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Relationship between the Vitória-Ecoporanga Dyke Swarm and the Vitória Structural High, Brazil

Camilo I. Ordóñez ARISTIZÁBAL^{1,*} and André Luiz FERRARI²

¹ NACAD/COPPE/UFRJ Centro de Tecnologia - Bloco H (anexo) Av. Athos da Silveira Ramos, 149 Cidade Universitária Rio de Janeiro, RJ - ZIP 21949-970 – Brazil

² Universidade Federal Fluminense/LAGEMAR, Departamento de Geologia Universidade Federal Fluminense Av. Gen. Milton Tavares de Souza s.n., Niterói, RJ - ZIP 24210-346 – Brazil

In Espírito Santo State, Brazil, between the municipalities of Vitória, Colatina and Ecoporanga, there is a mountainous region characterized by a shear zone which trends NNW-SSE and is filled by a diabase dyke swarm (Fig. 1). This system of fractures is approximately 300 km long and 40 km wide. The associated dyke swarm is named the Vitória-Ecoporanga Dyke Swarm (VEDS).

South of the VEDS, offshore, the Vitória Structural High (VSH) represents an elevated basement region which bounds the Campos and Espírito Santo basins, and it will be argued that the VSH is genetically associated with the 10s of dykes from VEDS.

Initial geological studies explained the fracturing of such system of fractures as caused by Araçuaí Belt deformation during the Brasiliano Cycle in the Neoproterozoic. It was characterized as a ductile to ductile-brittle shear zone. However, this kind of deformation was not identified in the basement, and also there is no evidence of dyke emplacement being controlled by the basement foliation. Therefore, the VEDS is better interpreted as a magmatism event that intruded syntectonically with the brittle structures and both are superimposed on basement rocks.

An $\text{Ar}^{40}/\text{Ar}^{39}$ plateau age of 128.4 ± 1.4 Ma (Texeira & Rodarte, 2003) was obtained for three dykes, and this age correlates with that for the volcanic rocks of the Cabiúnas Formation in both Campos and Espírito Santo basins (Novais, et al., 2004) which are pre-rift to rift (França *et al.*, 2007; Winter *et al.*, 2007). This ca. 128 Ma age would also match with the Parana magmatism of the combined Parana (Brazil) – Etendeka (Namibia) Large Igneous Province (Stica, et al., 2014). This correlation is reinforced

by petrological data (Valente, et al., 2007 and Valente, *et al.*, 2009).

Given the absence of a detailed study of the structural, geometric, kinematics and dynamic of the VEDS, the present study aimed to characterize the intrusive character of this diabase dyke swarm. For this purpose, fault striation data were obtained both along internal fractures within the dykes and also in the host rocks bordering the dykes. Also, the morphology and distribution of the dyke bodies were analyzed, as well their geometric correlations, such as *en-echelon* structures and morphological features like intrusive bridges, fingers, etc. (Figs. 1 and 2).

The dykes were oriented vertically, and their margins were typically glassy indicating a shallow level of intrusion (Fig. 1). Often the dyke margins are fractured and grooved with calcite fibers, suggesting tectonic control even at the intrusion time. However, the ductile structures (foliation) of the Precambrian basement have no control on dyke intrusion, because dyke trends are typically different to the orientation of host rock foliation.

Inversion of paired data, fracture geometry and morphological characteristics analysis of the dykes show a palaeostress field with σ_1 sub-horizontal and with NNE direction, σ_3 also horizontal with WNW direction and σ_2 vertical that support a NNW dextral transcurrent binary controlling the VEDS emplacement (Figs. 1 and 2).

A regional network of 2D seismic data had does allow analyze the correlation between VEDS and the Vitória Structural High (VSH) at the southern end of the swarm. The seismic interpretation focused mainly below the Cretaceous (and younger) sedimentary package and revealed an interesting morpho-tectonic segmentation of the basement, specially negative and positive flower structures, which bind the units below the salt beds until

