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THERMO-TECTONIC EVOLUTION OF THE PURROS SHEAR ZONE AND ITS IMPLICATIONS IN WALVIS BASIN, NW NAMIBIA

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Resumo – A margem passiva da costa da Namíbia registra uma longa história de atividade tectônica iniciada no Proterozóico. A colisão dos crátons do Congo e Rio de la Plata no Proterozóico Superior/Paleozóico Inferior gerou zonas de descontinuidade crustal no cinturão Kaoko que tornaram-se o local preferencial para as atividades tectônicas fanerozóicas. As reativações de estruturas pré-existentes em cinturões móveis estão intimamente relacionadas com a evolução das bacias de margem passiva adjacentes já que servem como corredores preferenciais para reativações e geração de falhas normais por abatimentos de blocos crustais. A Zona de Cisalhamento de Purros, de idade Pré-Cambriana, está inserida dentro do cinturão Kaoko e coloca lado a lado rochas do embasamento Proterozóico e basaltos vinculados com a abertura do Atlântico Sul. A aplicação da técnica de termocronologia por traços de fissão em apatita pode fornecer um maior entendimento sobre a cronologia das reativações tectônicas, taxas de denudação e paleotemperatura nesta região. Estes dados serão correlacionados com as principais quebras no registro estratigráfico da Bacia de Walvis.

Palavras-Chave: Reativações tectônicas; termocronologia por traços de fissão em apatita; Zona de Cisalhamento de Purros; Bacia de Walvis; Namíbia

Abstract – The Namibian marginal basins record a long history of tectonic activity since the Proterozoic. The collision between the Congo and Rio de La Plata cratons generated NNW-trend crustal weakness zones in the Kaoko mobile belt which became the preferential site to the Phanerozoic tectonic activity. The pre-existing structures reactivated in mobile belts are intimately related with the evolution of adjacent marginal basins. The Pre-Cambrian Purros Shear Zone is an important crustal discontinuity located in Kaoko mobile belt that put side by side basement rocks with basaltic lavas related to the South Atlantic opening. Apatite fission track thermochronology could provide a better understanding about reactivation phases, denudation rates and paleotemperature data. Through all these informations will be possible to make the correlation with the main uncoformities in the stratigraphic record of the Walvis marginal basin.

Keywords: Reactivation, apatite fission track thermochronology, Purros Shear Zone; Walvis Basin; Namibia.

1. Introduction

Namibian offshore basins were formed in a passive margin setting during the continental break-up and the opening of South Atlantic Ocean. The Walvis Basin (Fig. 1) is one of the four basins which compound the Namibian margin, the others are: Orange, Lüderitz, and Namibe basins. The aim of this work is to correlate unconformities of the stratigraphic record in the Walvis Basin with the main reactivations in the adjacent basement (Kaoko Belt). The Purros Shear Zone (PSZ) is a Pre-Cambrian lineament reactivated during the Phanerozoic tectonic history through low temperature condition in sinistral and normal movements of crustal blocks. Evidences from field work, remote sensing images and aerial photos show that the PSZ is the most important crustal weakness zone that put, further north (in Hoarusib–Gomatum valley), side by side deep crustal rocks (Proterozoic gneisses) and shallow crustal rocks (basaltic lavas). In the southern part, this is evidenced by a decametrical wide ultramylonitic zone that also occur in the northern portion.

Apatite fission track thermochronology is a powerful tool for constraining the low temperature history of the crust over a 60°-110° C range, which is directly correlated with the temperature range of the hydrocarbon generation. This technique can reconstruct the cooling history of the rocks as they approached to the surface in response to the erosion and tectonics processes (Raab *et al*, 2002), besides it can achieve chronological data of tectonics events, denudation rates and paleotemperature data.

