

# East African Exploration: Myths, Myopia and Misinformation?

Commercial accumulations of liquid hydrocarbons have remained elusive in East Africa, despite numerous shows and seeps. Could a reanalysis of the Petroleum Systems lead to renewed exploration?



Chris Matchette-Downes, Vice-President, Business Development, Black Marlin Energy, on a reconnaissance visit to EAX acreage Northern Madagascar. Chris is a petroleum geochemist who has worked for a number of oil companies and consultancies. Since 1995 he has worked in marketing and business development for seismic companies, including PGS and Jebeo, before co-founding East African Energy and Upstream Petroleum Services with Jeff Hume, CEO, Black Marlin Energy in 2005.

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Jane Whaley, Associate Editor

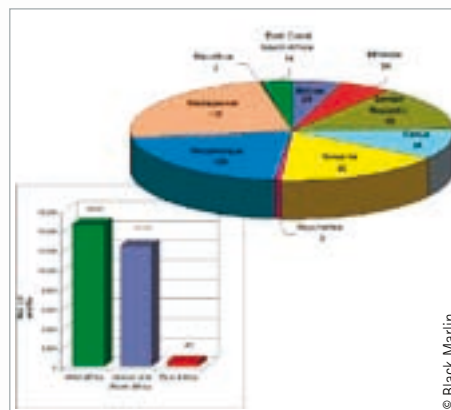
"Although interest in East Africa has risen in recent years, with a current dramatic uptake in acreage, the area is still vastly under-explored," says Chris Matchette-Downes, Vice President, Business Development at Black Marlin Energy, a company concentrating in exploration in this area. "The margin requires a better understanding of the basic geological fabric, a critical re-evaluation of the existing raw data, and, most importantly, a serious analysis of the myths and misinformation which flourish about the region."

### Myth 1: "Drilling in East Africa is bound to be unsuccessful"

"East African geology is far more complex than that of West Africa," Chris explains. "Understanding the movement on the margin and the consequent depositional settings is absolutely key. Early geological models were largely incorrect, predicting a true passive margin, similar to Kansas or Oklahoma, with tensional faulting showing small tangential displacements. East Africa is a passive margin, but only in a north-south direction. At the end of the Cretaceous this was overprinted by a lateral transfer margin similar to the San Andreas fault system. Work on understanding these more complex systems only really commenced with successful exploration in the passive margin of deep water Brazil."

"The original sedimentological models were derived from academic models of deposition under gravity loading. We now understand that depositional settings in East Africa are very varied, including rift margins, interior rift basins, failed rifts and Triple Junctions similar to the North Sea," concludes Chris.

This lack of comprehension of the complexity of the geology of East Africa, coupled with weak seismic resolution, appears to have resulted in poor well location, with consequent lack of success. In addition, as interest in the West Coast rose, it waned on the opposite side of Africa, so expertise was lost and the East Afri-



With a ratio of 1 exploration well per 56,000 square kilometres, the East African Margin is virtually unexplored, particularly when compared to the rest of Africa.

can coast, perceived as being unrewarding, was neglected by the oil industry for more than two decades.

Recent exploration efforts, however, have shown ample evidence of hydrocarbons, dispelling the myth that East African exploration is bound to be unsuccessful.

