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Pinda Reservoirs and Prospectivity

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Introduction: Along the Angolan continental margin, four major sedimentary basins are known. These are Lower Congo, Kwanza, Benguela and Namibe. These regional sub basins are within the global salt basin of West Africa. Over the decades of exploration in these basins, the Pinda play has emerged as the foremost one in Angola.

Exploration for Pinda reservoirs was extensive during 80's in Lower Congo and Kwanza. This has resulted in the discovery of numerous Pinda reservoirs. Until now, it is the primary producer for Angola. An insight into the regional distribution and characteristics of Pinda reservoirs provides an opportunity for further prospective zones on the Angolan margin.

Pinda reservoir types and depositional setting: Three major types of reservoirs are recognized on the margin. These can be grouped under (1) mixed siliciclastics and carbonates of marine origin, (2) shelf-margin dolomitized carbonates in shoal, back shoal and lagoonal environment and, (3) dolomites with evaporite interlayers. Each reservoir type has a characteristic depositional setting.

The mixed siliciclastic and carbonate reservoir (Figure-1) is predominantly developed in Lower Congo basin's southern flank and, in Cabinda region. Reservoir studies lead to the recognition of three principal facies: (a) lagoon and tidal flat sediments – argillaceous dolomudstones and wackestones with intermingle dolomitic sandstones, (b) inner shelf to shoreface sediments – bioturbated, argillaceous, dolomitic siltstones, very fine grained sandstones and silty/sandy dolowackestones, (c) beach/barrier bar complex sediments – well-sorted, very fine to fine-grained to poorly sorted, very fine to very coarse-grained subarkoses and arkoses. Each facies exhibit variable porosity/permeability and thickness.

The shelf-margin carbonate reservoir (Figure-2) in shoal, back shoal and lagoonal setting is well developed in lower Congo basin, to the south of Congo River. The shoals are high-energy Oölitic grainstone/packstone carbonate facies that follow the structural hinge line of the basin. The key to the prolific nature of the reservoir is dolomitization. Shoal facies exhibit good porosity-permeability and thickness. The back shoal and

lagoonal reservoirs are thin packstones, reduced in reservoir thickness and porosity-permeability.

The third type of reservoir is in dolomites with evaporite interlayers, which is more akin to sabkha environment. These are developed along the structural hinge at onshore Kwanza basin. The dolomite facies are tight packstones/wackestones with fracture porosity.

Pinda reservoir stratigraphy: The Pinda reservoirs span the entire Albian. In the sediment section, significant biostratigrphic sequences are discernible in the upper levels of Pinda. However, a number of marine transgressive-regressive cycles are identifiable from the gamma-ray log pattern. These are helpful to divide the dolomite reservoirs in the lower Congo basin into lower, middle and upper Pinda intervals. The transgressive sequence lithology such as tight argillaceous carbonates or claystone separates the reservoirs. In contrast the division of the sliciclastic-carbonate reservoirs of Cabinda is attempted using sequence boundaries on logs. The Kwanza Pinda interval is subdivided based on the lithology.

Pinda Structures: Three possible mechanisms are envisaged for the Pinda structures and, to the development of reservoirs.

The first mechanism for the evolution of Pinda structures is attributed to salt withdrawal in the basin. It relates to salt halokenisis that begins with a balance salt movement and followed by intensive withdrawal leading to salt escape. The resultant Pinda structures are bound by normal faults with high pitch and resemble “Piano Key” pattern. Potential reservoirs are thought to develop on the salt paleohighs.

The second mechanism propounds a post-salt extension tectonic model to attribute the observed rollers and rafts in Pinda section from near shore to deep offshore.

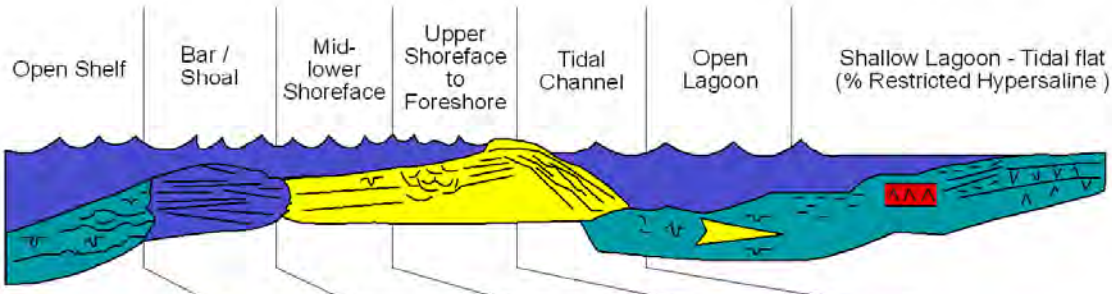
A third mechanism takes account the syn- and post- rift basin geometry to explain the Pinda structure. It notes a correspondence between the macro- to micro- scale structural trends in the basement and Pinda. It further exemplifies that synrift structural pattern actually controls Pinda sedimentation and, the located the upper-, middle- and lower- Pinda shelf-edge is in the vicinity of underlain basement fault. At this structural location, shelf-edge Pinda reservoirs are recognized.

