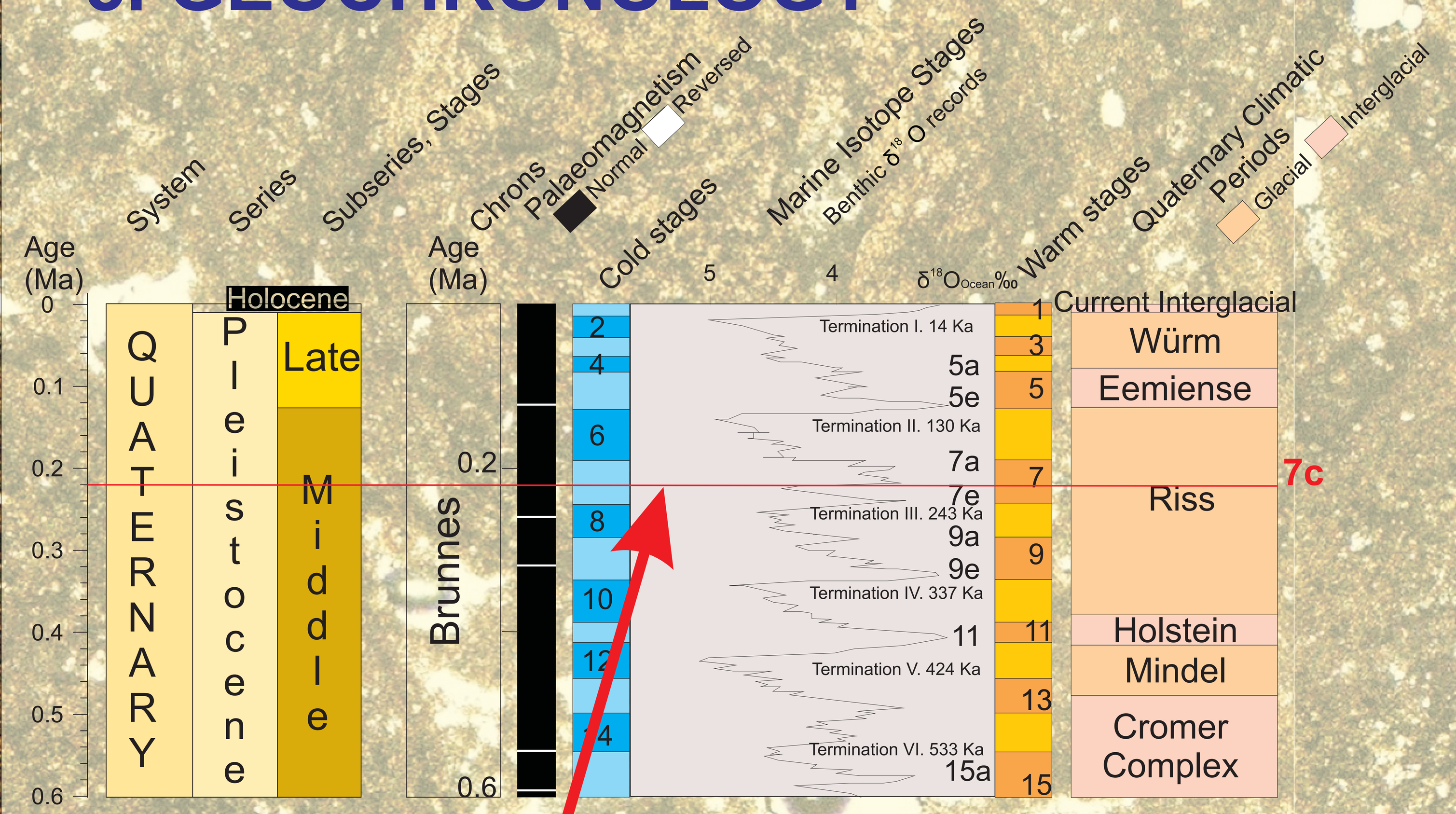

Figure 6: Global Chronostragraphical correlation table (IUGS, 2010).

Table 1. Results of the U-Th dating

Sample	U-Th Age
BV-a	209.8 ± 7.6
Bv-b	209.1 ± 6.2

By using **radiometric $^{232}Th/^{238}U$** dating methods we have obtained an **age of formation** of the **laminar crust** (Table 1) of **209 ka** (upper part of the Middle Pleistocene).

This age corresponds to the warm **stage 7c** within the **glacial Riss period** (Fig. 6).

As pointed out before, the studied calcrete appears subvertical as a result of the activity of the Carrascoy Fault.

Therefore, it can be concluded that **the fault was reactivated only after the calcrete was formed.**

6. CONCLUSION

Dating the last moment of calcrete formation indicates an **stability period** needed for the development of the calcrete profile **before any fault activiy**. This calcrete was later on folded and verticalised by the Carrascoy Fault.

The carbonate formed within the laminar crust capping the hardpan **will postdate** all the cement phases within the hardpan and the surface of detrital clasts.

Dating the moment of the laminar calcrete within a calcrete deposit permits to obtain a broad indicator of the time period over which this horizon was formed.

The age of the las carbonate cement forming the calcrete laminar crust is approximately 209.8 ka. This time interval is equivalent to the time **stage 7c**, a warm interval located within the **Riss glacial period.**

The climate in southern Spain has a **dry aspect during both interglacial and gacial periods,** being caused either by a semi-arid/arid climate or by seasonal moisture deficit. These type of climates permit soil moisture evaporation and promotion of carbonate precipitation.

BIBLIOGRAPHY

Candy, I., Black, S. and Sellwood, B. W. (2004). Interpreting the response of a dryland river system to Late Quaternary climate change. Quaternary Science Reviews, 23 (23-24). pp. 2513-2523.

Candy, I., Adamson, K., Gallant, C. E., Whitfield, E. & Pope, R.(2012). Oxygen and carbon isotopic composition of Quaternary meteoric carbonates from western and southern Europe: Their role in palaoenvironmental reconstruction. In : Palaeogeography, Palaeoclimatology, Palaeoecology. 326-328, 1-11.

Klappa, C.P. (1979). Calcified filaments in Quaternary calcretes: Organomineral interactions in the subaerial vadose environment. J. ediment. Petrol. 49:955-968.

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