### Myth 2: "The main source rock is Cretaceous"

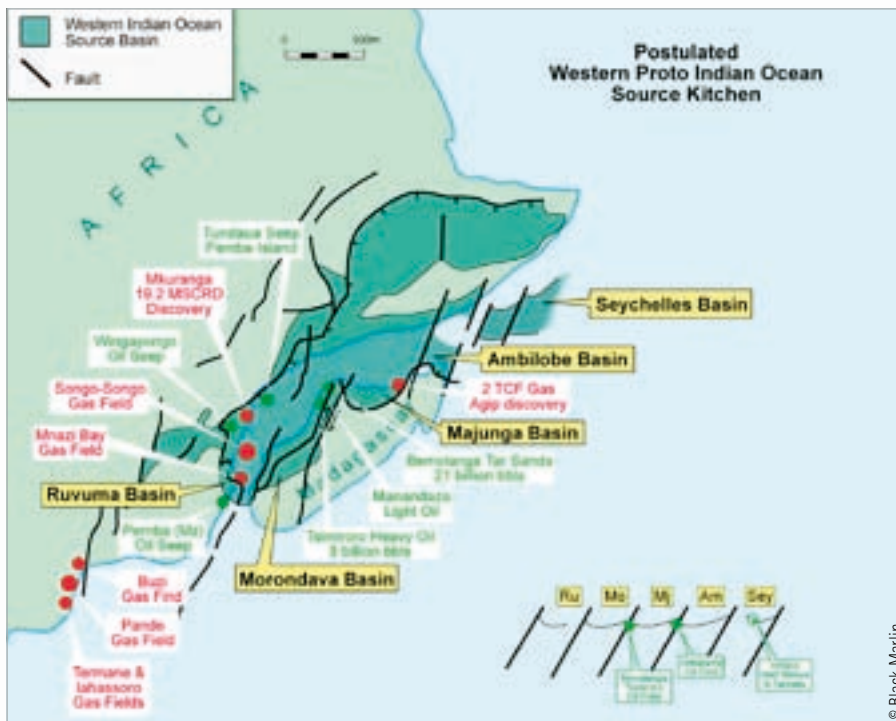
Several potential source rock units have been promoted as contenders for the oil and gas seeps found throughout East Africa. With local government support and access to GeoMark Research's 9,000 sample O.I.L.S. database, Chris has made an extended study and analysis of over 50 oil shows and seeps throughout East Africa. Through this he has critically re-evaluated the Petroleum Systems operative throughout the Western Indian Ocean Margin.

A phase of rift and drifting activity in the late Cretaceous separated Seychelles and India from Madagascar, after which a number of marine transgressions created well-oxygenated, deep water depositional settings. Until recently, rocks of this age had been thought to provide the primary sources for hydrocarbons in East Africa, but the geochemical work that Chris has undertaken discounts this theory.

"The tested oils cannot support the idea that the Cretaceous is the primary source rock in East Africa," he explains. "For example, whilst a "Campanian source rock" in Kimbiji East #1 in Tanzania had an excellent Total Organic Carbon (TOC) value of 12.2%, the corresponding Hydrogen Index (HI) value of just 129 does not allow this or any part of the penetrated Campanian to be classified as a source rock. The Cretaceous is not actually encountered as a source anywhere ▶



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Vast inland seas and lakes persisted throughout the Lower Jurassic, allowing the development of an extensive and potent source rock system.

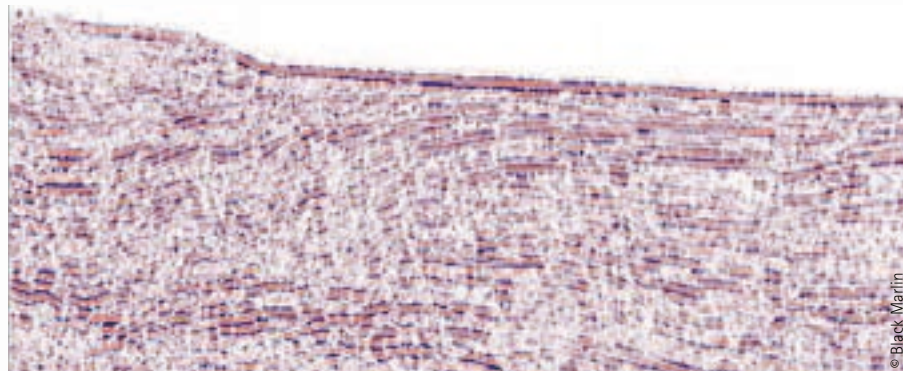
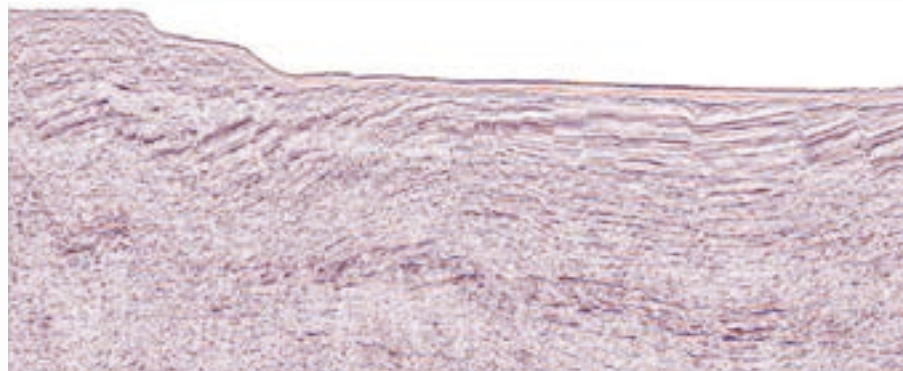
in East Africa. The latest Upper Cretaceous penetrations in wells Pimboo #1, Nyuni #1 and Simba #1 also found no source rock.”

