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REACTIVATED JOINTS AND RECENT ACTIVE FAULTS IN THE CAMPO DE DALÍAS (BETIC CORDILLERAS, SOUTHERN SPAIN)

CONTENTS

ABSTRACT

The Campo de Dalías is an emerged zone located at the northern boundary of the Alboran Sea. The Neogene-Quaternary sediments of the Campo de Dalías are deformed by E-W open folds that also uplift Sierra de Gádor. Field studies reveal the existence of several joint sets with trends comprised between N170°E and N120°E, characterized by an ENE-WSW horizontal extension and NNW-SSE compression in Pliocene and Pleistocene times. The best represented faults in the region are the Holocene transtensional faults with dextral and sinistral components. Their trends range between N170°E and N120°E and are compatible with a stress field with ENE-WSW extension. These faults are formed by the reactivation of previous joints and are active at present, determining the coastline, like the Balanegra fault zone.

KEY WORDS: Campo de Dalías, Betic Cordilleras, reactivated joints, active faults

1. INTRODUCTION

The Betic and Rif Cordilleras have developed in the boundary between the African and Eurasian plates. In this sector of the plate boundary, active deformations and seismicity are distributed throughout a band of more than 300 km in width. The Betic Cordilleras are located at the western end of the Mediterranean alpine chains. These mountain ranges have been divided into External Zones, Internal Zones and Campo de Gibraltar Flysch Units. The Internal Zones are formed by the superposition of three tectonic complexes that extend below the Alborán Sea. The Campo de Dalías is located at the southern border of the Betic Cordilleras (Fig 1), and is one of the few areas between Almeria and Malaga where Neogene and Quaternary sediments of the northern boundary of the Alboran Sea crop-out. Neogene-Quaternary sediments of Campo de Dalías lie unconformably on the Alpujárride Complex. This sedimentary sequence begins with Tortonian calcarenites and is followed by Pliocene marls and calcarenites. The top of the sequence is made up of Pliocene-Quaternary continental and marine detritic sediments.

Although the area has been the aim of stratigraphic (RODRIGUEZ-FERNANDEZ & MARTÍN-PENELA, 1993), marine terrace (GOY & ZAZO, 1986) and seismicity (STICH *et alii,* 2001) studies, research related to recent active tectonics in the region is scarce. BAENA *et alii,* (1983) and MARTINEZ-DIAZ (2000) indicate the presence of faults with recent activity in some sectors of the Campo de Dalías.

The aim of this contribution is to analyze the recent tectonic evolution of the region since the Pliocene, which determines the characteristics of the active faults during the Quaternary, and is active up to Present. In this region joints, faults and folds developed simultaneously.

2. GEOLOGICAL STRUCTURES

In the central and eastern sectors of the Cordilleras, fold growth (WEIJERMARS *et alii,* 1985; JOHNSON, 1997) is simultaneous with fault development. The Campo de Dalías is deformed by E-W to ENE-WSW open folds that have developed from Tortonian up to Present. The Sierra de Gador mountain range is the greatest fold of this region. The progressive development of other growth folds toward the south of this sierra results in the emersion of the Pliocene-Quaternary marine deposits.

The Campo de Dalías is historically affected by earthquakes, some of which reached up to IX in intensity (25 of August 1804). The recent tectonic activity of the region is highlighted by the presence of distributed seismicity with small intensity earthquakes (m_b<5.0). The seismic series of Adra, between 1993 and 1994, includes more than 700 earthquakes mainly located in the Balanegra fault zone (Fig. 1) and its prolongation towards the sea (STICH *et alii,* 2001). This fault zone may be considered as one of the most representative of the region. The focal mechanisms of these earthquakes indicate that the active faults develop in a complex setting producing generally normal faults, sometimes with dextral components, strike-slip, and even reversal faults.

Field studies show that since the Pliocene, the region has been deformed by joints with trends comprised between N120°E and N170°E. Joints are grouped into two sets indicating shear or hybrid origin and a main set of

