

The Majunga Basin of Madagascar – Review of Petroleum Systems and Exploration Potential

Piperi, Theodhora¹, Didier Arbouille¹ (1) IHS Energy, Perly-Geneva, Switzerland

The Majunga Basin is located along northwest Madagascar. It is a frontier basin with only eight NFWs drilled and no hydrocarbon discoveries so far. Lack of success can be attributed to the failure of wells to test valid closures, and poor understanding of source rock distribution, timing of charge versus trap formation and reservoir/seal combinations.

Two speculative petroleum systems are recognized. The Beronono - Cretaceous is likely to be the primary petroleum system, which could be active in the western passive margin of the province. The organic rich shale of Upper Liassic Beronono Formation is the main potential source rock, and Cretaceous sandstones, deposited during the prograding clastic margin shelf from Aptian to mid-Turonian times, are the principal reservoirs. Traps are structural and stratigraphic including lateral facies changes, incised valley fill, lowstand wedges and basin-floor fans.

The Middle Sakamena - Sakamena/Isalo Petroleum System is expected to be active in the failed rift portion of the province. Lower Triassic shale of the Middle Sakamena Formation is the principal source rock. Potential reservoirs include Lower/Upper Sakamena terrestrial sandstones of Late Permian to Early Triassic age, and Isalo sandstones of Middle Triassic to Early Jurassic age. The Sakamena/Isalo Play is proven onshore Madagascar and could be present in the failed rift province. Salt-related plays are identified in the deepwater part (Tari et al., 2004) but are considered as the most challenging plays.

The main exploration risks are the timing of trap formation versus source rock maturation and generation, and reservoir and seal qualities.

The Importance of the 'Davie Transcurrent Deformation Zone' on Hydrocarbon Prospectivity of the Offshore Blocks of the Rovuma and Tanzanian Coastal Basins, East Africa

Jacques, John M.¹, Kerri L. Wilson¹, Paul J. Markwick¹, Dave G. Wright¹ (1) Petroleum Systems Evaluation Group, GETECH, University of Leeds, Leeds, United Kingdom

Using satellite-derived gravity data, in combination with seismic, we show that the Davie Ridge represents a N-S-trending broad zone of diffuse deformation (~ 100-200 km wide) that extends from Tanzania to the southwest coast of Madagascar; and thus, it does not define the position of one discrete structure – the Davie Fracture Zone – as depicted on many published structure maps and palaeotectonic reconstructions. As such, we prefer here to use the term 'Davie Transcurrent Deformation Zone' (DTDZ) to describe this zone, which appears to be comprised of a number of N-S-trending major transcurrent fracture zones. A number of these fractures probably owe their existence to the time when Madagascar (and the rest of East Gondwana) was translated southwards, during the Late Jurassic (~155 Ma), from what is now the present day coastline of Kenya/Tanzania, down the east coast of Africa, to its final, present day position by the Early Cretaceous (~118 Ma).

During Neogene East African rifting, the DTDZ was reactivated to form an anastomosing set of N-S-trending transcurrent shear zones that controlled the siting of intense magmatic and extensional activity, expressed by axial basaltic extrusions and half-graben development (e.g., Lacerda and Kerimbass), respectively. The DTDZ is an integral part of the deep water areas of the Rovuma and Tanzanian Coastal Basins and, as such, must be considered in order to reduce risk and uncertainty, particularly in terms of heat flow (thermal maturation history), seismic activity (neotectonic faulting) and structuralisation, if we are to gain an understanding of the hydrocarbon prospectivity of this frontier province.

Using Planned Sidetracks to Efficiently Explore Lower Congo Basin Deepwater Miocene play: Reducing Exploration Risk and Appraisal Uncertainty, Angola's Block 14

Roth, Joy¹, Nelson Pacavira², Paula Joao³ (1) Chevron, Houston, TX (2) Cabinda Gulf Oil Co. Ltd, Luanda, Angola (3) Cabinda Gulf Oil Co. Ltd, Houston, TX

As part of the first Angola deepwater bid round, the Block 14 exploration permit was awarded in 1995 to the contractor group consisting of CABGOC (the operator, a Chevron company) Sonangol P&P, ENI, GALP, and Total. Key to quickly evaluating play potential over 4000 km² of deepwater was the use of pre-planned sidetracks in exploration and appraisal wells. To date, over 1 billion bbls of recoverable oil have been discovered in more than 25 Miocene reservoirs in the area covered by 2500 km² of pre-stack time migrated seismic with 6 km offsets. Utilization of this high quality seismic to pre-plan sidetracks enabled the drilling of 30 exploration and appraisal wells with only two dry holes. Sidetracks resulted in a step change reduction in deepwater cycle time and appraisal density for this play type.