Another suggested potential source rock interval in East Africa is the Lower Eocene. Again, Chris feels that his research indicates that there is not sufficient evidence to support this claim. “While localised Eocene marine source rocks have been seen in both Tanzania and Kenya, the evidence suggests that this is not yet mature. Only a few Tertiary higher plant biomarkers have been found in oil shows, seeps or migrant oil samples and these may be contaminants, collected during migration.

### Myth 3: “There are no Palaeozoic source rocks”

“The oldest proposed source rocks in East Africa are in the Upper Palaeozoic and Lower Mesozoic. The pulsed rifting and the initially unsuccessful commencement of the break-up of Gondwana in the Carboniferous eventually created optimal conditions for source rock development, similar to analogous areas such as the early North Sea. Potential source rocks of this age in East Africa include alternating lacustrine and marine transgressions into the Karoo rift system in Tanzania, carbonaceous shales in the Lake Nyasa region of Tanzania, with a TOC of over 27%, and the Upper and Lower Coal Measures, also found in

Tanzania, which have TOC’s ranging from 44 % up to 80%. The Karoo coal, found throughout East Africa, is also of this age. The Triassic Sakamena with its possible



Some of the most important technological developments of recent years have been in the area of seismic acquisition and processing, giving deeper records and more accurate images, leading to better well location. These examples show reprocessed data from offshore Kenya, compared to 2D seismic acquired in the same area by EAX in 2005.

equivalents in Kenya and Seychelles is a prolific source, giving rise to the multi-billion barrel accumulations of Tsimiroro and Bemolanga.”

“With these potential source rocks, the major questions are about maturity,” Chris explains. “It is possible that depth of burial means that they are post-mature, reducing the TOC and HI values. Alternatively, they could be in the gas window, particularly towards the west, and may be the source of East Africa’s dry gas, found in Pande, Termame, Mnazi, Songo Songo and more recently Mkuranga #1.

### Myth 4: “There are no contiguous source rocks”

“The break-up of Gondwana and resultant syn-rift setting allowed the deposition of a variety of Triassic potential source rocks. These include the Lower Pindirola Evaporates of Tanzania, with TOC’s of up to 10%, as well as a number of deposits found in Tanzania, Madagascar and the Seychelles, all with organic content over 5%.”

In Chris’s opinion, however, the most promising source rock candidates lie in the Lower Mesozoic, products of the syn and post-rift situation as Madagascar separated from Proto-India. “The Lower Jurassic restricted marine environments



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Chris thinks that working for a company that specialises in East African Exploration has definite advantages!

created optimally mature sources close to the shore," Chris continues. "Further inland in Tanzania, the Mandawa salt basin has thick deposits of lagoonal to marginal marine shales with a TOC of up to 10.9%, which have been described as the 'most promising source rocks in the whole of East Africa' by TPDC. Triassic to Lower Jurassic shales with TOCs of over 5% are also found in Madagascar and Seychelles, and may be present in Kenya and Mozambique."

"The existence and age of source rocks are therefore no longer the issue," Chris continues. "We can now look further at the Petroleum Systems, map the source distribution, which will be strongly influenced by the early break-up fabric, using modern seismic and potential fields data, and build up a series of plays."

### Myth 5: "East Coast Africa is gas prone"

"Contrary to the long held view that East Africa is, at best, gas prone, we now realise that there is a major early Mesozoic oil prone source system, with a possible underlying Upper Palaeozoic system, operative throughout much of coastal Kenya, Tanzania and perhaps Mozambique, Somalia, Madagascar and Seychelles," says Chris. "In fact, we believe that the gas present in the Mozambique and Tanzanian accumulations may possibly be anomalous."

"After deposition of the Lower Jurassic sources, the continuing break-up of the proto-continent meant that it took some time before they were buried to a sufficient depth for hydrocarbon generation to take place. In a cool passive margin setting such as East Africa, maturation is slow, and despite the age of the source rocks, not all have passed through the oil and gas

windows. In fact, in Seychelles generation may still be continuing to the present day."

### New advances lead to efficient exploration

Chris and his colleagues believe that the key to exploration in East Africa will be efficient use of the new technologies

now available. New and more accurate modelling techniques are affording a much better understanding of basin evolution, as well as of the underlying geology, heat flow and source rocks.