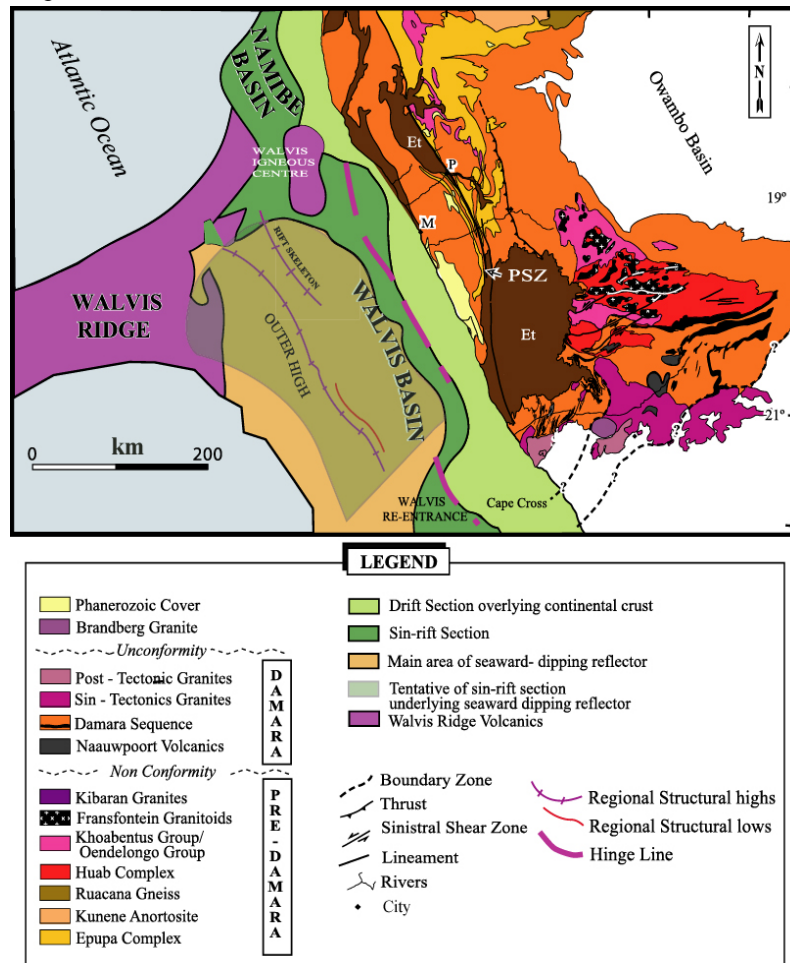


Figure 1. Geological map of the NW margin of Namibia showing the Walvis Basin and its adjacent basement (Kaoko Belt and Congo Craton). Note the parallelism between the basin structural arches and the main basement discontinuities in the Kaoko Belt. Et = Etendeka basalts, M = Möwebay and P = Purros.

2. Apatite Fission Track Thermochronology and Methodology

2.1. Apatite Fission Track Thermochronology

Apatite fission track analysis is a low temperature thermochronologic technique which range from 60° to 120°C that characterize the upper 4-5 Km of the continental crust and ideally compatible to the inferring denudation chronologies (Summerfield, 1991; Brown *et al*, 1994). This technique can be used to correlate the Phanerozoic tectonic processes of the basement with the main unconformities of the stratigraphic record based on paleotemperatures, chronological data and denudation rates.

2.2. Methodology

In order to construct the thermo-tectonic evolution of the basement adjacent to the Walvis Basin, 10 outcrop samples were taken from a variety of deep rocks (tonalite, trondhjemite and augen gneisses) and shallow rocks (basalt). The outcrop samples were collected along two transects cutting the PSZ: the first one in the Hoanib Valley and the second further north along the Hoarusib Valley. Both geotraverses comprised systematic sampling along the eastern, western and in Purros Lineament.

The ages were measured by the external detector method using the KAPTON detectors to record the induced tracks. The total number of habitual 100 individual apatite crystals were analyzed in a transmitted light microscope using a dry objective at a magnification of 100x. Ages will be calculated using the zeta parameter and will be expressed as central ages with percent variation. These data are still being processed at the fission track laboratory of the Universidade Federal do Rio Grande do Sul / Brazil.

3. Geological Data

3.1. Basement Adjacent to the Namibian Passive Margin

The Purros Shear Zone is the most important Pre-Cambrian structure located in the Kaoko belt. The Purros Lineament has a NNW trend parallel to the Namibian passive margin with approximately 530 Km of length.

Based on field geology it is possible to observe that this crustal weakness zone underwent Cretaceous to post-Cretaceous tectonic reactivations evidenced by: direct contact between the Proterozoic basement and Etendeka Basalt (Fig. 2 a and b), besides the occurrence of an ultramylonitic rock in the vicinity of PSZ (Fig 2 c).

This ultramylonitic rock (Fig.2 d) presents a volcanic appearance characterized by an aphanitic texture in hand sample view. The principal microscopic aspect (Fig. 2 e) is the millimetrical banding formed by mafic and felsic levels where it can be observed plagioclase microphenocrysts indicating top-to-SE movement of PSZ. The occurrence of white mica and quartz-filled microfractures indicates at least one important low-temperature tectonic reactivation probably linked with Cretaceous block faulting.

