Elephant hunting in Southern Africa: hydrocarbon potential of South Africa and Namibia

Jon Noad
Husky Energy

CSPG International Division: September 2014
Southern Africa: recent developments

- Two of the world’s biggest discoveries in the last two decades made in Angola and Mozambique
- Exploration ramping up in region

Huge offshore discoveries in Rovuma Basin since 2010

- Coal-bed methane discovered in Kalahari Karoo Basin in 2006
- South Africa’s moratorium on Karoo Basin shale gas lifted in 2012

Offshore oil reserves found in 11 prospects offshore Namibia

New exploration licenses awarded in 2012 in Orange River Basin

Mossel Bay production declining

AT Kearney analysis
Poor African relations?

- Huge Southern African discoveries in last two decades:
  - Angolan producing 2 MM bopd
  - Two Mozambique gas field discoveries at 700 MM boe
  - Between these two lie South Africa and Namibia

- South Africa
  - Currently producing 4000 bopd (Oryx and Oribi Fields)
  - Previously up to 40,000 bopd and some gas

- Namibia
  - Kudu Field around 1.4 Tcf of gas, Ibhubesi Field (South Africa) similar size
  - Other recent wells indicate potential source rock

- Despite relative paucity in current production and reserves, there is a buoyant exploration mood in the region
  - Supermajors picking up offshore South African acreage and farming in
  - Aggressive bidding offshore Namibia
  - Huge shale gas reserves indicated in the Karoo

- Today we will see what is getting everyone excited

<table>
<thead>
<tr>
<th>Reserves: 2010</th>
<th>Oil 2010 MM bbl</th>
<th>Gas 2010 Bcf</th>
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<tbody>
<tr>
<td>Libya</td>
<td>46,400</td>
<td>54,680</td>
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<tr>
<td>Nigeria</td>
<td>37,200</td>
<td>186,880</td>
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<tr>
<td>Algeria</td>
<td>12,200</td>
<td>159,000</td>
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<tr>
<td>Angola</td>
<td>9,500</td>
<td>10,940</td>
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<tr>
<td>Sudan</td>
<td>5,000</td>
<td>3,000</td>
</tr>
<tr>
<td>South Africa</td>
<td>15</td>
<td>☹️</td>
</tr>
<tr>
<td>Namibia</td>
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<td>2,200</td>
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Five largest African producers of oil and natural gas

Source: Oil & Gas Journal
NOSING INTO
SOUTH AFRICA'S GEOLOGY
Southern African onshore geological summary
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<th>Time</th>
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<tbody>
<tr>
<td>135 Ma</td>
<td>Atlantic opens, offshore basins form</td>
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<td>180 Ma</td>
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<td><strong>Wits Basin forms on craton</strong></td>
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<td>Kaapvaal craton underlies NE South Africa</td>
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<td>3500 Ma</td>
<td><strong>Early continental nuclei</strong> – greenstones</td>
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**A massive meteor impact 110 km to the south-west of Johannesburg 2020 million years ago brought Wits to surface**
## South African evolution (2)

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### Diagram

- **Simplified Geology of the Bushveld Intrusive Complex**
- **UG1 chromitite, Dwars River, Steelpoort**
- **Waterberg Red Beds**
- **Kaapvaal craton underlies NE South Africa**
- **Early continental nuclei – greenstones**
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![Reconstruction of Earth 100 MYA](http://www.largeigneousprovinces.org/12jun)

http://www.largeigneousprovinces.org/12jun
http://www.ncdc.noaa.gov/paleo/ctl/cliscibeyond.html
THE WORLD’S MOST VALUABLE OIL?
The world’s oldest hydrocarbons

- Witwatersrand deposited around 2900 to 2800 MYA
- Holds the world’s largest gold reserves, and has produced over 50,000 tonnes (50% of gold mined on Earth)
- Gold hosted in carbon seams and in conglomerates

- Archaean rivers flowed across basin forming conglomeratic fan deltas
- Algal mats propagated, later forming hydrocarbons
How did the gold get there?

- Gold forms an amalgam with carbon, which represents metamorphosed bitumen (cf. gilsonite).
- At 1000 g/tonne, in the carbon seam, this gives a price of around $27,000/barrel.
- More typical values are 30 g/tonne in the conglomerate, which hosts flyspeck carbon: $800/bbl.
KAROO BACKWATER
CHANGES ITS SPOTS
Hot air or Shale gas?