Satellite and remote sensing imagery can also be very useful, particularly for the offshore area. Recent re-analysis of bathymetric and seismic data gathered in the Mozambique channel during the Cold War has shattered some significant assumptions, such as the presence of volcanoes offshore Mozambique, which are now thought to be anticlinal, potentially oil-bearing, structures of Mesozoic age.

Modern petroleum geochemical techniques are proving very important, as evident from the work Chris has undertaken on source rocks, identifying signatures and linking oils geochemically across the region to show that there are consistent and contiguous sources. He uses stable isotope abundances to group oils into 'families' with characteristics of terrestrial or marine origin. In the past, ▶

## Evidence of hydrocarbons in East Africa

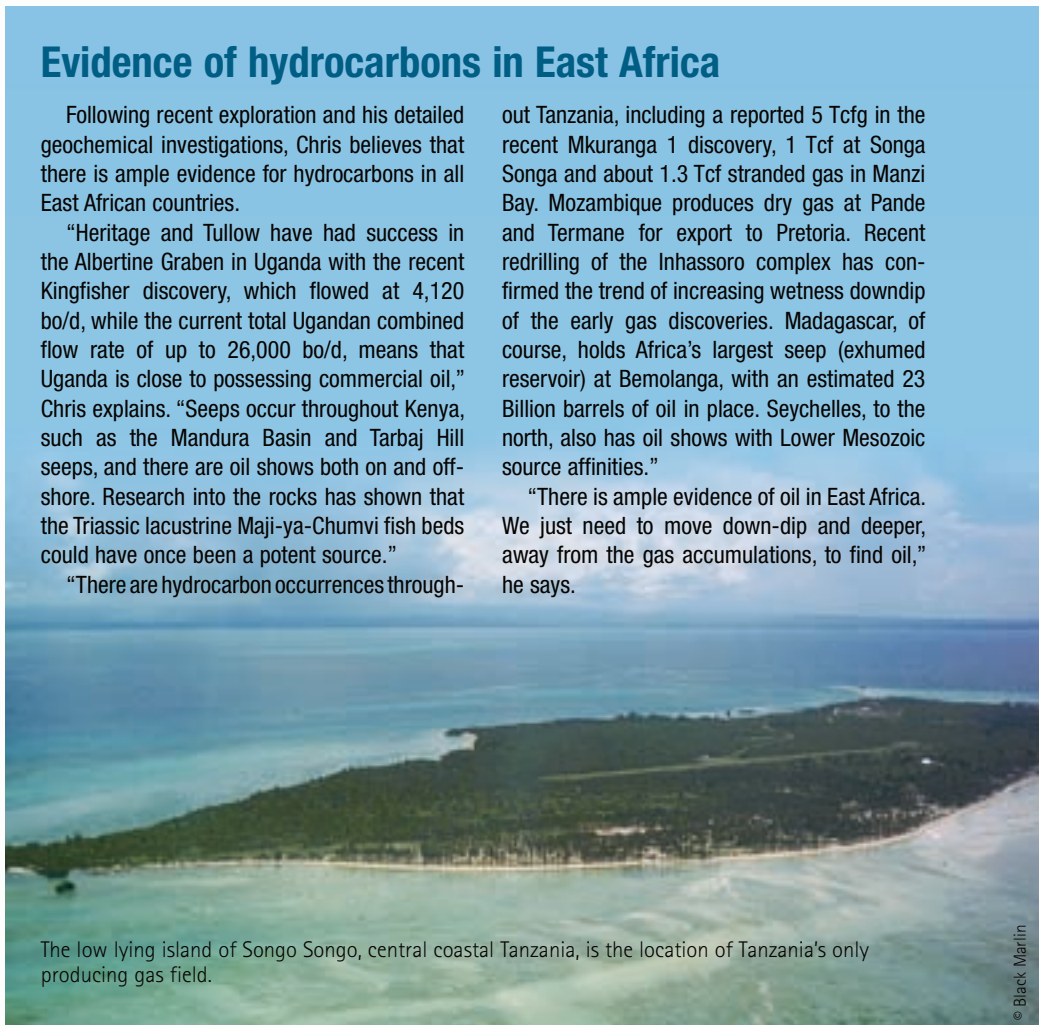
Following recent exploration and his detailed geochemical investigations, Chris believes that there is ample evidence for hydrocarbons in all East African countries.