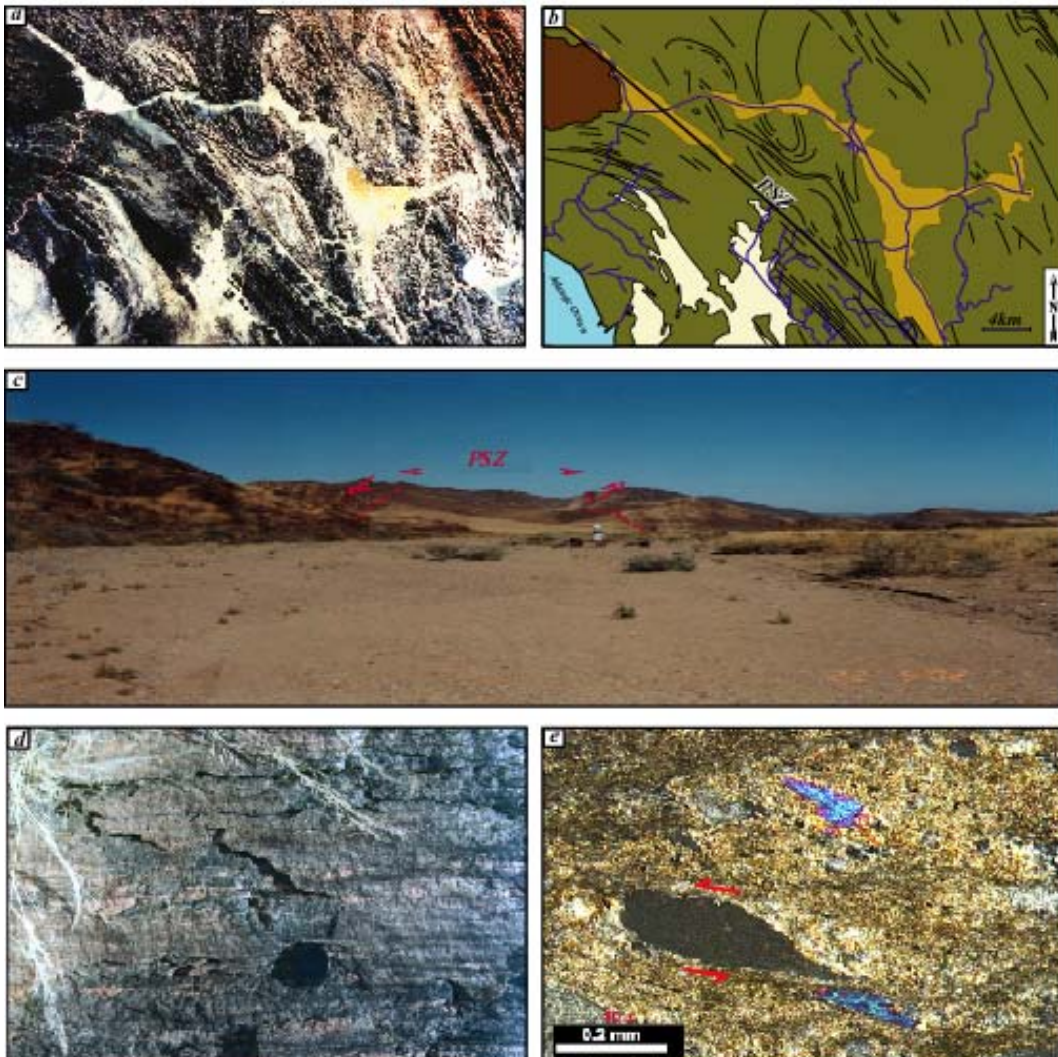


Figure 2. Plate with the main characteristics of Purrus Shear Zone: a) Remote Sensing image of NW Namibia where the green color is the orthogneiss basement, the brown color is the Etendeka basalt and the yellow are eolian dunes; b) Sketch showing the abrupt contact between basement orthogneisses and Etendeka basalts; c) E-W profile showing the field characteristic of PSZ (note the high dip of structures); d) mesoscale view of PSZ ultramylonitic outcrop; and e) photomicrography of the ultramylonitic rock showing sinistral sense indicator (plagioclase) and white mica suggesting low-temperature deformation for the PSZ.

