Finding Petroleum

How do we build on Zohr

The story of Energean Oil and Gas - Israel, Greece, Montenegro

Opportunities in Malta

Opportunities offshore Egypt and Lebanon

Is there oil offshore Lebanon?

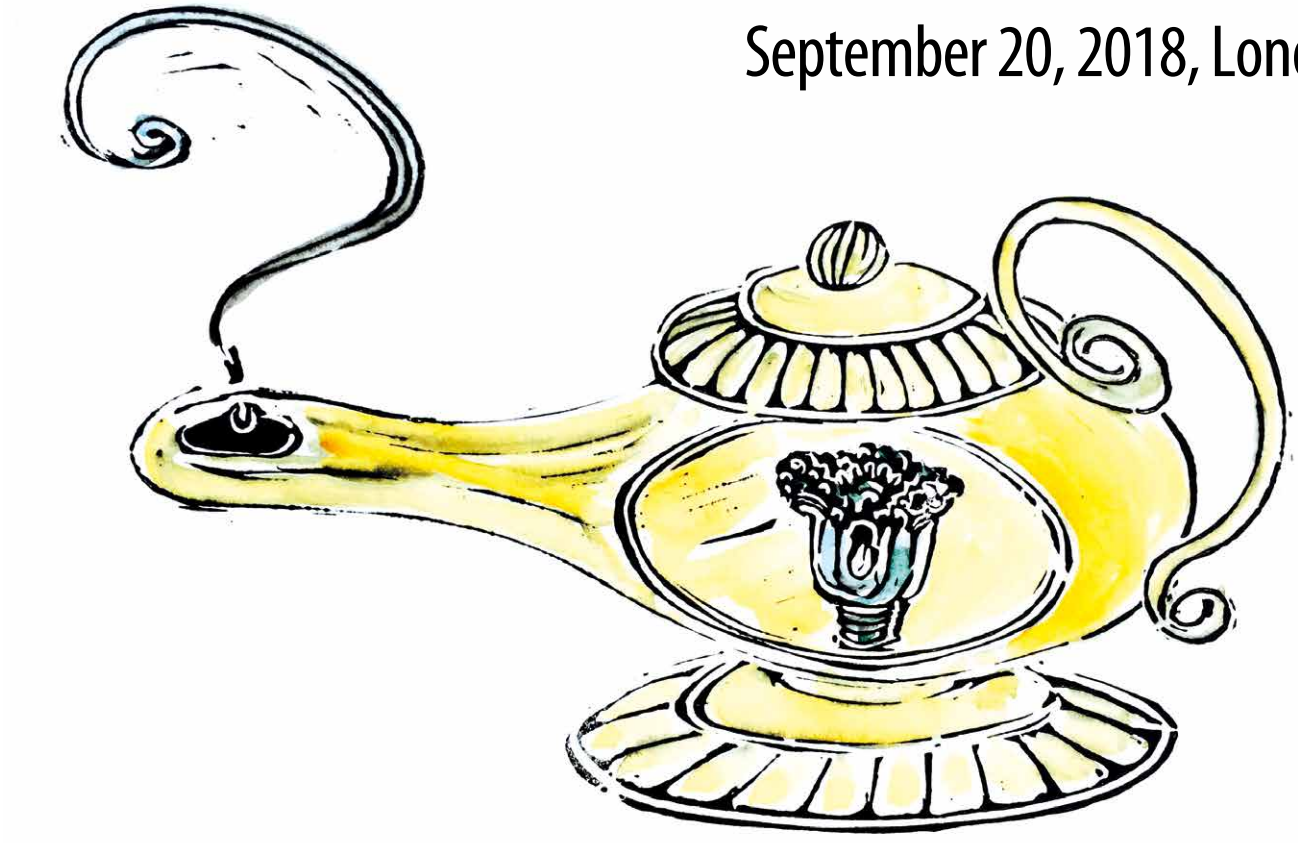
Why we still need exploration

Opportunities in the Eastern Mediterranean, September 20, 2018, London

Special report

Opportunities in the Eastern Mediterranean

September 20, 2018, London



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Opportunities in the Eastern Mediterranean

Finding Petroleum's London forum on Sept 20 2018, "Opportunities in the Eastern Mediterranean," looked at opportunities for explorers, particularly offshore Egypt, Malta and Lebanon. We also heard how Energean Oil and Gas is developing its oil and gas operations

This is a report from the Opportunities in the Eastern Mediterranean event, September 20, 2018, London

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Note:

Some of the slides and videos from this event can be downloaded free from the Finding Petroleum website event page
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Finding Petroleum's London forum on Sept 20 2018, "Opportunities in the Eastern Mediterranean," looked at opportunities for explorers particularly offshore Egypt, Malta and Lebanon, and the complex Mediterranean geology.

We also heard the story of how Energean Oil and Gas has developed its oil and gas operations, from a single 1,000 bopd, 26 year old oil well offshore Greece, to a FTSE 250 company, and its development plans.

There has been a big growth in interest in the region over the past few years, since the 2014 Zohr discovery, 30 TCF or 5bn barrels of oil equivalent, discovered in 2014 in Egyptian waters.

The region also saw the world's biggest single offshore discovery in the first half of 2018, "Calypso" offshore Cyprus, rumoured to be 6-8 TCF, equivalent to a billion barrels of oil.

Neil Hodgson, Executive Vice President Geoscience with seismic acquisition company Spectrum Geo, chairing the event, estimates that there is 60 TCF in the region altogether. It could supply gas into Europe as well as to Egypt and Israel.

"I think the Eastern Med has got more than enough to offer to keep us excited, perhaps has a bigger resource potential than Guyana."