"Heritage and Tullow have had success in the Albertine Graben in Uganda with the recent Kingfisher discovery, which flowed at 4,120 bo/d, while the current total Ugandan combined flow rate of up to 26,000 bo/d, means that Uganda is close to possessing commercial oil," Chris explains. "Seeps occur throughout Kenya, such as the Mandura Basin and Tarbaj Hill seeps, and there are oil shows both on and offshore. Research into the rocks has shown that the Triassic lacustrine Maji-ya-Chumvi fish beds could have once been a potent source."

"There are hydrocarbon occurrences through-

out Tanzania, including a reported 5 Tcfg in the recent Mkuranga 1 discovery, 1 Tcf at Songa Songa and about 1.3 Tcf stranded gas in Manzi Bay. Mozambique produces dry gas at Pande and Termene for export to Pretoria. Recent redrilling of the Inhassoro complex has confirmed the trend of increasing wetness down-dip of the early gas discoveries. Madagascar, of course, holds Africa's largest seep (exhumed reservoir) at Bemolanga, with an estimated 23 Billion barrels of oil in place. Seychelles, to the north, also has oil shows with Lower Mesozoic source affinities."

"There is ample evidence of oil in East Africa. We just need to move down-dip and deeper, away from the gas accumulations, to find oil," he says.



The low lying island of Songa Songa, central coastal Tanzania, is the location of Tanzania's only producing gas field.

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For shallow water inshore or lake surveys, Black Marlin use a small purpose built catamaran, seen here being launched at Kilwa Masoko Island.



Shallow water seismic pre-survey tests, offshore Tanzania.

the second marine 3D in East Africa in Mozambique. Using modern techniques of seismic acquisition and processing gives us deeper records and more accurate images, ultimately leading to optimal well location.

## Dismiss the myths

The future looks promising for East Africa. Commercial oil will be found in all East African countries, and more and larger finds can be expected, as the remaining available acreage is taken up. More seismic will lead to further drilling and an increasing understanding of the geology and petroleum systems in the region.

Chris also expects commercial changes. "At the moment the main players are small independents, but these will join forces with larger companies. I also anticipate greater Asian involvement as their energy requirements increase, and the appearance of indigenous companies such as the Kenyan Somken Upstream, bringing employment and wealth to East African nationals."

The political outlook for the area also looks good, with relatively stable governments welcoming oil companies with attractive production sharing terms.

"The key to success in the East African margin is an intimate understanding of petroleum geology through potential field analyses, palaeogeographical reconstruction, petroleum geochemistry, and new and processed seismic," Chris states.

"Dispelling the many myths which have grown up about East Africa is the first step towards major growth in the oil industry in this region." 🌱

important geochemical techniques like fluorescence, extract work, biomarkers and isotope data were not used or were used in isolation, overlooking important sources of corroborative information.

"The area has been effectively ignored since the early 1980s" Chris says. "However,

in the past three years more than 44,000 km of 2D proprietary seismic has been shot, mostly by Black Marlin's sister company, UPSL. The first lake 3D in Uganda as well as the first marine 3D survey in East Africa, off Madagascar, were acquired in the early 2000's. In 2007 Sasoil acquired

## Black Marlin Energy

Black Marlin Energy focuses on East Africa, exploiting the low entry cost, liberal fiscal regime and high upside potential of these unexplored basins. The exploration focus remains the Gondwana break-up margin.

"We're not glorified estate agents, sitting on blocks and then reselling," explains Chris Matchette-Downes. "We want to realize the full potential of our acreage, seeing through to discovery and confirmation of commercial hydrocarbons where possible. We can do this through our wholly owned subsidiary companies, EAX and UPSL, which can provide all the services required for successful exploration. We can accelerate our work programme

through using UPSL, our seismic company, but this company also undertakes client surveys, which can be paid through acreage, increasing our holdings. UPSL is pioneering the use of 3D seismic technology on land in shallow East Africa waters."

"The other part of Black Marlin is East African Exploration Ltd. (EAX), which offers geoscientist expertise. It is based in East Africa and is actively exploring Kenya, Seychelles, Tanzania, Mozambique, Eritrea and Madagascar. In EAX we believe that by combining our new data and modeling expertise with the reprocessing of old data, we can turn the 'possible' to the 'probable'."



The survey ship GeoMariner seen here approaching Victoria Harbour, Mahé, Seychelles having completed a 3,650km long offset (8.1km) survey for EAX this year.