3.2. Namibia Marginal Basins

The offshore basins of Namibia (from south to north: Orange, Lüderitz, Walvis and Namibe basins) were generated with the break-up of southwestern Gondwana and the opening of the South Atlantic Ocean. A very thick sedimentation begun to built out over an Early Cretaceous rift section until the Tertiary, constructing the basin system of the offshore area. A general stratigraphic column for the offshore basins shows four tectono-stratigraphic units separated by three important unconformities (Fig. 3).

The Walvis basin is a typical post-rift wedge shaped, with geometry of passive margin and water depths of 150–3000 m. Walvis is an unexplored basin and recent drilling results prove elements of viable petroleum system (Bray *et al.*, 1998). Vitrinite reflectance data from well samples of the Walvis basin show that Lower Cretaceous source rocks entered the early mature oil window prior to the Tertiary cooling. Apatite fission track data from wells in the same basin show that a heating episode occurred during the Tertiary.

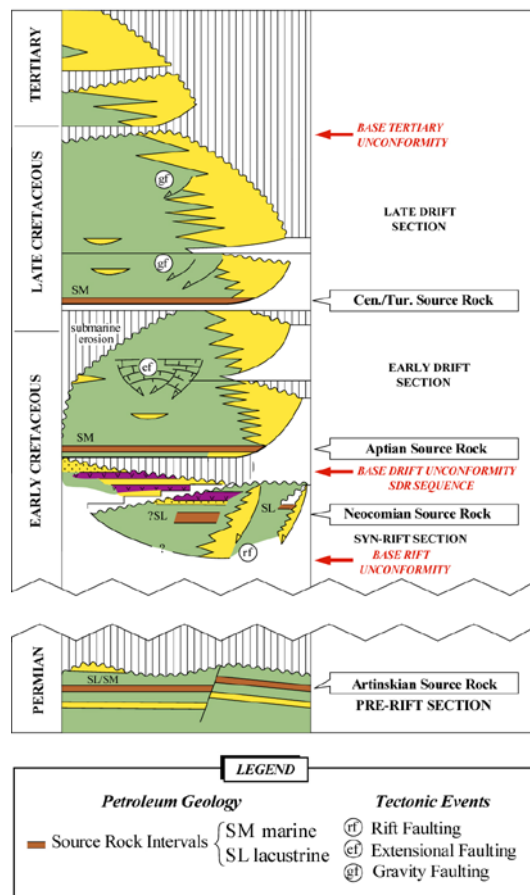


Figure 3 . General stratigraphic column for the Walvis Basin (after Bray *et al.*, 1998)

3.3. Fission Track Data

Previous fission track data from Brown *et al.* (2000) and Raab *et al.* (2002), shown an important crustal cooling from ca. 80 to 60 Ma in the western portion of Namibia margin. After Raab *et al.* (2002), the fission track data for the Omaruru Lineament–Waterberg Thrust point to a major period of tectonic reactivation occurring approximately at 70 Ma which was expressed by 2 Km of block tilting (south side up) with maximum paleotemperatures changing abruptly, from 80° to 120° C in the Omaruru Lineament. These data corroborate the previous data of Dingle (1992/1993) where it is suggested that during Late Cretaceous to Paleogene occurred a rapid terrigenous sedimentation in the Namibian margin. These evidences are coherent with the available onshore geological data which propose a major period of reactivation occurring during the Early Cretaceous or later.

The new fission track data for the Purros Shear Zone (Kaoko Belt) are still being processed, but the field and remote sensing evidences reinforce the Cretaceous tectonic reactivation as the main period of crustal movement in

response to a change in the spreading geometry between South America and Africa plates, and followed by the generation of South Atlantic escarpment by epeirogenetic processes. This dynamical setting implied in a rapid denudational response by the generation of relief in the vicinity of Purros Lineament. New fission track data will possibly suggest and confirm the Early Cretaceous reactivation postulated by Brown and Raab *op cit*, which will corroborate the basal Tertiary unconformity observed in the Walvis Basin by significantly amounts of sediment supply.

4. Conclusions

Based on the field works, remote sensing analysis and previous works further south (in the Damara Belt) it's possible to suggest that Purros Shear Zone underwent important Cretaceous reactivation with net displacement that probably could be correlated with the uncoformities described in the Walvis marginal basin.

5. Acknowledgements

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6. References

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