Understanding Zohr

Dr Hodgson explained the complex series of geological events which led to the formation of Zohr.

It began with a build-up of carbonates, a rock mound made from skeletons of sea creatures, which happened from the early Cretaceous (140mya) to the early Miocene (23 mya), a period of about 100m years.

The gaps between these reefs got filled in by clastics (transported rock fragments carried by the River Nile), containing a large amount of organic carbon. As they got buried, the organic material rotted and gave out biogenic gas.

In some parts of the Mediterranean, the carbonate build ups poke out just under the Messinian salt, forming a seal of any hydrocarbons trapped below the salt. This is what happened with Zohr. The gas migrated into the reefs and was trapped by a sealing layer of salt. This was deposited in the Messinian (7mya). The salt was deposited because at this point in geological time, the Mediterranean did not have an outlet to the sea, and dried up, leaving just the salt behind.

It helps that the geothermal gradient (how rock gets hotter as it gets buried) is really low in this part of the world.

This means that it takes a long time for the organic-rich sediments to get so hot from burial that the microbes producing the gas are killed off. With a long time to generate gas, the gas was not all lost before the salt layer was placed on top, Mr Hodgson said.

Building on Zohr

The first well drilled into this 'play type' after Zohr was called Onesiphorus. It did find gas but a relatively small amount 400 to 500 BCF (so Zohr, at 30 TCF, was about 60 times bigger). That was maybe due to the seal not being gas tight, Mr Hodgson said.

The Calypso well of 2018 did work, finding 6-8 TCF. Although on the seismic it is not so clear whether it would have worked, with a less clear salt seal, he said.

The requirement for salt as top seal is ambiguous, as several years previously another carbonate build-up field had been drilled in Israel, where the carbonates do not point into Messinian salt. The result was ambiguous, with the first attempt at drilling losing all drilling fluid into caverns in the carbonate platform. Then a side track managed to miss the carbonate platform entirely. So no-one knows if there is gas or not, Mr Hodgson said.

Lebanon is also an interesting place to look. It had a licence round in 2017, awarding blocks 4 and 9, with another license round expected in early 2019, Mr Hodgson said. Most people think there is only gas in the region, but there may well be oil there. So far no-one has drilled any wells, he said.

By undertaking basin modelling, you can see that there may be thermogenic liquids (formed due to organic matter at high temperatures), with sediment carried by the Nile Delta in the Eocene and Oligocene, he said.

50 TCF has been discovered offshore Israel so far, and there could be more, perhaps 50-100 TCF altogether in Calypso / Zohr type fields.

The Northern Levant Basin offshore Lebanon could have 50 TCF of gas or 10bn barrels of oil.

Energean Oil and Gas – building a position in the Eastern Med

Energean Oil and Gas is a FTSE 250 listed independent oil and gas company that listed in March 2018 following the UK's largest oil and gas IPO for four years in which it raised $460 million. The company was only founded in 2007, when it acquired a 37 year old field in Greece; over the last 10 years it has grown from being a company with a valuation of $1.5 million to more than $1 billion.

Energean Oil and Gas is headquartered in London. In March 2018, Energean delivered the UK's largest oil and gas IPO for four years, raising $460m and taking it into the FTSE 250.

Gareth Freeston-Smith, Head of Subsurface for Israel with Energean, told the story at Finding Petroleum's Eastern Mediterranean forum.

Subsequent to the Finding Petroleum conference, Energean took a secondary listing on the Tel Aviv Stock Exchange, expanding the accessibility of its story to Israeli investors.

Energean currently has 13 licences, including producing assets in Greece, major development and exploration assets offshore Israel and exploration acreage comprised of two exploration licenses in Western Greece two blocks offshore Montenegro. Energean actively assesses further opportunities in the Mediterranean region.

Energean was started in 2007 by CEO Mathios Rigas and, now NED, Stathis Topouzolglou, through the $1.5 million acquisition of the Prinos oil field in Greece. Over the past 10 years, Energean has significantly grown both production and reserves at this asset.

Energean saw its chance to expand when Noble Energy was forced to sell two of its smaller discoveries offshore Israel, Karish and Tanin, as part of efforts by the Israeli government to ensure there wasn't just one oil and gas operator in the region. Energean paid just $40 million up front for the 2.4 TCF of gas resources in these discoveries and the associated prospectivity in the leases. Subsequent to the acquisition, Energean progressed the project in less than six months, demonstrating the company's ability to fast track projects.

There are not many companies active in the Eastern Med compared to places like the North Sea or Gulf of Mexico, which should indicate there is room for more, Mr Freeston-Smith said.

There are a few export options. Gas could be carried by pipeline to Egypt, where there are 2 LNG facilities, so it could be liquefied for export to other markets. Energean has also proposed building a pipeline into Cyprus, which is a 0.5 – 1 bcm/year market.

There is also a memorandum of understanding signed between Israel, Cyprus, Greece and Italy to commit to studying the potential of an Eastern Mediterranean pipeline, supplying the rest of Europe with gas from the Eastern Med. Pre-FEED work on this project is attracting 50 per cent funding from the European Union.

Greece

Energean's story starts with Greece, where it acquired the Prinos field in 2007.

Prinos began production in 1981, with an initial production of 8,000 to 10,000 bopd, peaking at 27,000 bopd in 1985. This had dropped off to only 1,000 bopd by 2017 when Energean bought the asset.

Greece has a claim to having the first ever oil well, in 500 BC, where writing by Herodotus reported a bitumen well 100km west of Corinth, which can be still be seen today. The oil was used to coat hulls of boats, he said.

Prinos can be considered a "ultra-brown field", but also a greenfield, with some viable exploration acreage, and a new satellite tie-back in the Epsilon field, which contains 18 mmboe of 2P reserves and is currently being drilled.

