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SALT-TECTONICS PROVINCES ACROSS THE CONTINENTAL-OCEANIC BOUNDARY IN THE BRAZILIAN AND WEST AFRICAN MARGINS

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ABSTRACT

Recently acquired seismic data extends from the platform toward the continental-oceanic crustal boundary in ultradeep water along the South Atlantic conjugate margins. Preliminary interpretation, particularly along a regional transect in the Eastern Brazilian margin, reveals four main salt tectonics provinces that correspond to tectonic domains: the proximal (shelf to upper slope); the intermediate (mid to lower slope), the salt diapir province (lower slope to deep basin), and the deep basin to oceanic crust domain. Extensional tectonics predominate in the proximal and intermediate domains, whereas the deep-water domain is characterized by compressional features. The transition from rifted continental to oceanic crust is characterized by volcanic features, igneous intrusions and wedges of seaward-dipping reflecto.

INTRODUCTION

The understanding of salt tectonics in the ultradeep water provinces of the South Atlantic (bathymetries exceeding 2,000 m) constitute one major challenge for regional basin analysis and petroleum exploration (Mohriak, 1995; Dominey and Wiffe, 1998). In the South Atlantic, pre-salt source rocks and post-salt reservoirs are usually linked by migration pathways related to salt tectonics, and thermal maturation of source rocks is also dependent on the thermal conductivities of salt and overburden strata (Burwood, 1998; Sequeira et al., 1998). This work will complement a previous analysis that emphasized the salt tectonics styles in the West African margin (Jackson et al. 1998), by addressing tectono-stratigraphic elements observed near the continental-oceanic boundary of the Brazilian margin.

PREVIOUS WORKS

Several recent works have analyzed salt tectonics styles in the deep water region of the South Atlantic continental margins, particularly Chang et al., 1992; Demercian et al., 1993; Fonck et al., 1998; Norvick and Schaller, 1998; Karner et al., 1997; Hartman et al., 1998; Marton et al., 1998, Mohriak et al., 1998). This work will focus mainly on a regional deep seismic profile in the southern part of the Eastern Brazilian margin, will be used as a guideline to interpretation of the tectonic domains and structural styles observed in a regional transect from the platform towards the oceanic crust domain.

POTENTIAL FIELD DATA

Potential field data (e.g., Geosat) show that the southeastern region of Brazil is characterized by a negative Bouguer anomaly near depocenters in the platform and by increasing positive anomalies from the shelf towards the deep water region. The boundary between continental and oceanic crust may be interpreted by modelling the gravity anomalies and comparing with the regional seismic profiles. Major magnetic anomalies also indicate that different basement domains are crossed by the transect extending from the platform to the oceanic crust domain of the Campos Basin.

REGIONAL PROFILE IN THE BRAZILIAN MARGIN

Figure 1 (modified from Cainelli and Mohriak, 1998) shows the interpretation of a regional deep seismic profile corresponding to the transect mentioned above. Four tectonic compartments can be identified along the profile: 1) the proximal domain (shelf-to-upper-slope), thin to thick Aptian salt rests on Aptian siliciclastic rocks or locally, on continental volcanic rocks. Small normal faults, which predominantly dip basinwards in en-echelon to sub-parallel arrays, form prerafts of moderately extended Albian strata; (2) the intermediate domain (mid-to-lower-slope): the overburden underwent early major extension, forming turtle structures and rafts separated by low, reactive salt walls that eventually subsided because of extension. A major step in the basement-the extensional Atlantic hinge zone-appears to overlie the landward pinchout of the main subsalt rift basin; (3) the salt diapir province (lower slope-to-deep-basin): tall extensional

and contractional structures cored by concordant salt or by laterally squeezed or welded diapiric walls or by antiformal duplex stacks are separated by much broader minibasins. Basinward-migrating contraction resulted in buckling, inversion of synkinematic wedges, and rejuvenation of tall diapirs, forming bumps in the seafloor. Pre-salt sag basins, overlying continental to transitional crust, indicate oceanward shifting of the extension axis; (4) the crustal limit province (deep-basin-to-oceanic crust): thick Aptian salt may rest on oceanic or transitional crust characterized by subaerial volcanic wedges of seaward-dipping reflectors. Although the volume of salt is concentrated in the latter tectonic domain, the volume of allochthonous salt appears to be minor when compared to other salt basins, such as the Gulf of Mexico. Igneous masses may have buttressed salt flow and overburden extension. Fold belts comprise synkinematic buckle folds having superposed wavelengths, reverse faults of variable vergence, and erosionally truncated and uplifted slabs

