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Superposed ruptile deformational events revealed by field and VOM structural analysis

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Virtual outcrop models (VOM) is becoming an important application in the analysis of geological structures due to the possibility of obtaining the geometry and in some cases kinematic aspects of analyzed structures in a tridimensional photorealistic space. These data are used to gain quantitative information on the deformational features which coupled with numeric models can assist in understands deformational processes. Old basement units commonly register superposed deformational events either ductile or ruptile along its evolution. The Porongos Belt, located at southern Brazil, have a complex deformational history registering at least five ductile and ruptile deformational events. In this study, we presents a structural analysis of a quarry in the Porongos Belt, coupling field and VOM structural information to understand process involved in the last two deformational events. Field information was acquired using traditional structural methods for analysis of ruptile structures, such as the descriptions, drawings, acquisition of orientation vectors and kinematic analysis. VOM was created from the image-based modeling method through photogrammetric data acquisition and orthorectification. Photogrammetric data acquisition was acquired using Sony a3500 camera and a total of 128 photographs were taken from ca. 10-20 m from the outcrop in different orientations. Thirty two control point coordinates were acquired using a combination of RTK dGPS surveying and total station work, providing a precision of few millimeters for x, y and z. Photographs were imported into the Photo Scan software to create a 3D dense point cloud from structure from-motion algorithm, which were triangulated and textured to generate the VOM. VOM was georreferenced (oriented and scaled) using the ground control points, and later analyzed in OpenPlot software to extract structural information. Data was imported in Wintensor software to obtain tensor orientations, and Move software to process and interpret geometrical and kinematic data. Planar and linear structural orientations and kinematic indicators revealed superposition of three deformational events: i) compressive, ii) transtensional, and iii) extensional paleostress regimes. The compressive regime was related to a radial to pure compression with N-S horizontal maximum compression vector. This stress regime corresponds mainly to the development of dextral tension fractures and NE-SW reverse faults. The transtensional regime has NW-SE sub-horizontal extension, NE-SW horizontal compressional, and sub-vertical intermediate tensors, generating mainly shear fractures by reactivation of the metamorphic foliation (anisotropy), NE-SW reverse faults and NE-vertical veins and gashes. The extensional regime of strike-slip type presents a NE-SW sub-horizontal extension and NW-SE trending sub-vertical maximum compression vector. Structures related to this regime are sub-vertical tension gashes, conjugate fractures and NW-SE normal faults. Cross-cutting relations show that compression was followed by transtension, which reactivate the ductile foliation, and in the last stage, extension dominated. Most important findings show that: i) local stress fields can modify expected geometry and ii) anisotropy developed by previous structures control the nucleation of new fractures and reactivations. Use of field data integrated in a VOM has great potential as analogues for structured reservoirs.