* Corresponding author. E-mail: c.aristizabal@nacad.ufrj.br

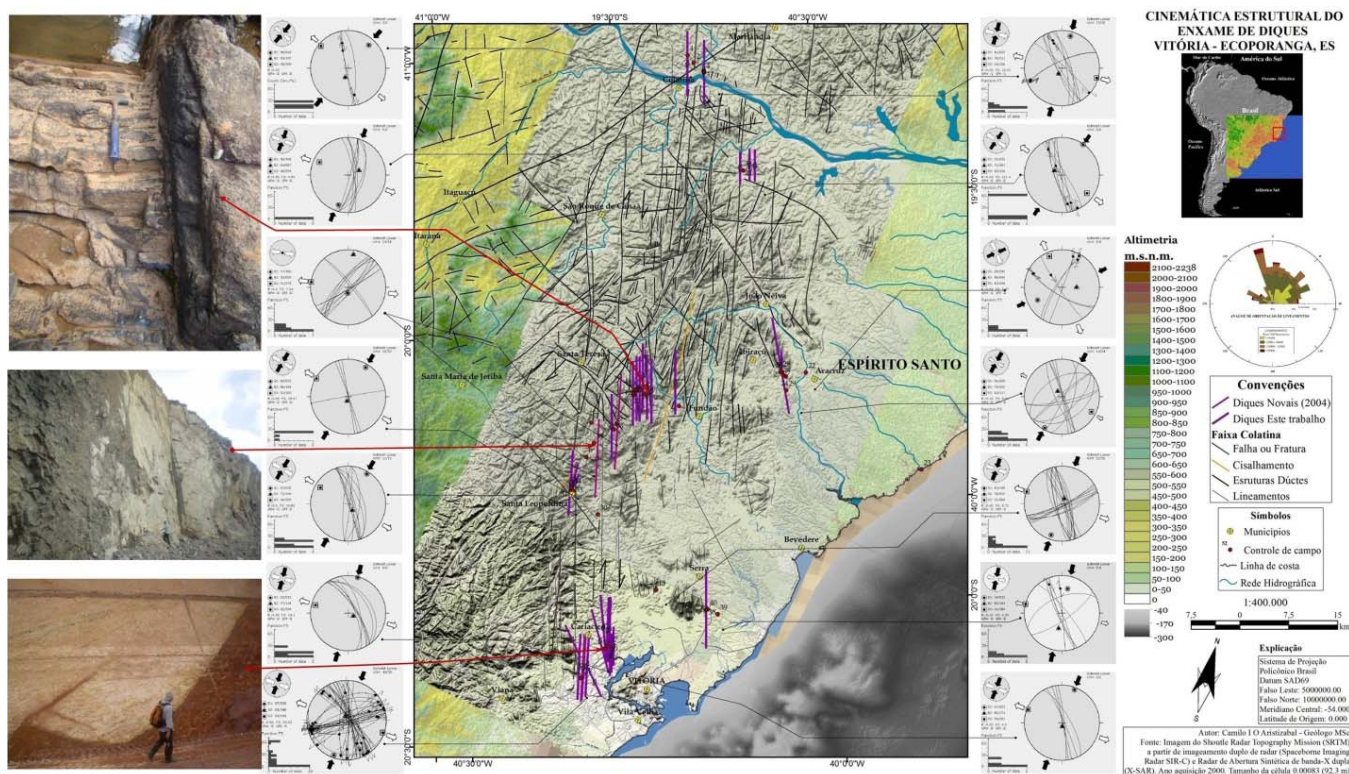
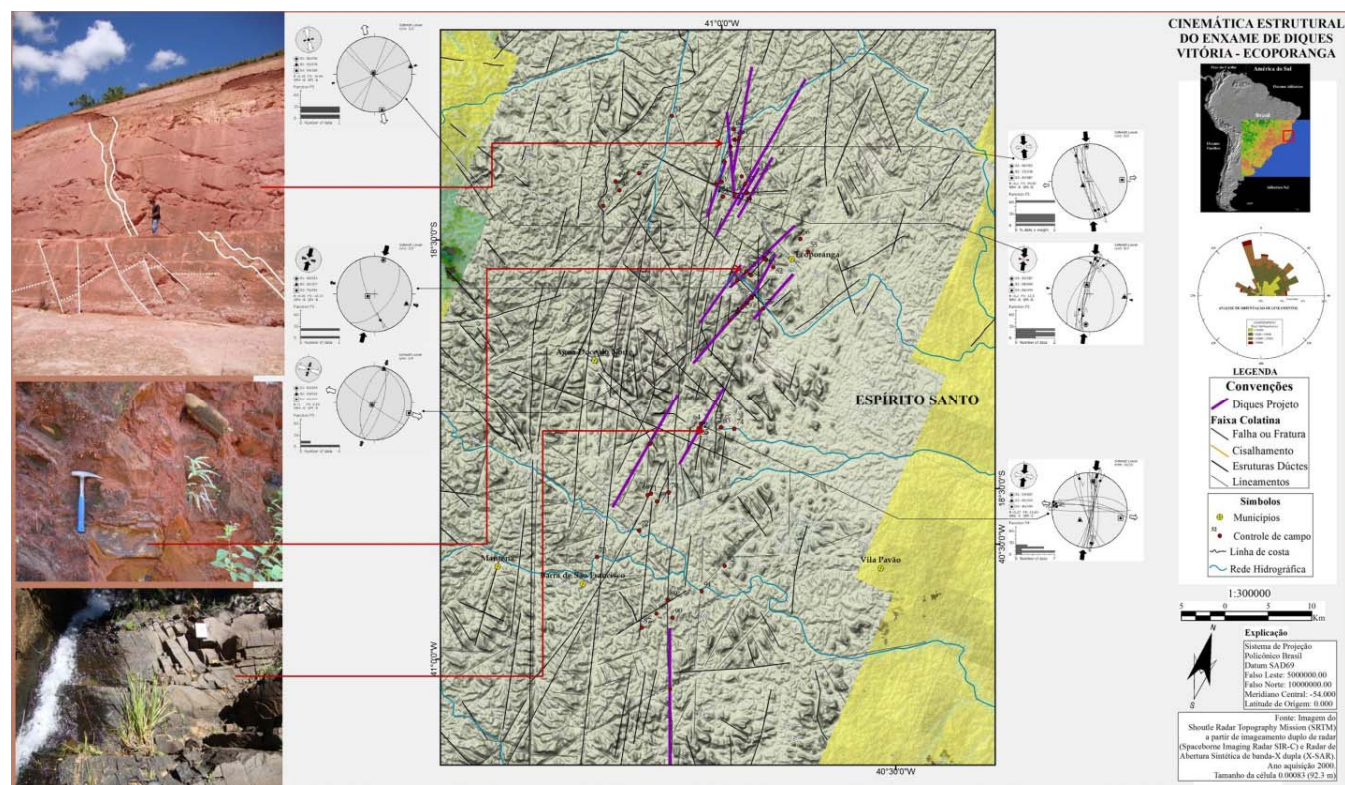