- US Energy Information Administration (June 2013) estimates that South Africa has 390 Tcf of technically recoverable shale gas (also 485 Tcf published 2012)
- Eighth in the world in shale gas resources
- Moratorium lifted in September 2012
- Regulations published in 2013
- Companies (especially Shell) awaiting news on exploration permit applications
- Amendments to mineral rights legislation announced in 2014, give government a free 20% carry in HC projects
- Other companies with permits include Total, Exxon, Chevron (latter with Falcon, which holds 7.5 MM acres of exploration permit in southern Karoo)
Karoo Basin Geology

- Karoo Basin covers 300,000 km²
- Deposition from 280 to 180 Ma, across Gondwana, continuing until break-up
- World's 9th largest coal reserves
Geology and Exploration

- Focus on Whitehill Fm.
- Extended to include Prince Alberta, Volksrust, Vryheid, Pietermaritzburg Fms. and Dwyka Shales
- Parameters used:
  - TOC >1%
  - Temps 130 to 170°C
  - VR of 1.35 to 2.5
  - CR/CT ratio of 0.85 to 0.94
- Still at preliminary stages, no wells yet drilled using modern fraccing techniques (gas seen in Vt wells)
- Shale thicknesses match North America plays
- Sill & dyke risks - leakage

Steyl and van Tonder 2013
SOUTH AFRICA'S OTHER 'MAIN' ONSHORE PLAYS
**Algoa Basin**

- Mesozoic rift basin with half grabens
- 24 wells drilled onshore and 9 offshore
- Rift fill of Jurassic clastics
- Colchester Member lacustrine source rocks
- Reservoir in barrier bar sandstones up to 6 m thick, average porosity of 18%
- Strat trap, shale seals
- Potential P50 reserves of 6 MMbbl
Onshore CBM plays

- CBM exploration in Ermelo
- 79,000 Ha in Witbank coal region
- Project area includes old coal mine rich in methane
- GIP of 0.8 Tcf, P10 of 3.45 Tcf

- Further CBM at Mopane, Ecca coals
- Possible 3 Tcf in 32.8 m of net coal
- 420 km NE of Johannesburg
- On edge of Tshipise Coalfield
OFFSHORE
SOUTH AFRICA PLAYS
(IN BLACK & WHITE)
Major offshore basins

- Offshore basins created by Mid Jur to early K riftting, and subsequent early K drift and divergent margin tectonism
- Orange Basin: divergent plate margin underlain by synrift grabens, up to 2200 m drift fill, fluvio deltaic deposition
- Outeniqua Basin formed when Falkland Plateau separated from Mozambique Ridge, with reactivation of Permian Cape Fold Belt compressional structures

- Bredasdorp Basin: 47 wells
- Pletmos Basin: 8 wells
- Orange Basin: 21 wells

- Around 300 offshore wells in total
Plays in major offshore basins

- 12 oil discoveries in lowstand basin floor fans of Bredasdorp Basins in strat traps in 2\textsuperscript{nd} order type 1 unconformities
- 24% success rate
- Eight wells in Pletmos Basin met limited success, did not target 2\textsuperscript{nd} order unconformities, poor sands
- Commercial gas flows seen in Orange Basin in structurally trapped, incise valley fills resting on 2\textsuperscript{nd} order unconformities
- Play is fluid migration from marine condensed sequences; vertical migration pathways; into stratigraphic pinch out traps or structural closures
Orange Basin sections

- Aligned normal to African margin
- Changes in sediment supply rates
- Sediment supply change to Orange River at 103 Ma, leading to basinward shift of depocentre
Seismic example – North Pletmos Basin

- Pletmos Basin
- Prograding deltaic sediments, incised valleys, slope and basin floor fans
- Partially fault controlled
- Detailed seq strat framework erected
New targets – Southeast coast

- Exploration focus on Bredasdorp Basin since 1980s
- Small oil and gas fields found, but poor seismic imaging led to many misses
- Disappointing bid rounds in 1994, 2007
- 2009 rights on SE coast taken by Silver Wave, and Impact farmed in, shortly followed by Angola discoveries
- Exxon farmed in in 2012
- Prograding, sand dominated shelf with associated turbidite and submarine fan systems
- Early Cretaceous source rocks
- Phillips’2010 well inshore with oil shows, also DHIs including gas chimneys and pockmarks
- Total/CNRL planning first ultra deep well (1450 m wd) off south coast
OFFSHORE SOUTH
AFRICAN FIELDS (YAWN?)
Oribi offshore oil field

- Discovered in 1990
- Reservoir sandstone with 27 m of 42 API oil
- Flowed at up to 8370 bbl/d with 3.4 MMscf/d of associated gas
- Porosity average 18%, perms >500 mD
- STOIIP estimates 47 to 74 MMbbl, P90 of 32 MMbbl
- Recovery estimated at 18 MMbbl over 4 years

- Appraisal wells found thin, water saturated sandstones
- AVO response due to volatiles
Oribi geology

- Deep marine channel complex sourced from SW
- Thin mass flow and channel deposits, with basal high density turbidites
- Sandstones encased in mud rich overbanks
- Poorly sorted, medium grained sandstones, fining up, derived from shelfal sands in Bredasdorp Basin

- Owned 80% by Soekor, 20% by Energy Africa
- Producing through Orca floating production facility in 390 feet of water
- Initial production from 2 production wells of 24,000 bbl/d
- Current production 1800 bbl/d
Ibuhesi Field summary

- South Africa’s biggest undeveloped gas field
- Production planned in 2017 at 100 MMscf/d
- Owned by Sunbird (76%) and PetroSA
- P&P reserves of 540 Bcf and 4.3 MMbbl of condensate (estimated 7.8 Tcf in block 2A)
- Channel sand deposits from Orange River
OFFSHORE GEOLOGY
OF NAMIBIA
Geology of Namibia