In the ten years since this deepwater concession was granted, 30 exploration and appraisal wells have been drilled. Of these wells, approximately 40% utilized planned sidetracks. The discoveries to date in Block 14 are upper continental slope turbidite channel complexes at multiple stratigraphic intervals within the Miocene. Preplanned sidetracks are utilized in order to accomplish a multitude of objectives from pressure data correlation to test multiple fluid contacts, testing confidence in seismic-based sand predictive tools, the coring of various facies, and the targeting of new play types while drilling pre-development wells.

This paper illustrates examples of the beneficial use of sidetracks and the stacking of multiple objectives to assess a new play for an incremental price, abate uncertainty in subsurface characterization, and reduce cycle time to first oil in deepwater developments.

The Tectono-Sedimentary Framework of the Jurassic Carbonate Platform in Atlantic Passive Margin of Morocco

Zizi, Mahmoud¹, Mohamed Nahim² (1) ONHYM, Rabat, Morocco (2) Onarep, Rabat, Morocco

This paper will focus on the tectono-sedimentary features of the carbonate Atlantic continental passive margin of Morocco.

The geological interpretation of the passive margin is based principally on the data acquired from petroleum industry including seismic reflection surveys and wells. Prior to the opening of the Atlantic Ocean, a continental rifting during the Upper Triassic–Lower Lias was marked by the deposition of continental red beds which grade upward to evaporates.

The break up unconformity is believed to be Toarcian in age. Carbonate sedimentation prevailed in the Jurassic time. More than 4000 m carbonate sequences were deposited on the shelf.

Laterally, the Jurassic becomes thinner towards the slope and the abyssal plain reflecting starved sedimentation with most of the carbonate being deposited in the shelfal areas. The carbonate sedimentation is marked by high energy carbonates which are expressed on seismic profiles as prograding reflectors. These progradations correspond to sand shoal oolitic carbonate beds which were deposited during the high stands. During the Lias and Dogger, these sand shoal oolitic deposit were prograding and aggrading. The carbonate platform evolved from ramp type platform in the Lower and Middle Jurassic to shelf margin platform in the upper Jurassic. This evolution is associated with rapid rise of sea level and the carbonate platform was catching up in the upper Jurassic.

However and locally salt tectonic prolonged the ramp type to up to upper Jurassic.

The salt uplift compensated for the rapid sea level rise and prevented the carbonate platform to evolve to self margin carbonate platform.

Exploration of the East African Rift System in the Lake Albert area, Uganda

Cassie, Bob¹, Chas Sheen¹, Justyn Wood¹ (1) Hardman Resources, Perth, Australia

Exploration Area 2 over northern Lake Albert and adjacent onshore areas was acquired by a Hardman/Tullow joint venture in 2001. Lake Albert is located on the border between Uganda and the Democratic Republic of Congo and is approx. 140 km long and 40 km wide. The lake is in the western arm of the East African Rift and while the area was virtually unexplored there were a number of positive features including aeromagnetic and gravity data suggesting up to 5,000 metres of sediment and numerous oil seeps. One of the best seeps, which was within the area, demonstrated the presence of a lacustrine algal oil source.

Hardman recorded a 1,589 km seismic survey on the lake in 2003 using a small multi-channel seismic system mounted on a fishing vessel. The survey defined the overall basin geometry, including northern and southern depocentres and a shallower eastern platform. The depocentres are separated by a structural nose which is a focus for both structuring and migration. The survey identified a number of leads including a large trap against the platform-bounding fault. In early 2005 an onshore/transition survey of 220 km was recorded and delineated similar prospects onshore, along the basin-bounding fault, at shallower depths (approximately 1,200 – 1,800 m). Oil seeps on the bounding fault near the prospects, indicated that oil charge was likely.

Mputa-1, the first of the current two well program, recovered oil from wireline samples and confirmed the existence of a petroleum system in the basin. The result provides encouragement for further exploration and appraisal drilling.

Application of Integrated Geophysical Strategies in the Albertine Graben and its Petroleum Potentiality

Nimmagadda, Shastri Lakshman¹, Reuben Kashambu², Ernest Rubondo³, Robert Kasande⁴ (1) Kuwait Oil Company, Kuwait City, Kuwait (2) Commissioner, Entebbe, Uganda (3) Assistant Commissioner of PEPD, Entebbe, Uganda (4) Principal Geologist, Entebbe, Uganda

Albertine graben, in the Western Uganda covers an area of 20,000 sq km, but only few square kilometers area has so far been studied. About 15000 line kilometers of aeromagnetic surveys conducted all along the Albertine graben, have established presence of sedimentary basins and several depo-centers along the entire length of this graben. There are total five sub-basins, each having an average of 5000 sq km area. Ground gravity and magnetic surveys conducted in the Semliki basin, which is falling in the south western part of Albertine graben; interpret a total column of about 6 kilometers thick sediments. There are several active oil seeps all along southern and eastern margins of these rifted basins.