Fig. 1. Northern and southern portion of the VEDS trending NNW-SSE location map divided in two. The main primitive basement structures (black lines) and the VEDS position and trending's representation (purple lines with estimated scale) are clearly indicating overlapped tectonic events. The first three diabase dykes dated by Teixeira e Rodarte (2003) and described by Novais, et al, (2004) are represented by red lines. Field pictures (left) show several aspects and relationship features of dykes along the study area. In both sides of the maps are the kinematic analysis from structural data inversion.

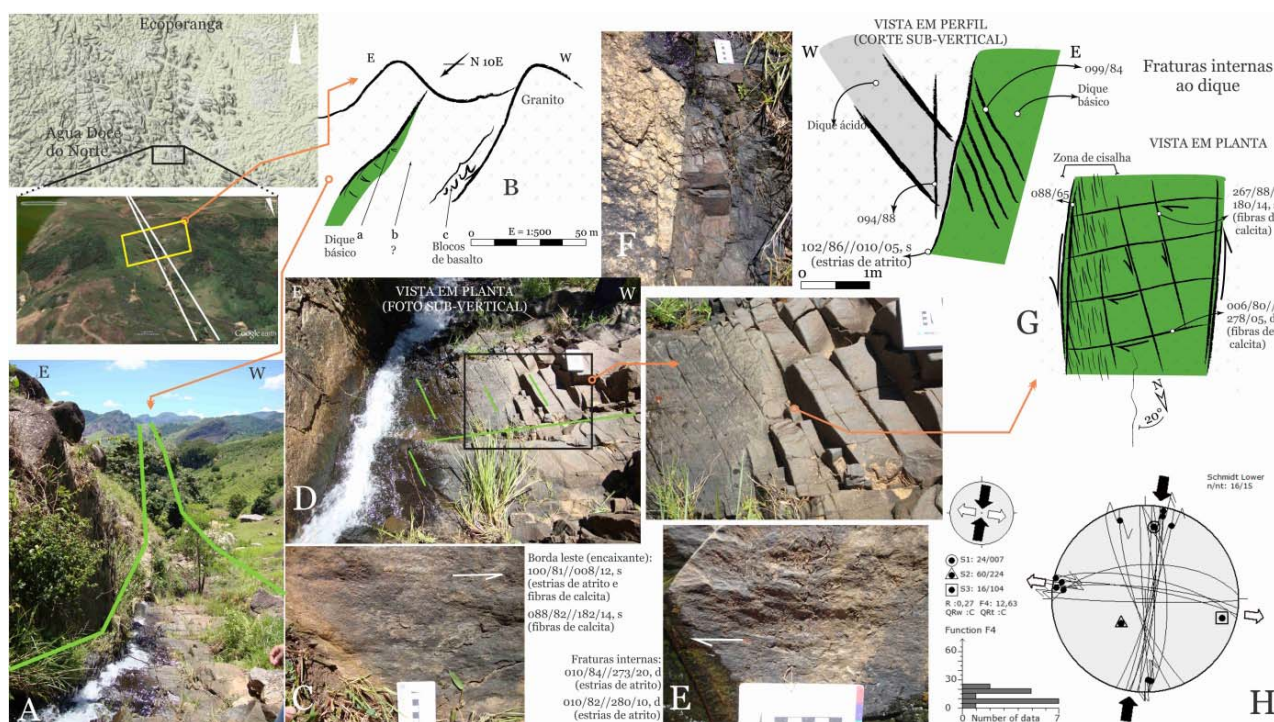


Fig. 2. NNE trending dyke located to northern area. Inner dykes fractures geometry and striations on the contact with its hosting rock reveal dextral binary during its intrusion, still during last cooling stage (calcite fibers). There is no direct relation between foliation, micro-pegmatitic pre-erit dykes and mafic dyke intrusion.