Since acquisition, Energean has managed to increase production to over 4,000 bopd. It now hopes to increase production to more than 10,000 bopd by 2021. The facilities were designed to handle 27,500 bopd, which means that production growth should result in significant operating leverage.

The company has a long term offtake agreement with BP to buy the entire production from the Prinos field and associated satellites, running until 2025.

Energean drilled an extended reach well into the Prinos North satellite discovery earlier in 2018, which has achieved rates of more than 1,500 bopd.

The nearby Epsilon development has 3 initial wells being drilled, commencing autumn 2018, which combined should provide 3,500 bopd when the Epsilon platform development is expected to come onstream. Longer term, there could be 15 wells "in a high case". To handle these fluids, the company has a normally unmanned platform being built in Romania, to be installed in summer 2019. The liquids will be exported to shore along an 18km flowline. An extended reach well is currently being drilled into the Epsilon accumulation from the Prinos facilities, and is expected to start producing towards the end of 2018.

Two big challenges are that the fields are high in hydrogen sulphide, and only 5km from a beach. However Energean's success in managing these challenges is now good marketing for the company, helpful in opening doors to operations in other countries, he said.

In March 2017, Energean agreed to farm-out to Repsol a 60% working interest in the Ioannina block, Western Greece. Repsol has become the Operator.

Energean also has field development approval for the Katakolo field in South West Greece, upon which it is expecting to decide on whether to develop this 10.5 mmbbl discovery at its existing 100% holding, or whether to farm down.

Further North, the company has 4 blocks offshore Montenegro, adjacent to blocks owned by Eni and Novatek. ENI has firm plans for 2 wells, which are expected in 2019. "We'll have the benefit of seeing what ENI find before commitment to any firm wells," he said. "We are shooting a modern 3D seismic survey, with acquisition expected to start at the end of 2018."

Israel development

The big story for Energean is the Karish and Tanin discoveries offshore Israel, which it acquired from Noble Energy and Delek group in 2016. The discoveries contain 2.4 TCF of 2P reserves between them.

Noble Energy drilled 7 wells offshore Israel and found biogenic gas in all of them. It was forced to sell the two smaller discoveries, Karish and Tanin, as an anti-monopoly effort from the Israeli government.

The Tanin and Karish fields will mainly produce

lean gas with "quite a lot of liquids", both condensate and light oil. The liquids give the project "significant upside", he said.

The company's field development plan involves a FPSO with gas processing onboard and liquid storage. The gas will be piped to Israel onshore, and the oil will be collected by tanker.

The field development plan was approved by Israel's Ministry of Energy in August 2017. Subsequently the company looked for funding for the project, raising $1.3bn debt financing and $460m in an IPO. It has signed gas sales agreement for 4.2 bcm/year over 16 years, securing a revenue of $12bn over 16 years. This reduces exposure to commodity prices.

Energean has a contract with Stena for its DrillMax drilling rig, to be mobilised at the end of Q1 2019, with 4 firm and 6 optional wells. The 4 firm wells are 3 development wells in Karish, and 1 exploration well in Karish North, "our best prospect".

It has signed an EPCIC (engineering / procurement / construction / installation / commissioning) contract with engineering company TechnipFMC. This includes building of the FPSO, construction of which began at the end of October 2018. The FPSO should be in place by Q1 2021.

The FPSO has an umbilical connecting to a seabed manifold, with 4 slots, three for the Karish producers and 4th for Karish North, if it proves to be a discovery. Or it could connect to a secondary multislot manifold.

For connecting the FPSO to more distant fields in the future, Energean is looking at insulated pipe technology, rather than injecting and reclaiming mono-ethylene glycol (MEG, an antifreeze). The seabed temperature is 14 degrees C in 2km water, quite warm for those depths. There are pipe heating systems which only require 10 watts of power per metre, which can be provided from the FPSO, he said.

The FPSO and gas pipeline to shore have a capacity of 8bn cubic metres (BCM) a year. The company has sales agreements for 4.2bcm/year so far, so it has room to expand, as more wells ae drilled.

This will be the first FPSO in the Eastern Mediterranean. Some people have asked why the company has gone for a FPSO, and not done what Noble/ Delek Group did on the Tamar / Leviathan development, where the multiphase production fluids are sent by pipeline to a shallow water platform for processing.

Having a platform can make it harder to add in a later developments than having a FPSO close to assets, he said. The FPSO can also provide power and avoids the need to send liquids to shore.

Having a FPSO also means there is less of a pressure drop between the well head and the processing facility, which can make the system easier to manage, with a fluctuating production rate. It also has the benefit of increasing the ultimate recovery from Energean's assets.

Further Israel development

Energean has a further 5 exploration licenses in Israel. The region has a number of other prospects from the late Miocene era, ranging in size from 300 BCF (8.4 BCM) recoverable to 2 TCF (57 BCM), Mr Freeston Smith said.

Many of them have flat spots showing on the seismic, so a direct hydrocarbon indicator. There is also an attribute anomaly on the seismic for many of the prospects which is the same as seen in the Karish and Tanin discoveries.

There has been 67.3 BCM of gas discovered in Karish Main, and Energean thinks there's about 20 BCM still to find, in thin sands above the traditional reservoir, or in deep prospects.

Gareth Freeston-Smith, Head of Subsurface for Israel with Energean,

Karish North looks very exciting, with an attribute anomaly the same as one seen at the gas water contact in the Karish 1 well. It "gives high confidence we're going to make a discovery in Karish North," he said

There is a Karish East prospect off the side, which does not show he same seismic anomaly, but that could be because of a limitation in seismic data, not because the prospect doesn't exist.

