Insights into the Geology and Prospectivity of the Joint Development Zone (JDZ)

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Executive summary – JDZ MC3D prospectivity review

1. PGS have a comprehensive dataset within the JDZ.

2. Well log and seismic interpretation show pro-delta reservoir facies within structural and stratigraphic traps.

3. Quantitative Interpretation work shows that hydrocarbon charge of reservoirs can be identified & calibrated.

4. The study shows that there are undrilled leads calibrated to 8 drilled wells.
The JDZ and the JDA

- In 2001 a treaty was signed between Nigeria and São Tomé & Príncipe which defined the Joint Development Zone (JDZ).

- The Joint Development Authority (JDA) was established to manage the activities relating to exploration for and exploitation of the resources of the JDZ, including the issuance of permits and licenses.
Wells and Fields

**Malanza-1X**
*Addax (2009), Gas Well, TD = 4172 m*
The well targeted nine reservoir sand intervals of which two contained biogenic methane. The well was plugged and abandoned.

**Kina-1XR**
*Addax (2009), Gas Well, TD = 3750 m*
The well encountered non-commercial quantities of gas from multiple reservoir sands. The well was plugged and abandoned.

**Lemba-1X**
*Addax (2009), Gas Shows, TD = 3758 m*
The well targeted 8 reservoir sand intervals of which two contained methane gas of biogenic origin and others were water bearing. The well was plugged and abandoned.

**Oki East-1X**
*Addax (2009), Gas Well, TD = 3840 m*
Multiple gas bearing deep marine turbiditic sands have been intersected by this well. The well was plugged and abandoned.

**Enitimi-1**
*Total SA (2012), Oil and Gas Well, TD = 3394 m*
Total has plugged and abandoned this well as a non-commercial oil discovery.

**Obo-1**
*Chevron Texaco JDZ (2006), Oil & Gas Well, TD = 4600m*
The well found a cumulative total of at least 45m of net hydrocarbons in multiple stacked reservoirs in a toe thrust structure. It has been plugged and abandoned as a non-commercial discovery.

**Obo-2**
*Total SA (2012), Oil and Gas Well, TD = 4270m*
The well encountered oil and gas pay and have been plugged and abandoned as non-commercial well.

**Bomu-1X**
*Sinopec (2009), Gas Well, TD = 3580 m*
Bomu-1 well was drilled to evaluate the potential for commercial discovery. It encountered gas shows.

**Obo-2**
*Total SA (2012), Oil and Gas Well, TD = 3394 m*
Total has plugged and abandoned this well as a non-commercial oil discovery.
Regional Geology
Niger Delta tectonic setting
Thrusting in JDZ study area

- JDZ lies on 2 depobelts - Shale swelling and Frontal toe trust zones
- The Shale Swelling Zone is typically associated with E-W trending toe thrusts, apparent within the Agbada Formation and detaching within the Akata mobile shales
- Akata shales have been injected up the fault planes isolating fault blocks
- The Frontal Toe Trust Zone is associated with NE–SW fault trends controlled by thrusting to the north
Regional stratigraphy of the Niger Delta

The Tertiary section of the Niger Delta is divided into 3 diachronous formations, representative of broad depositional setting:

- **Benin Formation** – representative of alluvial deposits
- **Agbada Formation** – representative of deltaic deposits
- **Akata Formation** – representative of deep water muds

The area of the JDZ MC3D dataset is located in a delta front to deep water setting and is dominated by Agbada Formation delta front deposits that is detached from underlying Akata shales.

From Freddy et al., 2005
PGS Data Package
Available data package

Well data available for brokerage

- Operator mud logs
- Formation evaluation logs
- MWD logs
- Vitrinite reflectance
- Biostrat data
- Bottom hole temperature
- Velocity data
- Pore pressure data
- All well reports

Well data available for brokerage:

- PGS MultiClient 2D data
- PGS MultiClient 3D data
- PGS MultiClient 3D MegaSurvey

- Malanza-1X (2009)
- Obo-1 (2006)
- Obo-2 (2012)
- Bomu-1X (2009)
- Enitimi-1 (2012)
- Kina-1XR (2009)
- Lemba-1X (2009)
- Oki East-1X (2009)
Well Log processing workflow for JDZ