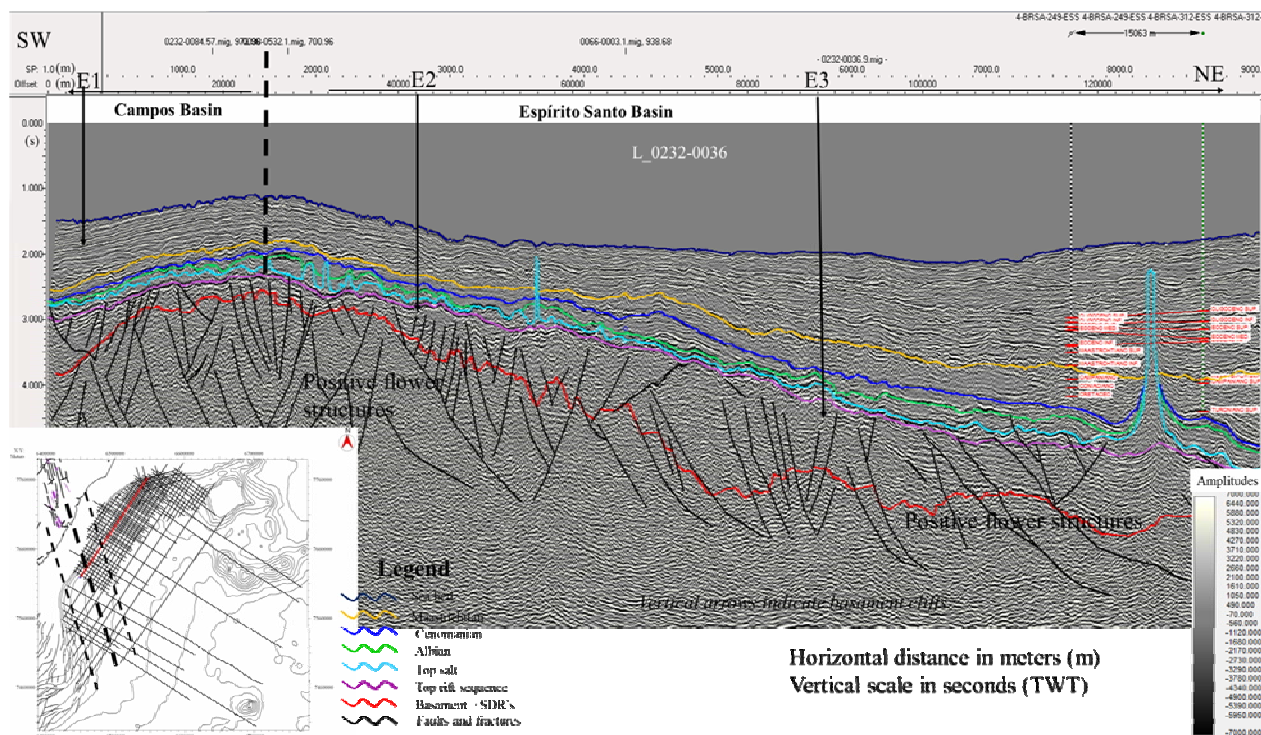


Fig. 3. Example of one of the seismic sections interpreted offshore the continental shelf slope, south of the VEDS. Basement faults affected the pre-rift sedimentary units until top of the rift sequence (purple horizon). From Salt sequence (Albian) to the younger units, the fracturing could have been reactivated, affecting the Cenozoic sequences. E1 to E4 indicate basement cliffs.

