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Recess drawn by the internal zone outer boundary and oblique structures in the paleomargin-derived units (Subbetic Domain, central Betics): An analogue modelling approach

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Abstract

The Subbetic Domain, comprising the South Iberian paleomargin-derived units, is a fold-and-thrust belt developed over a ductile substrate showing a complex structural pattern. In the central Betics, a main trend can be defined, with respect to which frequent oblique structures are observed. These oblique structures, often subperpendicular to the main trend, are not located along transfer zones but rather are present everywhere in the fold-and-thrust belt. Moreover, they are coetaneous with those drawing the main trend. This complex pattern is situated in front of a recess marked by the outer boundary of the internal zones – the Alboran Domain – which acted as backstop. Analogue models were designed to study the influence of such a recess on a ductile-brittle multilayer. One of the models, in which the backstop recess is symmetric with respect to its direction of movement, shows a high variation in the orientation of the resulting structures, being not only qualitatively but also quantitatively similar to the studied natural case.

Keywords: Betics; Structural pattern; Oblique structures; Ductile substrate; Recess; Analogue modelling

1. Introduction

The Alpine-Mediterranean orogenic belt, and in particular the Gibraltar Arc area, is generally known as a case study of extensional processes that went hand in hand with compressional ones. During the Miocene, the Betic-Rif orogen was affected by rifting in the internal part of the Gibraltar Arc, while folding and thrusting took place in its external part (Platt and Vissers, 1989; Frizon de Lamotte et al., 1991; García-Dueñas et al., 1992). Over the past two decades, much attention has been paid to the extensional processes that affected the Alboran Domain, that is, the internal zones common to both branches of the Gibraltar Arc (see review in Frizon de Lamotte et al., 2004). In contrast, only a few papers address the structural evolution of the external zones, namely the External Rif and Subbetic Domains, respectively, south and north of the Gibraltar Strait. Within the Subbetic units of the central Betics, Crespo-Blanc (2007) recently described a very complex fold-and-thrust geometry resulting from Early to Middle Miocene shortening. Oblique structures with respect to the main structural trend are frequent, most notably in an area where the external–internal zone boundary draws a recess. Superposed buckle folding has also been described for the same area (Crespo-Blanc, 2007). The present paper sheds some light on the various hypotheses that may be put forth regarding the formation of such oblique structures – which are distributed throughout the area, and not located along transfer zones – by applying the analogue modelling tool.

The analogue experiments presented in this paper help to broaden the available experimental templates for natural thrust wedges. Together with a review of previously published analogue models, they allow us to test whether a simple recess of the backstop geometry might be evoked to explain the genesis of oblique structures in a tectonic domain thus far poorly understood from a structural point of view.

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2. The Betic-Rif orogenic wedge

The Betic and Rif arc-shaped mountain belt around the Strait of Gibraltar closes, to the west, the Alpine-Mediterranean orogenic system, which developed during the late Mesozoic to Cenozoic convergence between Africa and Iberia. Various tectonic domains can be differentiated around the Gibraltar Arc (Fig. 1). The South Iberian and Maghrebian paleomargin-derived units consist of autochthonous, parautochthonous and/or allochthonous non-metamorphic Mesozoic and Tertiary covers. They respectively detached during Miocene times from a Variscan basement, the Iberian Meseta and the Moroccan Meseta, and now constitute the Prebetic and Subbetic Domains in Spain, and the Pre-Rif, Meso-Rif and Intra-Rif Domains in

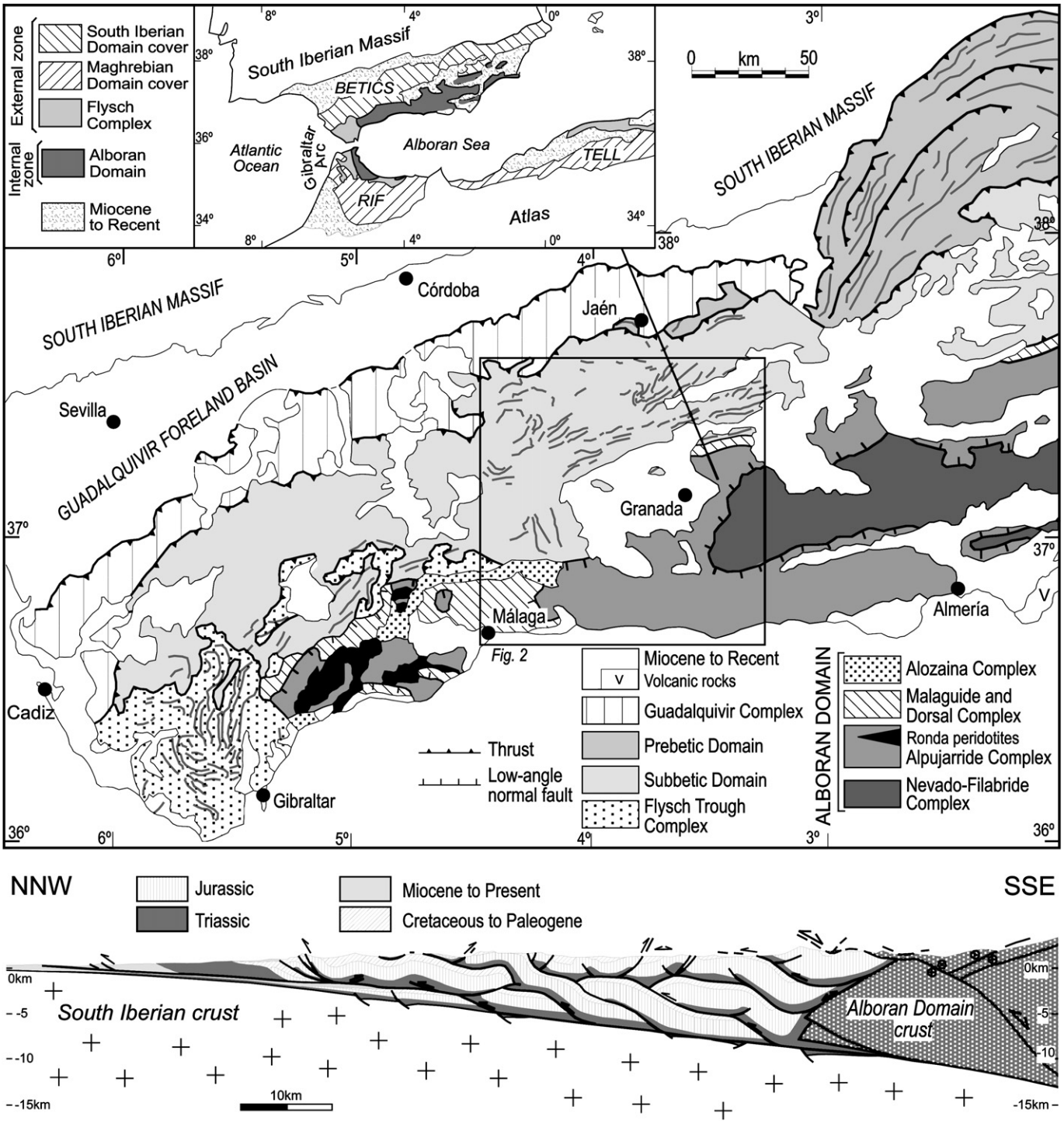

Fig. 1. Tectonic map of the Subbetic Domain in the central and western Betics (northern branch of the Gibraltar Arc) and trend of the structures associated with the main shortening. Large-scale cross-section (located on the map) according to Frizon de Lamotte et al. (2004). Inset: Alpine orogenic belts in the westernmost Mediterranean region.