The Karish North and Karish East fields could be connected, since the interpreted gas water contact on under-filled Karish North prospect is at the same depth as the 'spill point' of Karish East structure.

The company anticipates developing 3 or 4 of the additional prospects at a time, and "daisy chaining" them on, gradually stepping out.

The company is working with 2010 seismic data which has recently been reprocessed to PSDM in September 2018.

Market for Israeli gas

There is a question about how to get the gas from the Israeli production to market.

To begin with, Israel's domestic gas market is one of the fastest growing in the world, anticipated to double by 2025.

There have been discussions about building an Eastern Mediterranean pipeline connecting Israel to Europe via Cyprus and Greece. "It seems that is getting a bit of traction with Israel committing to make a decision on the pipeline," he said.

Energean has also given a proposal to the Cypriot government to build a 200km pipeline from Karish to Cyprus. Cyprus has a 1bcm/year domestic gas market. Another option is a LNG plant on Cyprus.

Mediterranean tectonics and petroleum geology

Owen Sutcliffe, manager of Neftex Insights with Halliburton, gave an overview of the tectonic history and petroleum geology in the Eastern Mediterranean, and the factors driving exploration success.

Owen Sutcliffe, manager of Neftex Insights with Halliburton, gave an overview of the tectonic history and petroleum geology in the Eastern Mediterranean.

Dr Sutcliffe sees a steady progress in development of resources over period 1998 to 2015, with big discoveries including the Scarab (1998) and Saffron (1999) fields of the Nile Delta, Tamar (2009) and Leviathan (2010), and Zohr (2015), he said.

The Eastern Mediterranean has a complex tectonic history and high sedimentation rates. Furthermore, the Eastern Med has some of the oldest oceanic crust on the planet. This means that the basin is generally colder than many others around the world and conventional hydrocarbon generation thresholds are depressed promoting the extensive development of biogenic gas in the subsurface. This also has an impact on the ability to preserve reservoir quality. These are some factors that are important to the success of this region.

Typical geology

Dr Sutcliffe showed a line of play cross section going from the Eratosthenes Continental Block, South of Cyprus to the Nile delta, which illustrates typical geological features of plays in the region.

Going from oldest to youngest, the first of these are the carbonate mounds of the Cretaceous. Above these, clastic plays dominate from the Oligocene onwards, which reflects the development of the Nile Delta and its associated influx of clastic sediments.

Owen Sutcliffe, manager of Neftex Insights with Halliburton

A major geological event occurred at the end of the Miocene in the Messinian Stage. During this time, the Mediterranean was fully enclosed and restricted and as a consequence, the water evaporated out of the sea, the sea level dropped by 1500m, which resulted in the deposition of significant thicknesses of salt over the seabed of the time. This event is often referred to as "Messinian salinity crisis".

After deposition of the salt, sedimentation rates increased throughout the Plio-Pleistocene, which influenced the development of canyons on the Nile Delta and increased sedimentation on the delta slope.

Other factors

The plate tectonics of the region are complex and Halliburton has put together a plate tectonic model showing how the different pieces of continental crust moved around. Collisions, separations and interactions between these plates generate significant trap-forming events in the subsurface. In the early Triassic, the separation of North Africa from Europe resulted in the development of some of the oldest traps in this region.

After separation, the subsequent closure of the initial (Tethys) Ocean caused additional phases of trap formation by compression. These compression events occurred in the late Cretaceous and early Miocene. The last of these resulted in the emplacement of oceanic crust (an ophiolite) on top of continental crust and also lead to the formation of the Eastern Med as we see it today.

Adding to this complexity are a number of sea level changes. These are very clearly recognised in clastic rocks that are Oligocene in age or younger. These cycles "give a heartbeat to stratigraphy of the region," he said, whose recognition can be used to aid geological predictions.

In addition to these, the flux of sediment being delivered to the area was not constant and changed over time. During the transition from the Oligocene to the early Miocene, there was a significant reduction in supply. Sedimentation rates then increased in the middle to late Miocene and further accelerated in the Pleistocene.

Understanding heat flow

When building an understanding of hydrocarbon generation having a robust model for the development heat flow and burial is essential. It is now well-known that the former is generally low in the Eastern Med. This factor is very important, he said, as it allowed the accumulation of biogenic gases to occur in early forming structures like those over the Tamar field. However, it should be noted that this structure is under-filled.

At the present day, most realistic scenarios for heat flow suggest that the Miocene rocks of Tamar are now too hot for generating and accumulating biogenic gas. This is important for understanding why Tamar is under-filled because with the onset of the Messinian sea-level fall, there would have been less pressure in the reservoir, allowing the accumulated gas to expand and ultimately leak out of the structures. On subsequent burial, the temperature in the reservoir was too great to generate biogenic gas, so the large structures would never get refilled.

The Zohr reservoir is "different", with the Messinian salt effectively sealing the gas and in this structure. Therefore, the trap could not form until the Messinian salt was deposited. It should also be noted that the overburden over Zohr means the temperature at the level of the reservoir is lower than at Tamar, which allows the generation of biogenic gases today.

There still remains the possibility of thermogenic charge in this region, with Oligocene rocks being the most likely target.

"The key thing about this thermogenic charge is the timing of maturation relative to the phases of structuration," he said. If the charge is developed too early, before there was a trap formed, the oil would leak. The high-grading of regions where this charge could accumulate remains a conundrum for all involved in exploration of the region.

TGS - Opportunities in Malta

The waters around Malta have not been extensively explored so far, especially in the deeper basin to the south. But the area has potential, since it lies between the producing regions around Sicily to the North and Libya and Tunisia to the South, says seismic company TGS.