Under Commonwealth Fund for Technical Cooperation (CFTC) project, two sub-basins of the rifted Albertine graben have been studied. All the gravity, magnetic and seismic data have been integrated. Several structure maps have been prepared at different unconformity surfaces along with time-thickness, paleo-reconstruction, interval velocity maps and seismo-geological cross sections. Several seismic anomalies, which are attributed to stratigraphic and hydrocarbon indicators have been examined. Prospective areas have been identified and ranked them for further exploration. Recently drilled well data on an anticline structural closure have provided significant oil and gas shows, which have shown worldwide attention and interest of exploration venture in the Western Ugandan Albertine graben.

New Exploration Understanding from the Ruvuma Block (Tanzania), and its Regional Significance

Pereira-Rego, Michael C.¹ (1) Aminex PLC, London, United Kingdom

The Ruvuma Basin of Tanzania is located to the west of a NE-SW trending transfer fault, the trace of which is followed by the Ruvuma River, with parallel fault trends to the NW. Unlike most other East African margin basins where the drift succession increases rapidly in thickness across coast parallel faults, here the entire drift and rift successions are

preserved in a ramp setting that dips at low angles towards the Ruvuma transfer fault. One consequence is that the rich and thick Permo-Triassic rift succession source rocks functioned as a long term source contributing hydrocarbons through time to the entire drift succession. Additionally, there is sufficient burial in the East of the block to place the Lower Jurassic oil-prone source succession in the Oil and perhaps offshore also in the Gas Window.

Only recently have Jurassic sources become important to East African exploration. Now, where burial was more gradual, the rift succession has joined the growing list of effective sources. Where there is strong coast parallel faulting, timing between oil and gas charges can become reduced and pure oil legs may not be found. Since the NE-SW trending transfer faults were repeatedly tracked by rivers draining from the interior of Africa a wide range of channel related plays evolved. Understanding the interplay in a simple ramp setting from Ruvuma between maturation, expulsion, sand supply and trap development may help to reduce the risk of finding gas offshore.

Deep Structure of the Argentine and Conjugated South African Continental Margins

Schnabel, Michael¹, Dieter Franke¹, Stefan Grassmann¹, Soenke Neben¹, Volkmar Damm¹, Hugo Pelliza², Paulo Ricardo Dos Santos² (1) BGR - Fed. Institute for Geosciences and Natural Resources, Hannover, Germany (2) Petrobras Energia S.A,

The last phase of the break-up of Gondwana during the Late Jurassic and Early Cretaceous is associated with a complex history of rifting and magmatism on the conjugate continental margins of southern Africa and Argentina. The opening of the South Atlantic resulted in the development of passive continental margins of the volcanic type on either side.

We present results of two seismic refraction lines, which were acquired by the Federal Institute for Geosciences and Resources (Germany) across the continental slopes. We evaluated these profiles using a 2-D joint refraction and reflection seismic tomography. This method yielded reasonable information about the velocity depth distribution. It also allows assessing the final model in terms of resolution and non-uniqueness.

On both margins, the crust shows a landward decrease in seismic velocity. This fact is due to the transition from oceanic to continental crust. Offshore Argentina, we were able to identify a distinct velocity anomaly within the upper crust in the area of the seaward dipping reflector sequences. The lower crust is characterised by a high velocity (7.3 to 7.5 km/s) body. We can show that the thickness of this body varies across the continental slope, which reflects the episodic character of the opening of the South Atlantic.

With these results, we are able to deliver some constraints on the rifting processes which have governed the early formation of the South Atlantic. Further on, our results are narrowing down some key factors (crustal thickness, heat flow) for a HC maturity modelling study.

Seychelles and the Western Indian Ocean Palaeo-Reconstruction by Recourse to Biomarker Assemblages from Significant Oil Accumulations and Shows in the Present Day Indian Ocean Margin

Matchette-Downes, Chris¹, Eddie Belle² (1) East African Exploration & Upstream Petroleum Services, N/A, United Kingdom (2) Seychelles Petroleum, N/A, United Kingdom

In the same way that West African geochemical data derived from oil accumulations in coastal South America and conjugate West Africa were used to predict the likely Palaeoenvironment of deposition on each side of the Atlantic was determined by recourse to stable isotope measurement and biomarker analysis using gas chromatography-mass spectrometry data, the more complex break up of Gondwana and the separation of East Africa, Seychelles and India can also be charted.

Oil samples and oil show extracts from the limited number of wells and the known seeps are used to help understand the multiphase break up of the East African margin, India and the Seychelles Microcontinent.

Geochemical data is presented with current plate tectonic reconstruction models to contribute to the understanding of the rifting sequences that were initiated during the Triassic that have resulted in the present day continental settings with seemingly contradictory oil geochemical signatures.