Pinda Prospectivity: Prospective Pinda reservoir zones (Figure-3) on the Angolan margin can be further identified from the insight of current distribution and structural setting on the margin. It is observed that the NE oriented, three major transfer fault zones played a prominent role on the distribution of Pinda reservoirs. To the north of the transfer fault zone, greater subsidence leads to the deposition of siliciclastics. To the south of the transfer fault zone, less subsidence and shallow margin lead to the carbonate deposition.

Significant siliciclastic reservoirs to the north of transfer fault zone have developed near the shelf to slope break at the edge of Albian platform in Cabinda. Such a feasible scenario exists further south on the margin in Luanda and Benguela zones. Significant siliciclastic deposition is known on the Albian platform near Luanda. New exploration is required to locate the narrow zones of shelf-edge siliciclastic reservoirs.

Prominent carbonate shoal reservoirs are present to the south of transfer fault zones in Lower Congo and Kwanza. These are localized along a narrow zone at the Albian shelf-edge. Dolomitized reservoirs are more prolific relative to the non-dolomitized ones. It is interesting to note that the dolomitization of the reservoirs occurred, where the shelf-edge is proximal to the present coastline. Possible cause of dolomitization is attributable to either burial and/or meteoric-sea water mixing. Further prospectivity of the dolomitized shelf-edge carbonate reservoirs on the margin exists to the south in Benguela and Namibe basins. In these basins, Albian platform is proximal to the coastline and, a relative easy delineation of the shelf-edge will favor the development of carbonate reservoirs. Moreover, narrow fronts of dolomitized reservoirs are feasible to recognize in Congo and Kwanza basins within the current understanding of basin structural setting.

PINDA RESERVOIRS



Porosity	3-20% (11%)	10-15%	3-24% (12%)	2-27% (10%)	3-27% (10%)
Permiability	< 0,01-1930 md	< 0,01-2,0 md	< 0,01-165 md (15md)	< 0,01-1320 md (20md)	< 0,01-704 md (11md)
Thickness	1-15m	0,5-7m (3m)	1-5m (3m)	0,5-5m (3m)	0,5-8m (4m)