- Onshore dominated by ancient sediments, underlain by basement
- Minor potential for Karoo style gas plays
- Otherwise relatively low potential
- Four main offshore basins
  - Namibe
  - Walvis
  - Luderitz
  - Orange
- All relate to opening of the Atlantic
Offshore Namibian evolution

Four tectono-stratigraphic units:

- Pre Karoo Permo-Carboniferous
- Early Cretaceous syn-rift (Kudu reservoir is in upper part)
- Base drift marks transition to marine sedimentation
- Early drift late Barremian to Cenomanian comprises claystone with organic rich intervals
- Turonian to Recent late drift is main basin fill, with series of transgressive-regressive cycles, overall progradation
Offshore Namibian Source Rocks

• Four potential SRs identified, two proven by drilling - Cenomanian (up to 6% TOC).
• Aptian extends N and S, type II with up to 20% TOC (140 m of SR seen in Kudu)
• Aptian oil mature in Walvis, Luderitz
• Whitehill Fm. is oil prone onshore, and coals (common in Karoo) would be a gas source
• SRs and HCs match Brazilian Campos Basin (Kudu and 2815/15-01 wells)

• 18 wells, 8 wells on Kudu structure
• 3 deep water; oil and gas shows
• Significant undrilled structures
RUNNING ROOM
IN NAMIBIA –
HEAD & SHOULDERS
ABOVE THE REST
Play summary in Namibia

- Entire shelf area covered by seismic
- Studies available on thermal history, maturity, HC generation, VR
- Recognise Cretaceous marine oil prone source rocks (Kudu and seeps)
- Traps formed and sealed by late Cretaceous, prior to possible charge
- Series of marine sandstones build out from palaeo-coastline

Case study:
- Chariot Oil & Gas
- 8000 km² seismic
- 2 wells

<table>
<thead>
<tr>
<th>Area</th>
<th>Status</th>
</tr>
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<tbody>
<tr>
<td>Northern</td>
<td>Tapir South well encountered <strong>excellent reservoir and fluid inclusions</strong> Turbidite and subsalt potential Zamba prospect 375 MMbbl unrisked</td>
</tr>
<tr>
<td>Central</td>
<td>Potential shallow petroleum system U Cret turbidites, <strong>strat and struc traps</strong> Series of leads @ 200 to 1500 MMbbl</td>
</tr>
<tr>
<td>Southern</td>
<td>Petrobras and BP pulled out, Chariot renewing 3 year license Dry Kabeljou-1 well in 2012 found <strong>excellent SR</strong>, marginally mature Acquired 2128 km of 2D seismic</td>
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Pancontinental plays in Namibia
Moosehead prospect

- NW of Kudu Field in block 2813A
- Turonian turbidites drape over Aptian carbonates
- Possible Aptian buildups: microbialites
- Marked by bright and dim spots, may be associated with HCs
- Pmean of 1880 km² with 4 Bbbl reserves similar to Tupi Field, Brazil
- Other prospects of similar size
KUDU FIELD
Geology of the Kudu Field

- Barremian aeolian sandstones, 50 m thick with porosity of 12%, at 4400 m depth
- Sealed by basalt volcanics associated with the Atlantic opening
- Excellent analogue onshore in Damara Basin
- Correlates to Parana Basin in Brazil

View of dune topography preserved under flood basalt layers
Development of the Kudu Field

- Discovered in 1974 by Chevron (Kudu 9A-1)
- Has been owned by Shell and Energy Africa, bought by Tullow in 2004, who currently hold 31%, Itochu 15% and Namcor 54%
- Deal made with Gazprom in 2010, they reneged in 2011
- Gas reserves of 1.3 Tcf proven, 9 Tcf potential: Kudu-3 well tested 38 MMscf/d
- 8 wells drilled in total
- Planning to pipe gas 170 km to plant at Oranjemund, operated by Nampower
SUMMARY (BULLISH)
Current HC licenses – Majors involved
Hot prospects

- Owambo Basin
- Luderitz-Walvis Basins
- Karoo Shale Gas
- East London offshore
Summary

SOUTH AFRICA

• Karoo
  • Moratorium lifted on fraccing
  • Proven production from vertical gas wells

• Pletmos Basin
  • “2nd order type 1 unconformities” play cf. Bredasdorp

• Bredasdorp Basin
  • Little running room, more potential outboard

• Orange Basin
  • Gas prone, possibly oil outboard

• Other East Coast basins
  • Underexplored and considered prospective

NAMIBIA

• All basins significantly underexplored
• Walvis and Orange Basins very prospective
• All play elements present
  • Recent wells with flowing hydrocarbons
  • Proven oil source rocks
  • Carbonate mounds, Cretaceous turbidites
  • Canyons and associated fans
• Large prospects e.g. Moosehead
• Similarities to Brazil and Angolan plays

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We will wait to see if....
THANK YOU!!!