1. Well data collection and management
2. Well data cataloguing
3. Collation of operator data
4. Well log scanning & digitising
5. Well log QC, splicing & environmental corrections
6. Workstation Ready Log Suite (WSR)
Well Log interpretation workflow for JDZ

1. Lithological interpretation
2. 8. Sequence stratigraphic interpretation
3. 9. Depositional Environment and Facies Interpretation
4. 10. Petrophysical analysis (CPIs).
5. 11. Reservoir fluid elastic attribute analysis
6. 12. Acoustic attribute to pre-stack trace calibration
7. 13. Well to seismic tie using checkshot, VSP & synthetics
Well sequence and depositional environment interpretation – Kina-1XR

- **Biostrat data**: ✔
- **Operator shows**: ✔
- **H/C from CPI**: Gas @ 2575m, 2940m, 3120m, 3480m,
- **Check shot**: ✗

**Operator shows**
- **M. Tortonian**
- **E. Tortonian**
- **Serravalian**
- **Langhian**

**Biostrat**
- **Top Oligocene?**
- **Top Eocene?**

**Check shot**
- Well does not penetrate Akata Fmn
Total SA (2012), Oil and Gas Well, TD = 3394 m
Four of the primary reservoirs were encountered. Only one reservoir intersected oil. Water in the deepest level at 2932 TVDSS.
Build and interpret sequence framework in 3D dataset
Example time and depth structure maps

Intra Tortonian two way travel time map with 100ms contour interval

Faulting associated with Shale Swelling Zone

Faulting associated with Frontal Toe Thrust Zone

Intra Tortonian depth map with 100m contour interval

**Interval velocities have been used in preSeis for depth conversion**
Play analysis - an example of a structural lead

**Structural Lead:**
Closure within a toe thrust, very bright amplitudes at crest

**Reservoir:** likely to be Lower Shoreface sands

**Seal:** likely to be intra-formational TST transgressive muds.
Play analysis - an example of a stratigraphic lead

Stratigraphic Lead:
Sand prone body pinching out against thrust fault.

Reservoir: likely to be Offshore Transition mass flow or Lower Shoreface
Seal: likely to be intra-formational TST transgressive muds.
Quantitative Interpretation
Reservoir analysis - quantitative interpretation workflow

Rock physics shows elastic attributes can discriminate shale – brine sand – HC sand.

Well log elastic attributes discriminate lithology & fluid (shale – brine sand – HC sand). This pattern is consistent with the seismic elastic attributes (Ip and Vp/Vs).

Seismic sections of elastic attributes clearly show the difference between – shale, brine sand & HC sand with strong changes at hydrocarbon water contacts.

With such a clear pattern in elastic attributes we can auto-detect areas of specific values (low Ip and/or Vp/Vs) as ‘geobodies’. These are calibrated to well log reservoir properties and identify many untested leads.

We have mapped the top or base of anomalies in leads and discoveries to understand the relationship between HC fill and structural closure / fill.
Example well tie with seismic elastic attributes

Well log petrophysics

Elastic well logs

Seismic inversion (relative)

Gas in CPI

Gas sand seen in seismic inversion volume

Minor gas in CPI

Minor gas in CPI
3D view of wells and leads: Geo-bodies extracted from Ip & Vp/Vs
Basin Modelling
Sub Akata Prospectivity
PGS Discovery Webinar – Deeper Insight into the Niger Delta
Tectonic domains through southern Niger Delta

Zone of outer thrusting

Zone of shale diapirism

Zone of minor thrusting

Late Cretaceous

Danian

Oceanic Crust

Akata Shale

Thrust onset

Late thrust

Thrusted conformable layer

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PGS Discovery Webinar – Deeper Insight into the Niger Delta
The South-eastern front – sub-Akata opportunities
Conclusions

- JDZ is significant hydrocarbon prone area. All the elements of working petroleum system have been identified and evaluated.
- 8 wells have been drilled with both oil and gas discovered.
- Depositional sequence interpretation shows that reservoirs are lowermost shoreface sands and pro-delta mass-flow sands (channels, fans and lobes).
- The sub-Akata section may be provide a secondary petroleum system.
- Quantitative interpretation is an important tool for derisking.
- Opportunities to develop discoveries and drill stacked reservoirs.
Thank You

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