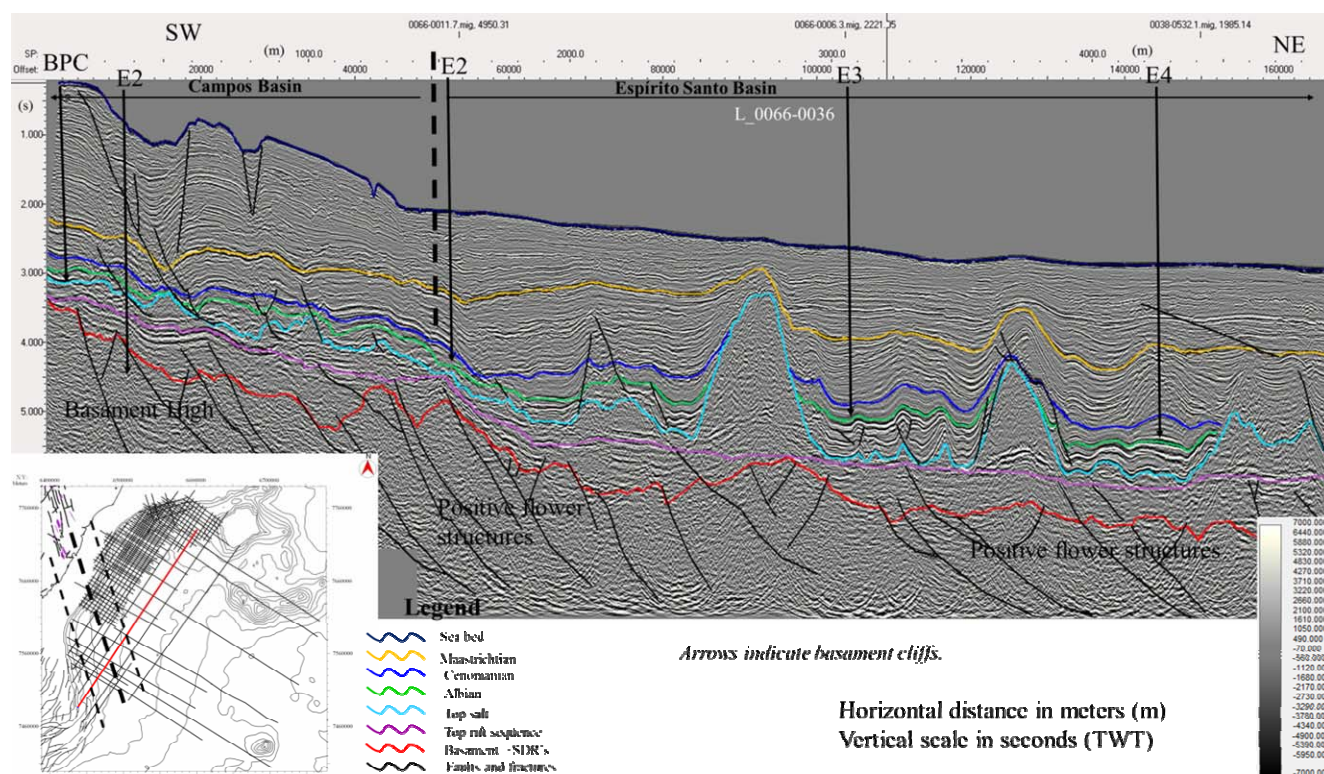


Fig. 4. Example of another seismic section interpreted offshore distal basin, south of the VEDS. Basement faults affected the pre-rift sedimentary units until top of the rift sequence (purple horizon). From Salt sequence (Albian) to the younger units, the fracturing could have been reactivated, affecting the Cenozoic sequences. E1 to E4 indicate basement cliffs.

the Late Cretaceous, i.e. during the rifting time (Figs. 3 and 4). This observation means that the VSH is correlated with the orientation of the VEDS structures and the whole system can be related to a transfer zone that evolved from the rifting process. Hence, it represents a new perspective about the sedimentation and structural segmentation of the syn-rift depocenters in the region between Espírito Santo and Campos basins (Fig. 5).

Regionally, the discussions in this study emphasizes that the system of rifts and grabens arranged *en-echelon* along the Sergipe-Alagoas transcurrent