

Complementing the Earthquake History of Andalusia (Spain) by ¹⁴C-Dating of Paleosols

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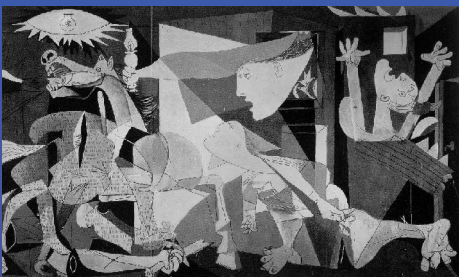


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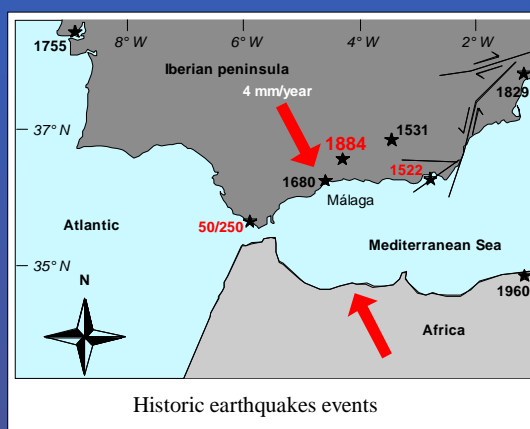
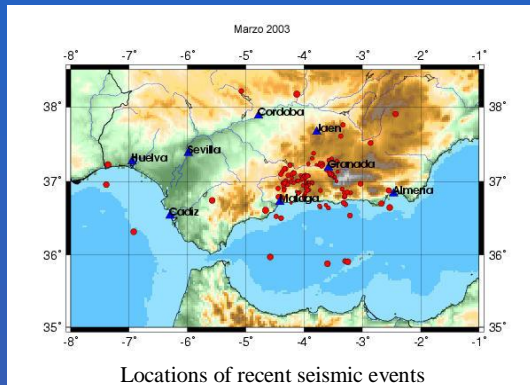


Introduction

Most Europeans think of sun, sea, flamenco, the Alhambra in Granada and Picasso, when they think of Andalusia. But the southern autonomous region of Spain, especially the Granada basin, is also an active tectonic region with a high frequency of microseismicity. Little is known about earthquakes in prehistoric times, and the historical records are partly doubtful. Several stratigraphical records of these seismic events have been revealed during the last years when funds from the EEC helped to develop the region, which is one of the driest parts of Europe with often less than 200 mm annual precipitation. With the available high amount of sunshine plus irrigation plus cheap plastic foil greenhouses (invernaderos) the formerly poor farmers now produce two or three harvests of vegetables per year, and with the funds highways were driven straight through the geologic formations, thus establishing the necessary fast connection to the markets in the North, and at the same time, opening the tectonic and pedogenetic archives.



Pablo Picasso was at the age of three, when he experienced the 1884 earthquake and subsequently the birth of his sister, and childhood psychologists argue that this trauma let him create such impressive paintings of people in distress and despair like in "Guernica".



Abstract

The seismicity of southern Spain during the Holocene is characterized by frequent moderate to strong earthquakes distributed along several active faults in the Betic Cordilleras.

Seismic data have been recorded routinely only after one of the most destructive earthquakes in Spain which occurred at December 25, 1884, with its epicenter near the village Arenas del Rey.

For less frequently occurring seismic events of a magnitude >5.5, prior to that date, only few doubtful historical descriptions are available.

Along major fault systems in Andalusia, we found profiles with several stratified paleosols, preserved in the hanging walls of faults.

By radiocarbon dating of disturbed displaced and undisturbed soil layers, together with paleoseismic and neotectonic studies of the surface ruptures, we were able to gain missing dates of the earthquake history of this region.

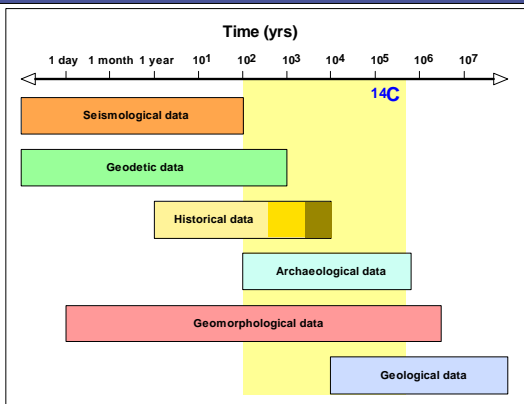
We identified two further Holocene (last 9.000 years) earthquake events with magnitude > 6 besides the one of 1884 along the fault through Ventas de Zaffaraya and Llanos de la Donna.

The obtained ¹⁴C dates fit well to the Richter-Gutenberg relation between frequency and magnitude of seismicity for the Granada region, which was established by the data of Morales et al. (1996) for frequently occurring recent small earthquakes and the strong Arenas del Rey event.