The waters around Malta have not been extensively explored so far, especially in the deeper basin in the south. But the area has potential, since it lies between the producing regions around Sicily to the north and Libya and Tunisia to the south, explained Felicia Winter, Geophysical Interpretation and Potential Field Analyst with seismic company TGS.

The government of Malta is keen to renew interest in the area, and is currently working together with TGS to assess the existing data and evaluate the area.

The tectonic background of the region is the break-up of the plates in the East of the Mediterranean in the Triassic and pre-Triassic, then rifting between north and south in the Jurassic and Cretaceous, which changes into a compressional regime when Africa collides with Europe. The latest tectonic stage, a trans-tensional regime connected to the transform fault going from Gibraltar to Sicily "gives us very interesting basin structures and oblique compressional structures."

It is not known whether there is a connection between the Libya or Tunisia and Sicily petroleum systems, or a need to differentiate between them, she said. Considering both basins started with the same rifting period in the Triassic, they could have a common source rock deposition history, which remains to be determined.

Libya's prolific Sirte Basin is mainly located onshore but continues offshore. The south of the area to be evaluated has several fields offshore nearby Tunisia and Libya, where a Jurassic and Cretaceous petroleum system is proven offshore. And the north shows hydrocarbon production in the Sicily Graben between Malta and Sicily. "We believe, that the current hydrocarbon evidence infers potential and prospectivity in the Southern Malta area," she said.

Drilling history

So far there have been 13 wells drilled offshore Malta, of which 6 were dry, 4 had oil shows, 2 had gas shows, 1 had both oil and gas, she said. Although these are not very many wells, they are telling a positive story.

Even in the deeper basin south of the tested carbonate shelf of Malta itself, the Tama-1 well, drilled in 1993, justifies this optimism with oil shows far from the platform.

TGS recently gained full access to well data during the cooperation with the Malta government, and can now correlate it with seismic, from North West to the South East of the island, where TGS holds regional 2D seismic data that has been reprocessed in 2013.

Subsurface analysis

A big challenge for the seismic imaging is the regional and continuous and carbonate deposition which masks a large part of the seismic signal, she said. Significant erosion and deposition of the evaporites (salt) in more recent times during the Messinian crisis amplified these effects.

TGS did some basin modelling in 2004, but it was hard to map anything below the salt with the seismic technology of the time, and therefore make statements about the basin subsidence or thermal regime, even though the basin interpret-

ation was supported by gravity and magnetic subsurface models where seismic interpretation was most challenging.

With the typical regional section of rift basins separated by horsts and both showing later compression, TGS did "pseudo well" studies to work out the potential maturation regime in those depocentres of possible source rock deposition.

The main source rocks of the wider region are from the Eocene (around 40 Ma) and from the Upper Triassic / Lowermost Jurassic (around 200 Ma), which might be present as or have an equivalent to the "Streppenosa" shales known from offshore Sicily in offshore Malta.

Since seal is a hot discussed topic for the area, it had to be mentioned that although regional seal is known to be deposited in the Messinian, there are concerns about older traps and deeper local seal. "The Mediterranean is a very complicated basin complex over a relatively small geographical area," Ms Winter said.

But it is known that Jurassic shales, marls and evaporites and Paleogene shales and marls have good sealing capability in addition to the regional Messinian truncation and evaporites, there are traps, features and leads which appear to be locally sealed "all over the place".

TGS's previous basin modelling was updated by calibrating the well data with the newly available data. The pseudowells have been modelled in prominent depocentres, as shown on a typical cross section offshore Malta. The models assume possible Streppenosa source rock deeply buried in Mesozoic rift basins and results showed that the source rock was in the oil window. Possible migration paths and charge scenarios were pointed out with the reservoirs in local anticlines, with oil carried through the rift faults.

TGS showed a discussion of the prospect that was targeted by the Medina Bank-1 well. The models show that oil can also be present in addition to the gas that showed in the borehole. Isopachs and charge scenarios seem to indicate another deeper busied prospect is connected to the play fairways causing these particular shows. "There's a lot of potential to drill more wells," she said.

This proposition was then extrapolated to the south, to offshore Libya, where there is hydrocarbon evidence, such as several fields and shows offshore and onshore, including condensates and gas.

"Seismic interpretation shows that reservoir thickness is really good in places, and the fields and wells have proven good reservoir quality throughout most of the area", with 30 wells drilled offshore Libya so far.

Survey data

Since there is not a huge amount of seismic available offshore Malta yet, but still a good structural understanding has been gained by insights from gravity and magnetic data, such as crustal studies, analysing the crustal depth and thermal regime - the seismic re-processing, and any new acquisition can be guided well informed in future.

Other ways to better target new acquisition and prove hydrocarbon source potential would be a regional multibeam survey, which is "a good method to start exploring in an area where most are tentative to move into", Ms Winter said,

Such a high resolution bathymetry survey can also map the hardness of the seabed (based on back scatter of the beam). If there are hydrocarbon seeps, there will be backscatter from the shells of the organisms feeding off it. Another practical side effect is that gas plumes can be mapped since they interrupt the multibeam sonar fan.

But of course, the mapping of pockmarks on the seabed, themselves evidence for hydrocarbon seepage, is crucial. When identifying any of the above, gathering piston cores to sample and analyse the oil in a seep is the next logical step. Nowadays this often happens during the same acquisition. Analyses such as the oil's age and maturity can help with assessments about biodegradation, biogenic or thermogenic maturation.

Finding Petroleum

PGS – opportunities offshore Egypt and Lebanon

Seismic company PGS believes there are hydrocarbon opportunities offshore West Egypt and Lebanon. Matthew Pyett of PGS explained further, and how PGS seismic can help

Seismic company PGS believes there are hydrocarbon opportunities offshore West Egypt and Lebanon. Matthew Pyett, project geoscientist, new ventures for Africa, Mediterranean & Middle East with seismic company PGS explained further.