zone are all N-S structures. The development of this whole tectono-sedimentary system occurred concomitantly with the transition between Rio da Serra and Aratú Local Stages (133-127 Ma) associated with N-S stress caused by the Sergipe microplate counterclockwise rotation (Fig. 5). This direction of stress is correlated with the results obtained in the kinematic analysis performed in this study along the VEDS and, at such time, with the intrusion ages recorded on dykes near Vitória city.

This research clarifies the genetic relation between the VSH and the Early Cretaceous emplacement of the VEDS,

adding information about the dynamics of the evolutionary model of Gondwana rifting breakup. Also the major (previously unidentified) structures that define the VSH as a limit between basins and determine the syn-rift framework adjacent to the structural high were identified both onshore and offshore.

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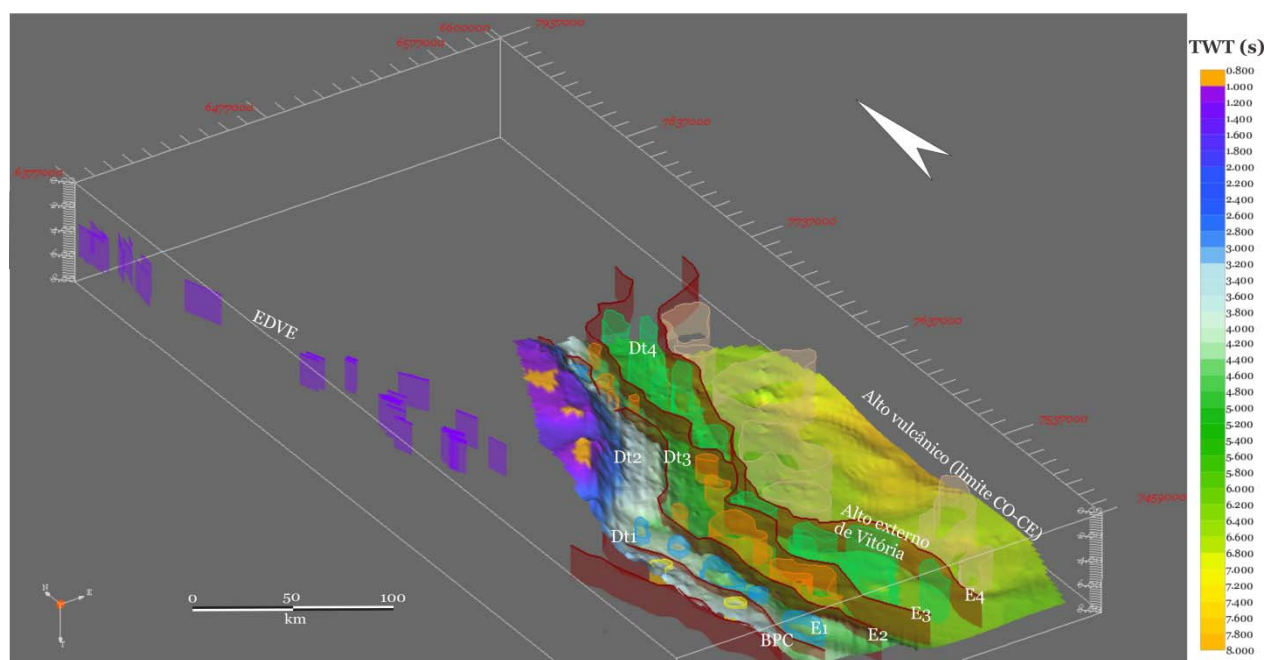