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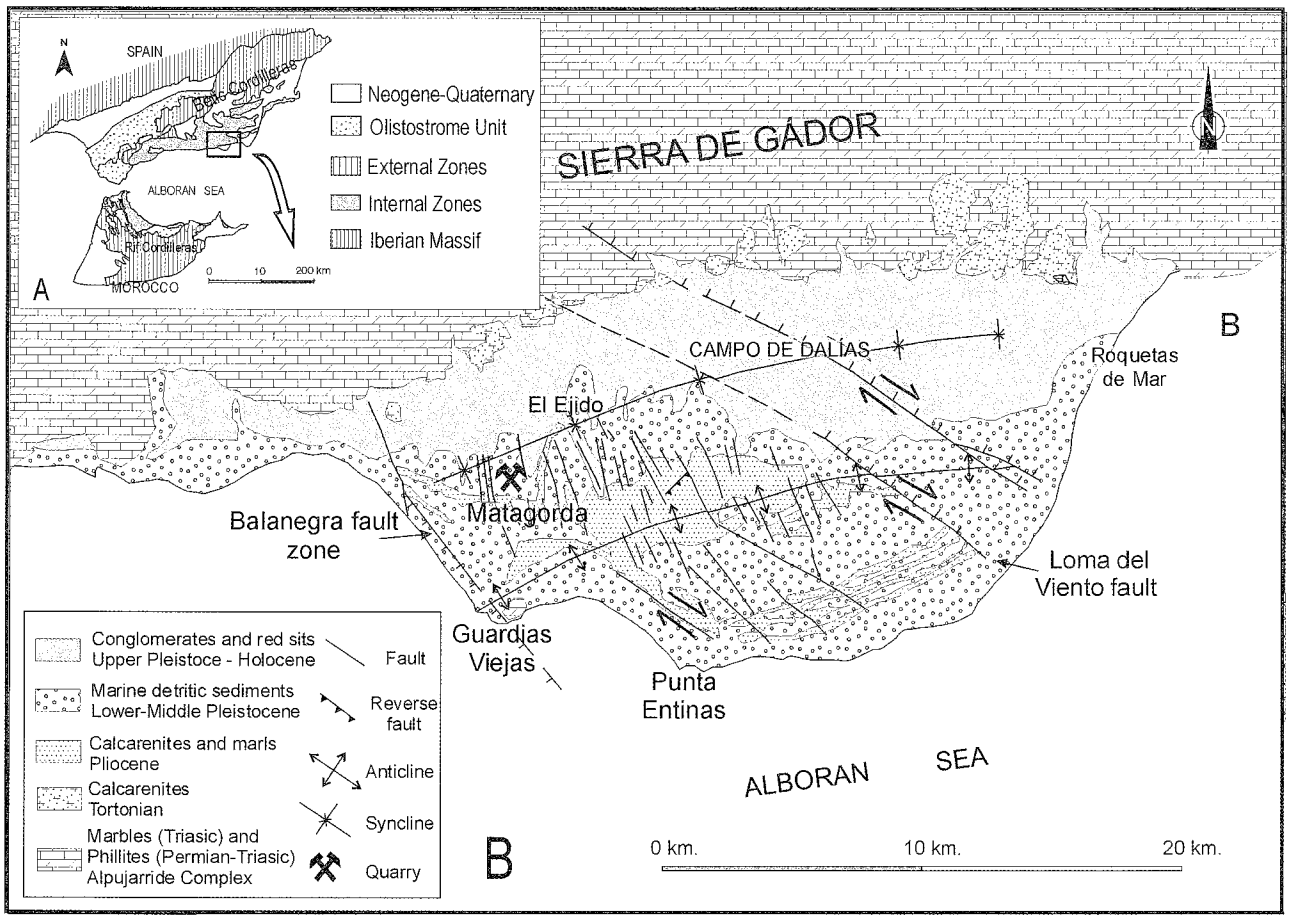

Fig. 1 - Geological setting of study area. A) The Betic and Rif Cordilleras. B) Geological Map of the Campo de Dalías.

tensional joints. These structures indicate a NNW-SSE trend of maximum horizontal compression and an ENE-WSW trend of extension. Only one set of joints is well developed in the Holocene deposits pointing to a WSW-ENE extension.

The area features N140°E normal faults with very high angle dipping planes, and transtensional faults with a dextral slip component (trends approximately between N140°E and N120°E) or with a sinistral slip component (trends from N140°E to N170°E). Most of the faults develop a half-graben structure in their hanging wall (Fig. 2) that is filled by a wedge of sediments showing the progressive fault activity during Quaternary.

Recent tectonic activity in several sectors of the Campo de Dalías is signaled by the presence of fault scarps associated with the main faults which can locally reach several tens of meters, deformation of the drainage network, the coast line alignment and deformation of marine terraces dated at 100.000 yrs (Goy & Zazo, 1986).