Starting with Egypt, he said that PGS spent over a year modelling Egypt's subsurface, including regional interpretation, gravity, magnetics and basin modelling, in different geological domains.

On the continental shelf offshore West Egypt, there is a continuation of play types of onshore Western Desert, which are oil and gas prone, he said.

In the Herodotus basin, offshore West Egypt, there are some carbonate build-ups similar to Zohr, directly sealed by salt, with a good lateral seal.

Biogenic gas has been seen in shallow reservoirs offshore West Egypt. However it is hard to model. "I'm not sure anyone fully understands it, but they accept it works," he said.

Seismic in Egypt

Seismic is being acquired by PGS across West Egypt and the Nile Delta. Acquisition ran from June 18 to Nov 18, initial time products are due to be available from January 19 onwards with the final depth product available mid-2019. It adds to the existing 10,150km of vintage data which

Matthew Pyett of PGS

was reprocessed in 2016, and a further 7,400 km of GeoStreamer data acquired in 2016. There are two legacy 3D data sets covering 1571km2 and 4826km2.

PGS is acquiring new data, a long offset 2D survey, imaging down to 20km depth. It wants to infill its existing 2D grid, and add new azimuths to its existing grid. The new azimuth may help with additional illumination across the basin and pre-salt structures.

The final objective is to tie it to the Eastern part of the Nile, generating the first multi-client product across the Nile.

It might help show how east and west Egypt 'communicate' – looking at interaction between the sediments on a regional scale.

License rounds

The first license round for offshore West Egypt is coming up "shortly." Initial blocks have been announced, although they may change in size and shape. There could be multiple opportunities, linking Western Desert, Nile and carbonate plays, he said.

The average block is 5000km2. Roughly speaking, blocks 1-4 are the "shelfal" Canyon, block 5 covers the transform margin and Nile Delta Extension, and blocks 9-11 are the outboard extension and Herodotus basin and also the part of the Nile Delta Extension.

PGS has mapped out a number of leads, with different stratigraphic intervals and a range of overall size, covering carbonates and clastic reservoirs.

Lebanon

Looking Eastwards to Lebanon, Mr Pyett showed a seismic line running west to east, based on multisensor 3D seismic.

There is a Pliocene package on top (3-5mya) which is up to 1700m thick. There have been gas discoveries in Israel in this zone. There is "very well imaged" salt beneath it.

Beneath this, in the mid-upper Miocene (7-20mya) there are very continuous, non-chaotic, beds, and high amplitudes features, and "some nice channelized fans".

The sediment is coming from the North, rather than from the Nile to the South. There are unanswered questions about where exactly this sediment supply would have come from.

Below this we have a Paleogene (23-60mya) package, "perhaps a little less interesting, shalier", he said. There are pulses of sand prone intervals. The question is whether there would be some sort of thermogenic system in this part of the basin generating additional hydrocarbons.

The last zone is upper Mesozoic (around 100mya) with a "large wedge shaped package", an offshore extension of the lower cretaceous carbonate platform.

Two wells are planned towards the second half of 2019 with one exploration well planned in blocks 4 and 9, the awarded blocks from the first offshore license round.

License rounds

The second offshore license round offshore Lebanon will take place during 2019. The blocks to be included in this round are 1, 5, 8 and 10.

Spectrum – maybe oil in Lebanon

Offshore Lebanon is generally believed to be a gas province, but there may be oil too, said Karyna Rodriguez, director of geoscience with seismic company Spectrum.

Offshore Lebanon is generally believed to be a gas province, following the Tamar (2009) and Leviathan (2010) gas discoveries. But there may be oil too, said Karyna Rodriguez, director of geoscience with seismic company Spectrum.

Not all of the gas is biogenic – there have been reports of a deeper thermogenic gas zone, taking us closer to the conditions for making oil, she said. And also note Energean believes that the Karish field has some thermogenic oil (also presented at this forum).

Ms Rodriguez showed seismic imagery showing the South Levant Basin to the North Levant Basin, with very laterally continuous stratigraphy. Spectrum has highlighted on the seismic where it thinks the oil might be, in a band between 200m and 1km thick.

Sediment forming the reservoir could be coming from the Nile Delta to the North, with the basin floor, collecting the sediment, being the North Levant basin.

You can see sand being transported along channels, from the Nile, splaying out into the basin, indicating a south to North direction of deposition, she said.

There are possible source rocks – including data presented by ENI from its dry wells, Onasagoras and Amathusa. They did find source rock in the Oligocene (23 to 33mya). They did an integrated biostratigraphic study and geochemical analysis, and also believe it could be oil prone, she said.

Another piece of evidence is that the source rock gets deeper going out into the basin. As source rock gets deeper, it can move from the biogenic gas window to the oil window.

Source rock analysis

Spectrum did a detailed basin modelling exercise together with consultancy Stratochem Services (based in Cairo and Denver), to see which source rocks were present, what hydrocarbon window they might be in, and which way they are migrating, looking at the basin's tectonic history.

The analysis included 3D modelling, to find out what the 'kitchen' areas were, looking at quality, maturity and history, taking data from 17 modelled wells, 3 pseudo wells, and 12 depth / thickness grids.

The study looked at four main source rocks, from the Oligocene (average 100m thick, 3 per cent total organic content or TOC); from the Palaeocene – Eocene (33 to 66 mya) with 30m thick, 3 per cent TOC; and from the Cenomanian-Turonian (89 to 100 mya), with 60m thick, 3 per cent TOC, and the Jurassic, (145 to 201 mya), with 60m thick, 3 per cent TOC.