Fig. 5. A 3D visualization of the basement structural map showing the projection of VEDS to offshore, controlling the VSH structural settings, the depocenters' framework and the Campos Basin slope linearity and staggered, being bounded by cliffs, indicated in marron lines.

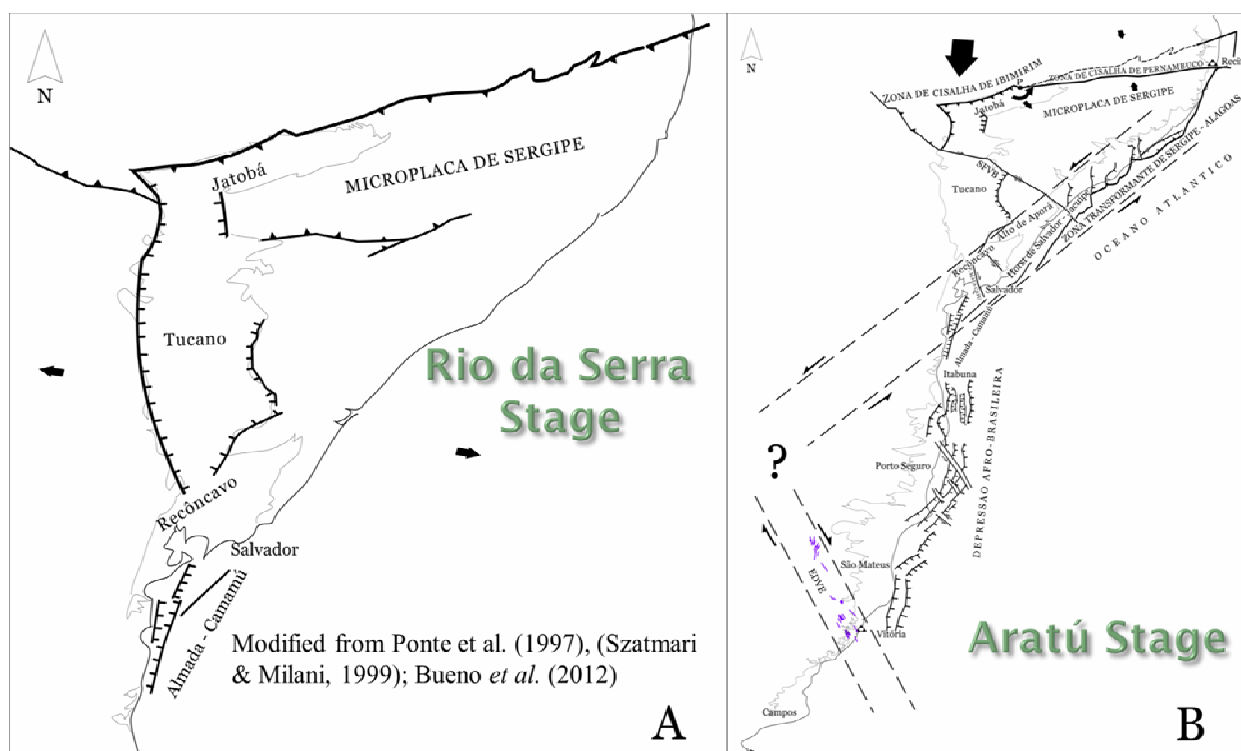


Fig. 6. Regional kinematic model illustrating that the Sergipe microplate rotation to the north influences the VEDS's dextral transcurrent trending NNW-SSE, as a consequence of the main regional palaeostress (bold black arrow). Such σ_1 position is responsible for the N-S trending of *en-echelon* Sergipe-Alagoas basins to the northeastern Brazil, as well as their sinistral transcurrent trending NNE-SSW.

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