This implies recurrence rates of strong earthquakes in the order of 2.000.-3.000 years along that individual fault.

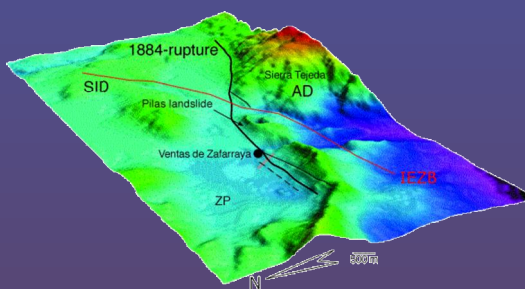
¹⁴C Dating

Besides geomorphological and archaeological evidences, due to the absence or doubtfulness of historic records, ¹⁴C dating is the method of choice for the regarding time interval, provided that samples are available which meet the requirements of the method.

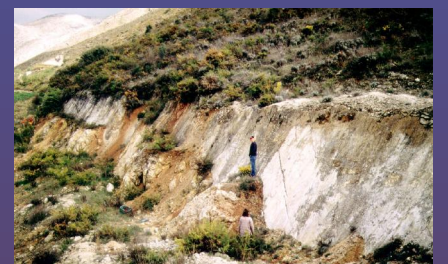


Study Area

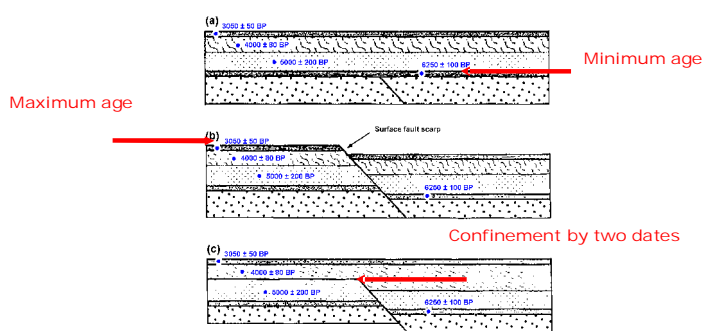
Along the fault with last major activity on December 25, 1884



Fault scarp at the site „Llanos de la Donna“



Palaeosols as time marker



Soil as Dating Material

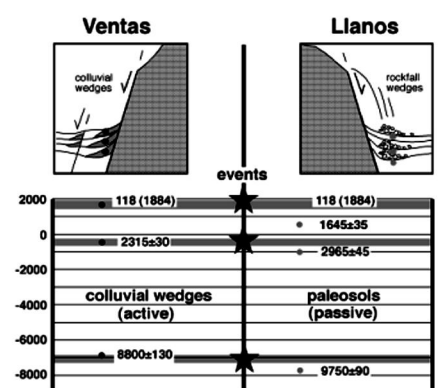
Where tectonic faults have been active repeatedly with a frequency low enough for soil development in the time between the events often two or more buried paleosols can be found. If the topsoil was buried by the event and isolated from further rejuvenation and contamination, the earthquake can be dated by the radiocarbon method of the bulk soil organic matter of the buried topsoil. In less favorable cases it is often possible to receive either upper or lower date limits or perhaps a time window for the events by ¹⁴C dating of soil organic matter from the soil horizons above and below the fault within a soil profile, hereby accounting for the increased age of deeper soil horizons compared to the topsoil material.



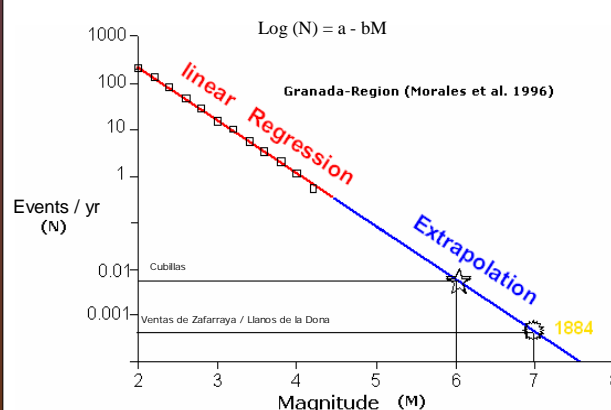
Highway cut with fault filled with colluvial wedges and a series of two distinguishable buried paleosols near the Cubillas reservoir north of Granada.

Results

Several paleosols were dated. At three sites (Cubillas, Ventas de Zaffaraya and Llanos de la Donna) series of subsequently buried soils permit first assumptions about event frequencies and the verify the high magnitudes part of the Richter-Gutenberg relation between earthquake frequency and magnitude for Andalusia, which so far could only be extrapolated from the microseismic data compiled by Morales et al.



Richter-Gutenberg Relation



Conclusion and Outlook

To further confirm the frequency magnitude relation for Andalusia and thus improve risk assessment, more systematic investigation is desirable and planned. As next step, we will excavate trenches along selected faults and conduct series of ¹⁴C dating.

Acknowledgements

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