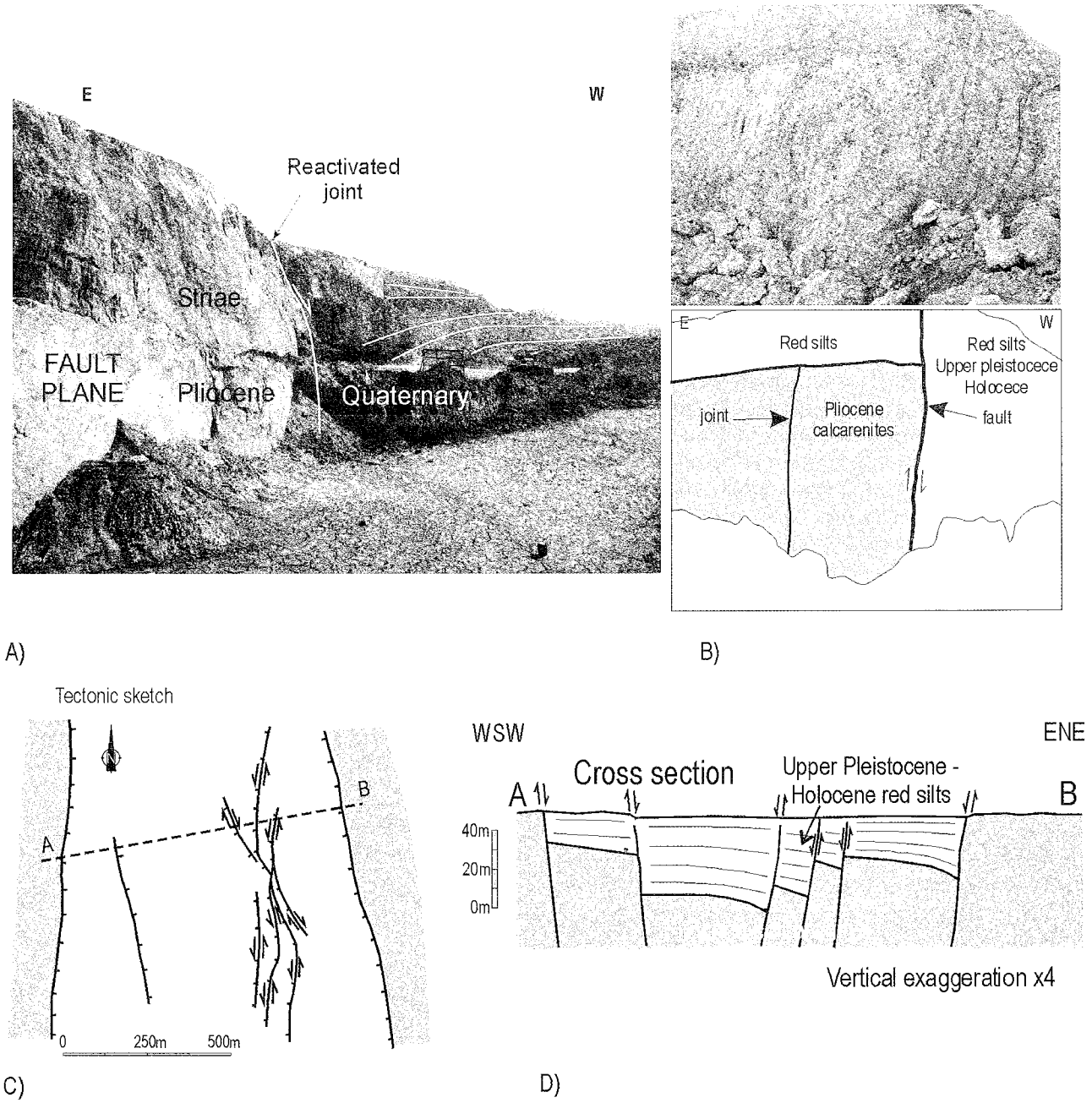

Fig. 2 - Faulted joints and related structures in Matagorda Quarry. Location in Fig. 1. A) Half-graben filled by Holocene deposits. B) Joints parallel to faulted joints in Pliocene calcarenites. Note the presence of an unconformity between Pliocene and Upper Pleistocene-Holocene rocks. C) Tectonic sketch of Matagorda Quarry showing the fault pattern that is similar to the joint pattern at outcrop scale. D) Cross section of Matagorda Quarry with the development of a half graben structure during Late Pleistocene-Holocene.

3. DISCUSSION AND CONCLUSIONS

Faults developed probably by reactivation of the joints, because most of the fault planes are subvertical and parallel to the main joint sets. The pattern of faults at map scale is similar to the distribution of joints at outcrop scale. The great variability of the slips may be a consequence of the reactivation of previous fracture planes in a single recent stress field. The recent faults developed in a tectonic setting similar to that determined by the earthquake focal mechanism at Present, and allow us to understand the apparent discrepancy between slips of active faults. The Balanegra fault is one of the most active structures in the area and determines the present-day orientation of the coast line. At any rate, the E-W trend of the coast line between Malaga and Almeria is mainly a consequence of the development of large E-W folds.

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