CONCLUSIONS

Some similarities in salt tectonics styles are observed in conjugate margins across the South Atlantic when seismic data in the Eastern Brazilian margin are compared with equivalent regional profiles in the West African margin (Jackson et al., 1998; Marton et al., 1998; Mohriak et al., 1998). Previous geodynamic models for evaporite deposition in the South Atlantic suggested that syn-rift sediments and salt layers were contemporaneously deposited across the conjugate margins, and the salt basins were subsequently split apart as a consequence of oceanic crust inception and continental drift (e.g., Asmus, 1984). The data provided by the regional profiles in the ultradeep water region of conjugate basins indicate that the deposition of Aptian salt post-dates the rift-phase along the Brazilian and West African margin, as suggested by by Fonck et al., 1998 and Marton et al., 1998. The salt distribution is highly asymmetric, with some segments characterized by very wide salt provinces (example, Campos and Santos basins), as a function of preferential of emplacement of oceanic ridges along one of the margins (Mohriak et al., 1998). The salt distribution and tectonic domains seem to be controlled by the deep structure of the rifted continental crust, and not by the present-day bathymetry. The boundary between continental and oceanic crust is characterized by igneous features, particularly intrusive plugs, volcanoes, and wedges of seaward-dipping reflectors extruded during inital stages of oceanic crust emplacement.

REFERENCES

Asmus, H.E., 1984. Geologia da margem continental brasileira. In: Schobbenhaus, C., Campos, D.A., Derze, G.R. and Asmus, H.E. (coord.), Geologia do Brasil, Ministério das Minas e Energia/DNPM, Brasília, 1984, p. 443 - 472.

Burwood, R., 1998. Angolan Atlantic margin petroleum systems: pre- and post-salt. In: M. R. Mello and P.O. Yilmaz (eds.), Extended Abstract Volume, 1998 AAPG International Conference and Exhibition, Rio Janeiro, Brazil, p. 814-815.

Cainelli, C. and Mohriak, W.U., 1998. Geology of Atlantic Eastern Brazilian basins. 1998 AAPG International Conference & Exhibition Short Course – Brazilian Geology Part II, November 8 – 11, 1998, Rio de Janeiro, Brazil.

Chang, H. K., Kowsmann, R.O., Figueiredo, A.M.F. and Bender, A., 1992. Tectonics and stratigraphy of the East Brazil Rift system: an overview. Tectonophysics, v. 213, p. 97 - 138.

Demercian, L.S., Szatmari, P., and Cobbold, P.R., 1993. Style and pattern of salt diapirs due to thin-skinned gravitational gliding, Campos and Santos basins, offshore Brazil. Tectonophysics, v. 228, p. 393 - 433.

Dominey, J.R., and Wiffe, S., 1998. Salt tectonics and sedimentation: an integrated interpretation ultradeep water area, Lower Congo Basin, Offshore Angola. In: M. R. Mello and P.O. Yilmaz (eds.), Extended Abstract Volume, 1998 AAPG International Conference and Exhibition, Rio Janeiro, Brazil, p. 590-591.

Fonck, J.M., Cramez, C. and Jackson, M.P.A., 1998. Role of subaerial volcanic rocks and major unconformities in the creation of South Atlantic margins. In: M. R. Mello and P.O. Yilmaz (eds.), Extended Abstract Volume, 1998 AAPG International Conference and Exhibition, Rio Janeiro, Brazil, p. 38-39.

Hartman, D.A., Swanson, W.A., Smith, P.R., Goulding, F.J., and Kelly, C.A., 1998. Structural Development of the continental margin of Congo and Northern Angola. In: M. R. Mello and P.O. Yilmaz (eds.), Extended Abstract Volume, 1998 AAPG International Conference and Exhibition, Rio Janeiro, Brazil, p. 370-371.

Jackson, M.P.A., Cramez, C., and Mohriak, W.U., 1998. Salt tectonics provinces across the continental – oceanic boundary in the Lower Congo and Campos Basins on the South Atlantic Margins. AAPG Bull., v. 82, p. 1926.

Karner, G.D., Driscoll, N.W., McGinnis, J.P., Brumbaugh, W.D., and Cameron, N.R., 1997. Tectonic significance of syn-rift sediment packages across the Gabon - Cabinda continental margin. Marine and Petroleum Geology, vol. 14, n. 7/8, p. 971 - 1000.