Fig - 1

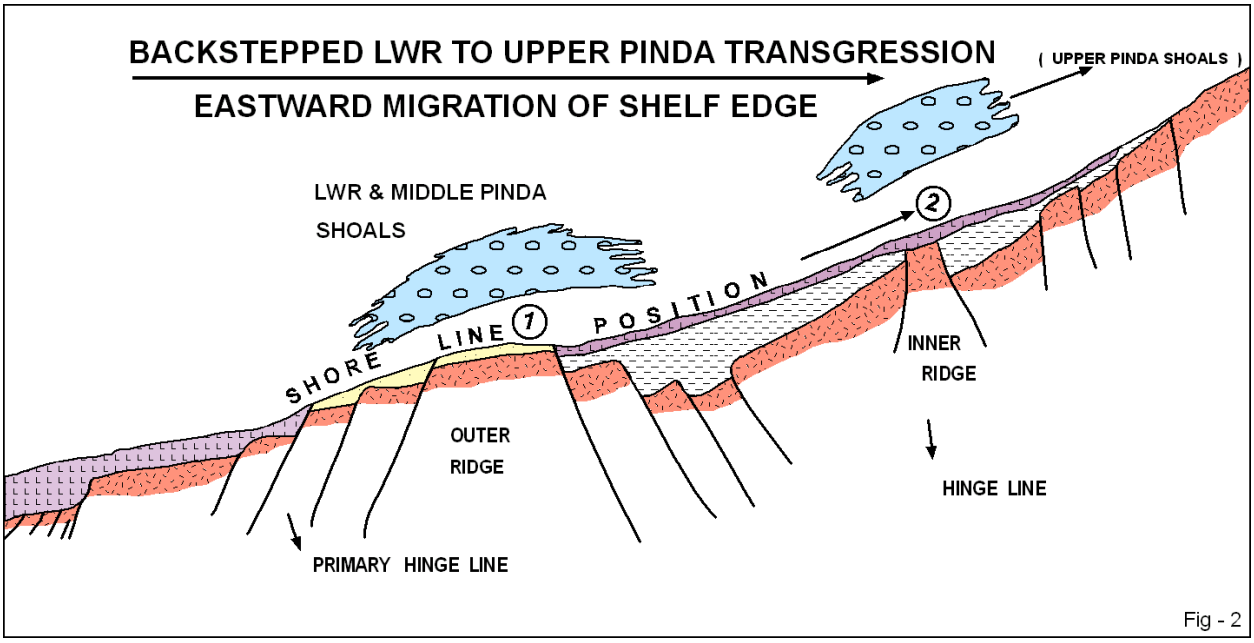


Fig - 2

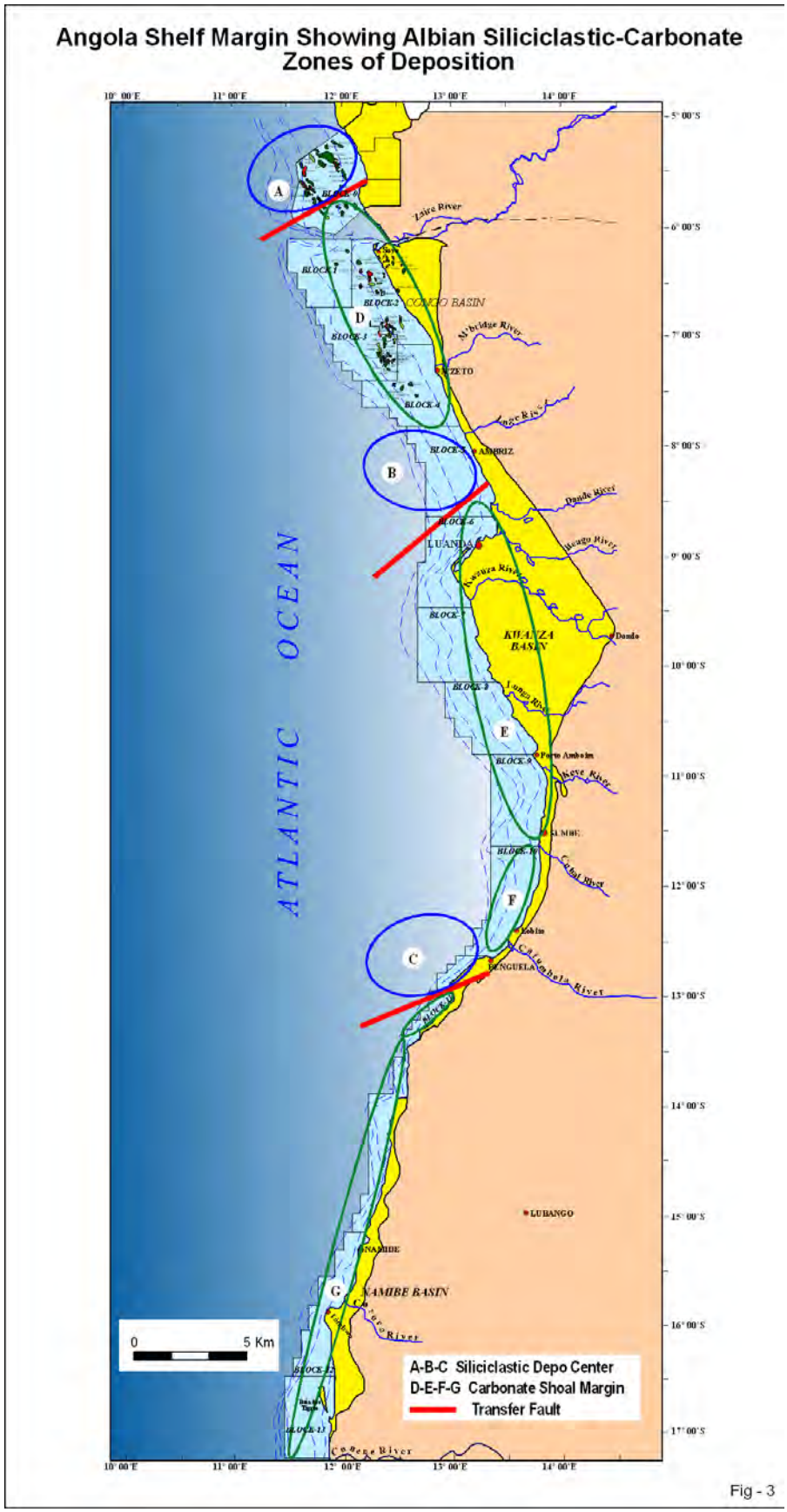

Angola Shelf Margin Showing Albian Siliciclastic-Carbonate Zones of Deposition
ATLANTIC OCEAN
A
B
C
D
E
F
G
LUANDA
KWANZA BASIN
CONGO BASIN
NAMIBE BASIN
LUBANGO
BENGUELA
Zaire River
Dande River
Bengo River
Kwanza River
Longa River
Keve River
Catumbela River
Cooper River
0
5 Km
A-B-C Siliciclastic Depo Center
D-E-F-G Carbonate Shoal Margin
Transfer Fault

Fig - 3