The Oligocene studies show that it can generate oil, based on an oil gas chromatogram.

The analysis shows there should be a good amount of oil being generated in the North Levant basin from this source rock from the Messinian times (7mya) to today. The reservoirs are currently in "mid mature age". These results are "very encouraging," she said.

The Palaeocene-Eocene had three source rock intervals with a high TOC. For the Cenomanian-Turonian, Stratochem did 1D and 3D modelling, showing that all the source rocks would be in today's oil window.

The source rock from the Jurassic would be 'late' (the oil would have converted to kerogen, probably too solid to produce).

Evidence of oil

A next question is whether there is any evidence of oil today, looking at all the available information. There is seep data from satellite images, which are repeated in the same location, indicating they are "very likely to be naturally occurring". Spectrum believes these seeps are probably coming from the Oligocene section.

All of the oil seeps to the surface at the exact point where the Messinian salt, forming a seal on top, "pinches out", i.e. thins to nothing.

Some people might think, if the oil is seeping out, then there can't be anything left in the reservoir. But that isn't how it usually works. For example the Canterell field offshore Mexico, one of the world's largest oil fields, has many seeps on the ocean above.

Karyna Rodriguez, director of geoscience with seismic company Spectrum

"Seeps are just telling you there is a working petroleum system – a lot of oil in the system," she said.

Also, near that seep, it is possible to see a pockmark on the seabed, often left by oil coming out at the seabed.

It is also possible to see "fluid pipes" which can be seen carrying fluid through the subsurface, to shallow reservoirs, she said. There are a series of fluid pipes which can be seen on the seismic, running in a NE to SW direction, which seem to be getting younger. The evolution of fluid pipes could be due to the movement of salt, and by studying the fluid pipes, the movement of salt can be measured.

It can mean that the pore fluid in the reservoir has been recharged 20 times by each new fluid pipe. "There is a very clear HC system charging this structure," she said.

Structures

Looking now at the structures, there are huge anticlines, which looked they formed at the same time as extensional faults, a difficult geological story to work out.

The faults are "layer bound", only extending through a limited number of stratigraphic layers. Something similar has been seen in Canyonlands, Utah, she said. This may be due to the Oligocene layer below the faults generating hydrocarbons and more ductile (and so less inclined to break or fault).

Ms Rodriguez showed a map of offshore Lebanon taken from 3D seismic, showing a series of anticlines, cross cut by normal faults. If there is oil in one of them, there could be oil in all of them, she said.

The fields around the South Levant basin are very heavily faulted. But structures to the North are "so much simpler," she said.

Other intervals

There are other potential intervals to look at.

In the late Miocene (20 to 23 mya) there may have been some sands coming from the North.

There are also some interesting amplitude anomalies (unusual seismic response) just below the Messinian Salt (around 11mya).

"The message is, we see huge potential," she said. "We see about 25 of those lower Miocene structures."

In the last licensing round, only blocks 4 and 9 were awarded – the other blocks should be in the next round. Spectrum thinks blocks 3 and 5 have "huge potential".

Finding Petroleum

Neil Hodgson – why we still need exploration

Neil Hodgson gave compelling arguments why oil and gas is still important, in his introductory address

In his introduction to the forum, chairman Neil Hodgson shared some interesting data and views about the big picture of exploration, not directly relevant to the Eastern Mediterranean but worth reporting here.

Mr Hodgson said he thought that talk about "energy transition" – a move from fossil fuels to renewables - is just a tiny bubble in the bigger picture of all energy use, with renewables still counting for a tiny blip out of all energy consumption. "When the bubble is in front of our eyes it looks really big. But when you stand away from it, it is small," he said.

The big picture is that consumption of hydrocarbons is still increasing, with 100m barrels of oil consumed every day so far in 2018. This means that if we find a 100m barrel oilfield, that's how much the world uses in a day.

You can easily see from this how much exploration we need to do – with a big gap starting to grow in a few years between demand and production based on the currently known discoveries, which Mr Hodgson shows in a coloured chart, with a large green area. "We haven't got a Scooby where that is coming from as of today," he said. I've been "standing in front of students saying, 'you guys are going to have a full on career filling that bucket.'"

Neil Hodgson

It means that every 5 years, the industry will need to discover the production equivalent of a new US unconventionals play just to stand still – and demand for energy globally is still strongly growing. Increasing energy use is a good thing – it has improved economic opportunity and quality of life around the world and still 1bn people do not have access to mains electricity, he said.

This year, the 100m barrels consumed every day means 35bn barrels consumed in a year. As of Sept 2018, 4bn barrels had been found. "That's pretty good, we're only 31bn barrels short of a balance," he said. But the 4bn barrels has cheered everyone up."

Also, 75 per cent of this 4bn barrels has come from deepwater – although 60 per cent of wells drilled in the world are onshore. Oil Companies should get into deepwater because that's where the big reserves are. And when the oil price is down, it is cheaper to get acreage and drill wells in deepwater.

For example, much of this year's 4bn barrels is in Guyana, where ExxonMobil has discovered 3.5bn barrels so far. After the Calypso discovery in Cyprus the next big discovery has been the gas discoveries made by Equinor in Tanzania this year, he said.