Marton, G., Tari, G., and Lehmann, C., 1998. Evolution of salt-related structures and their impact on the post-salt petroleum systems of the Lower Congo Basin, Offshore Angola. In: M. R. Mello and P.O. Yilmaz (eds.), Extended

Sixth International Congress of the Brazilian Geophysical Society

Abstract Volume, 1998 AAPG International Conference and Exhibition, Rio Janeiro, Brazil, p. 834.

Mohriak, W.U., 1995. Salt tectonics structural styles: contrasts and similarities between the South Atlantic and the Gulf of Mexico. In: Travis, C.J., Harrison, H., Hudec, M.R., Vendeville, B.C., Peel, F.J., and Perkins, B.E. (eds.), Salt,

Sediment and Hydrocarbons, GCSSEPM Foundation 16th Annual Research Conference, Houston, Texas, p. 177 - 191.

Mohriak, W.U., Palagi, P.R., and Mello, M.R., 1998. Tectonic evolution of South Atlantic salt basins. AAPG Bull., v. 82, p. 1945.

Norvick, M.S. and Schaller, H., 1988l. The post-rift paleogeographic evolution of the South Atlantic basins of Brazil and West Africa and the influence of hinterland uplift on drainage and sedimentary depocenters. In: M. R. Mello and P.O. Yilmaz (eds.), Extended Abstract Volume, 1998 AAPG International Conference and Exhibition, Rio Janeiro, Brazil, p. 36-37.

Sequeira, Jr., J., Campbell, M., and Smith, P., 1998. Comparison of key play elements of proven and potential petroleum systems of the South Atlantic margin – offshore Brazil and West Africa. In: M. R. Mello and P.O. Yilmaz (eds.), Extended Abstract Volume, 1998 AAPG International Conference and Exhibition, Rio Janeiro, Brazil, p. 104 – 105.

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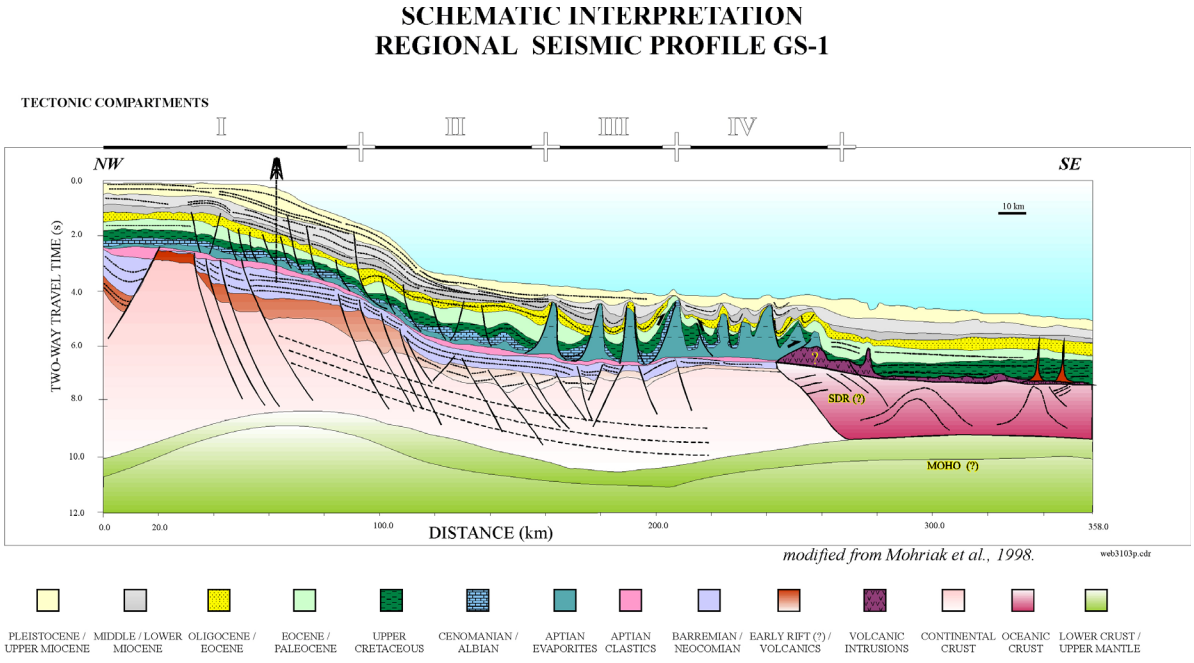

Figure 1: Schematic interpretation of a regional deep seismic profile in the Eastern Brazilian margin, with identification of tectonic compartments from the continental shelf towards the oceanic crust domain.