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Domino structures evolution in strike-slip shear zones; the importance of the cataclastic flow

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ABSTRACT

The Porto-Tomar-Ferreira do Alentejo dextral Shear Zone is one of the most important structures of the Iberian Variscides. In its vicinity, close to Abrantes (Central Portugal), a localized heterogeneous strain pattern developed in a decimetric metamorphic siliceous multilayer. This complex pattern was induced by the D_2 dextral shearing of the early $S_0//S_1$ foliation in brittle-ductile conditions, giving rise to three main shear zone families. One of these families, with antithetic kinematics, delimits blocks with rigid clockwise rotation surrounded by coeval cataclasites, generating a local domino structure.

The proposed geometrical and kinematic analysis, coupled with statistical studies, highlights the relation between subsidiary shear zones and the main shear zone. Despite the heterogeneous strain pattern, a quantitative approach of finite strain was applied based on the restoration of the initial fracture pattern. This approach shows the importance of the cataclastic flow coupled with the translational displacement of the domino domain in solving space problems related to the rigid block rotation. Such processes are key in allowing the rigid block rotation inside shear zones whenever the simple shear component is a fundamental mechanism.

1. Introduction

The kinematics of shear zones is not an easy subject due to the complexities arising during heterogeneous internal deformation (*e.g.* Passchier and Trouw, 2005 and references herein). Dominos (sometimes called bookshelf structures) are one of the common strain accommodation structures developed in shear zones. They have been described from low to high-grade metamorphic rocks, although they are commonly developed in brittle to ductile-brittle deformation regimes (Mandl, 2000; Ribeiro, 2002; Goscombe and Passchier, 2003; Figueiredo et al., 2004), obeying the Coulomb criterion for failure (Jaeger and Cook, 1979).

These structures are usually characterized by the rotation of blocks, often bounded by one dominant shear/fracture orientation (Mandl, 2000; Nixon et al., 2011; Fossen, 2010). However, in some very specific situations, dominos can be developed without block rotation, because each block could slide past each other during bulk shearing (Samanta et al., 2002). Thus, dominos are often used as a shear sense criteria (Passchier et al., 1990; Mandl, 2000; Goscombe and Passchier, 2003; Goscombe et al., 2004; Passchier and Trouw, 2005; Fossen, 2010), helping to understand the kinematics of shear zones. The careful analysis of their geometry, kinematics and genetic mechanism becomes essential to a correct dynamic interpretation of shear zones.

Dominos and domino-like structures can either have antithetic or synthetic rotation relative to the main shear (Fig. 1A; Goscombe and Passchier, 2003; Dabrowski and Grasemann, 2014), which is a major constrain for their use as kinematic criteria. This is not a major problem in extensional regimes, where rotation of dominos generally occurs antithetically to the main low angle ductile décollement (Wernicke and Burchfiel, 1982; Mandl, 1987; Axen, 1988; Fossen and Hesthammer, 1998; Bahroudi et al., 2003; Karlstrom et al., 2010). Nevertheless, as in strike-slip environments both types of block rotations are common, their use as a kinematic criteria is more problematic (Cowan et al., 1986; Mandl, 2000; La Femina et al., 2002; Goscombe and Passchier, 2003; Goscombe et al., 2004; Nixon et al., 2011; Dabrowski and Grasemann, 2014; Dias et al., 2017). In such regimes, the synthetic or the antithetic block rotation seems to be controlled by factors as flow type, rheological contrast, initial angle of the previous foliation to the main shear zone, existence of previous anisotropies bounding blocks or the shape of the block (Mandal et al., 2000; Goscombe and Passchier, 2003; Dabrowski and Grasemann, 2014). However, analogue experiments indicate that the orientation and the spacing of fractures in the

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be accommodated with such mechanism. In any model trying to explain the genesis of dominos, such inconsistency must be explained.

The issues stressed above are no resolvable invoking homogeneous deformation, unless the shear zones are operated in a transpressive regime, or if a local volume variation exists at the interfaces of the blocks.

The geometrical and kinematical studies in the Abrantes domino highlights the importance of cataclastic flow within brittle-ductile shear zones. The cataclastic material behaves as a plastic matrix, removing material from the overlap domains into the gap zones. In cases where β_0 is greater than 90°, gaps prevail between blocks (Fig. 1C), facilitating their rigid rotation.

The presence of subsidiary antithetic shear zones (SF1), together with the main boundary shear zones (MSZ), generates an internal clockwise flow, responsible for the rigid block spinning. Such process, coupled with the cataclastic flow, led to important translational mechanism within the domino domain (Figs. 10C and 11B). This became paramount as a length conservation mechanism, parallel to the trend of the shear zone.

Such heterogeneous deformation can be accounted for the development of these complex patterns in the shear zones. Thus, the interpretation of domino structures must be done carefully, and their kinematic and dynamic analysis must be supported by the general framework.

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