Finding Petroleum

Opportunities in the Eastern Mediterranean London, September 20, 2018, Attendees

Hugh Ebbutt, Director, A T Kearney

Muktadir Ur Rahman, Director, Apex Consulting Ltd

David Craik, Consultant, Atlaslocal

Christian Richards, Sales Manager, AustinBridgeporth

Robert FE Jones, Director, Caithness Petroleum

Chris Matchette-Downes, MD & Owner, CaribX and MDOIL Limited

James Andrew, Busines Development Mgr EAME, CGG

Andrew Webb, Manager, Petroleum Reservoir and Economics, CGG

Micky Allen, Consultant

Abdulmohsin Dolaijan, Consultant

Neil Simons, Consultant

Nick Steel, Consultant

Manouchehr Takin, Consultant

John Hall, Consultant geophysicist

Peter Farrington, Consultant Geophysicist

Graham Clevett, Managing Director, Cornhill Economics Ltd

Richard Walker, Consultant Geophysicist, Cornhill Economics Ltd

Ian Newth, Director, Count Geophysics

Raffaele Di Cuia, Technical Director, Delta Energy Limited Ltd

Stephen Norman, Business Development Manager, DNV GL

Alexandros Pastos, Engineer, DNV GL

Brian Donnelly, Consultant Geophysicist, Donnelly

Tom Richards, Regional Manager, North Africa, Drillinginfo

Gareth Freeston Smith, Head Sub-surface for Israel, Energean Oil and Gas

Martin Riddle, Technical Manager, Envoi

Jorgen Keyser, Equinor

Anne-Mette Cheese, Exploration Geologist

Avinga Pallangyo, Events Manager, Finding Petroleum

Richard McIntyre, Sales Manager, Finding Petroleum

Karl Jeffery, Editor, Finding Petroleum / Digital Energy Journal

Nick Norton, Senior Energy Advisor, Foreign Office

Mike Cline, Director, Gaffney, Cline & Associates Limited

Jeremy Berry, BD Director, GCA

Bryan Moseley, Geologist

Neil Mundell, Consultant Geophysicist, Geoseismix Ltd

Phillip Hicken, Sales Advisor, Getech

Owen Sutcliffe, Head of Stratigraphic Research, Halliburton

David Jenkins, Director, Hurricane Energy plc

Phil Carpenter, Business Development Manager, Ikon Science

John Foyle, Account manager, global multiclient sales, ION

Christian Bukovics, Independent Director, JKX Oil&Gas Plc

Sigrún Stanton, Regional Geoscientist, Landmark Exploration Insights

Peter Allen, consultant, Layla resources

Rupert Simcox, Data Analyst, Lynx Information Systems

Chris Morgan, Managing Director, Lynx Information Systems Ltd

Duncan Macgregor, Consultant Geologist, MacGeology

Adrian Gregory, Principal Consultant, MORE Consultancy plc

Mike King, Oil & Gas Manager, NPA Satellite Mapping

Mark Robinson, Managing Director - Geoscientist, Oil and Gas Consultancy

Ulrich Knauthe, OMV

Abi Mirkhani, COO, OPG Supply

Dave Waters, Director and Geoscience Consultant, Paetoro Consulting UK Ltd

Antoine Darque, Petroleum Deals in Play (petroDIP.com)

Matthew Pyett, Project Geoscientist, New Ventures - Africa, Mediterranean & Middle East, PGS

Peter Wijnen, New Ventures - Africa, Mediterranean & Middle East, PGS

Alex Vartan, V.P. Africa MultiClient, PGS

Kevin Shrimpton, PGS

Frederic Yeterian, Director, Philax International (UK) Ltd

John Clure, Managing Director, Phoenix Hydrocarbon Resources Ltd

David Contreras, Regional Geoscience Manager, Polarcus

Josh King, Analyst, RAB Capital

Robert Snashall, Consultant, RGSConsult

Andreas Exarheas, Assistant Editor, Rigzone

Mike Larsen, Business Development Director, EAME, RPS Energy

Chris Hayes, Well Operations Director, RPS Energy

Stephen Boccioli, Technical Director, SCDM Energy

Oguz Gurbuz, Scotiabank

Alice Gulliford, Exploration Geoscientist, Shell International

Paul Tricker, Team Lead, Portfolio New Business, Shell International E&P

Tom Martin, Director, Shikra Consulting

Simon Bradbury, Director, Simelis

Hannah Aylwin, Geoscientist, SLR Consulting

Karyna Rodriguez, Director of Geoscience, Spectrum

Ian Setterfield, VP Sales, Spectrum Geo

Neil Hodgson, EVP Mediterranean and Middle East Region, Spectrum Geo Ltd

Nigel Flood, Multiclient Sales Manager, Spectrum Geo Ltd

Andy Harris, SpectrumGeo

Felicia Winter, Interpretation Geophysicist, TGS

Chris Anderson, Sales Director, TGS

Ben Sayers, Business Development Manager, AME, TGS

Diveena Danabalan, Upstream Energy Analyst- Oil and Gas, The EIC

Tim Clarke, Troika International Ltd

Jill Lewis, Managing Director, Troika International Ltd

Steve Bottomley, Director, Upstream Consultants Limited

Julie Branston, Region Manager, EUR & Russia, WesternGeco

Alastair Bee, Westwood Global Energy

Robert Helme, Business Development, Wood Plc

Nikos Volikas, Pipelines Group Manager, Wood Plc

Deirdre ODonnell, Managing Director, Working Smart

Reza Sedaghat, Director, Zagros Energy Ltd

Sara Stephens, Sales Manager, Zebra Data Sciences

What did you enjoy most about the event?

Talks and atmosphere. Good format.

Exceptional presentations from all, not just my colleagues!
Nigel Flood (Spectrum Geo Ltd)

Good value. The useful snippets of technical information you pick up at these events.

Networking.
(MDOIL LIMITED)

The standard of all the presentations was excellent.

Great to catch up on the Levant - a long time since I looked at it.
Bryan Moseley (Geologist)

Excellent and wide-ranging set of talks covering this very active area.
Richard Walker (Cornhill Economics)

Talks, meeting people.

All presentations very professional.

The great turnout! The place was buzzing with discussions.