Finding Petroleum

Why fractured carbonate reservoirs are hard to understand

Modelling fluid flow in fractured carbonate fields

Where are the Middle East exploration opportunities? - by former head of exploration at BP

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Event Report, Finding Petroleum opportunities in the Middle East, May 16th, 2017, London

Finding Petroleum opportunities in the Middle East

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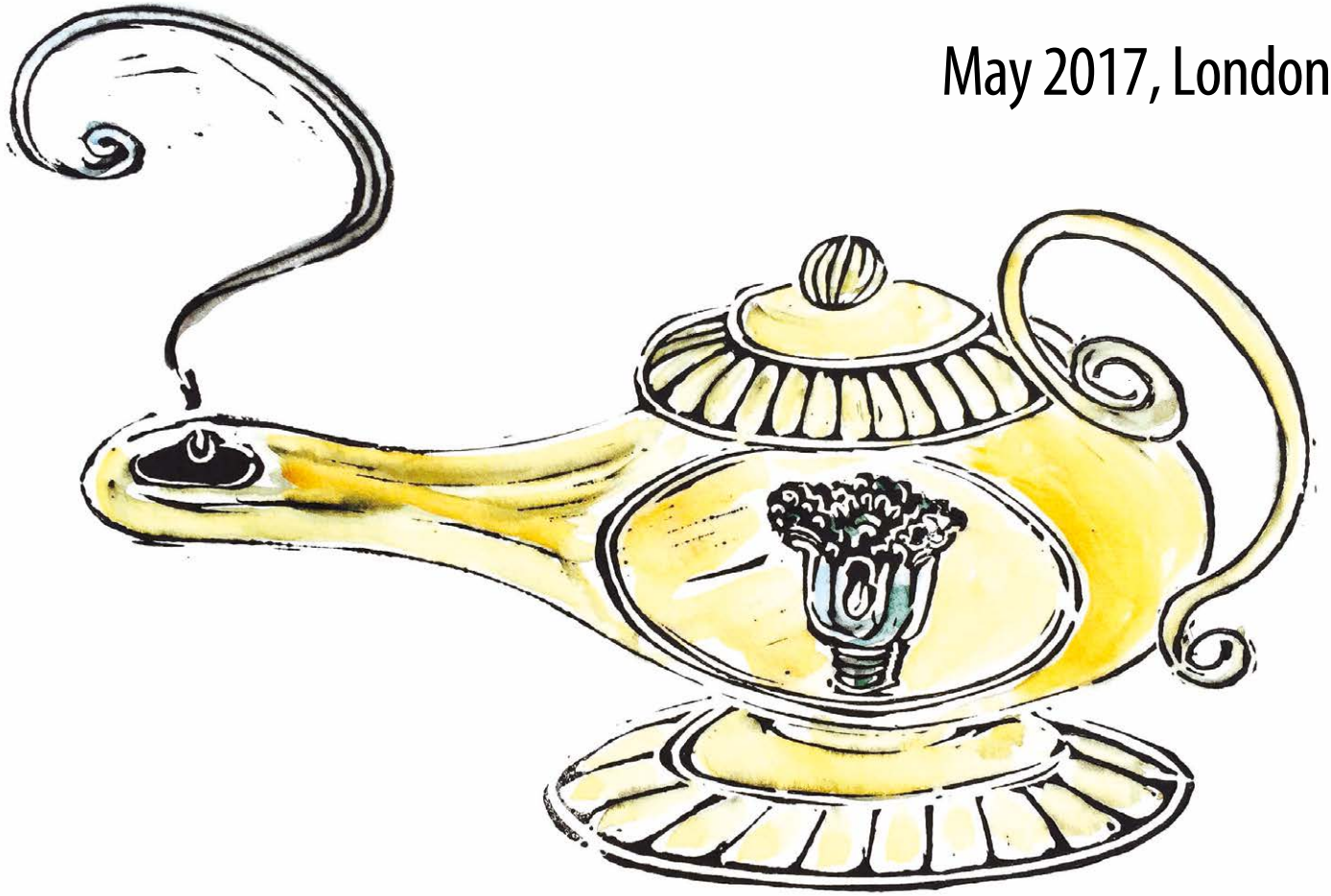

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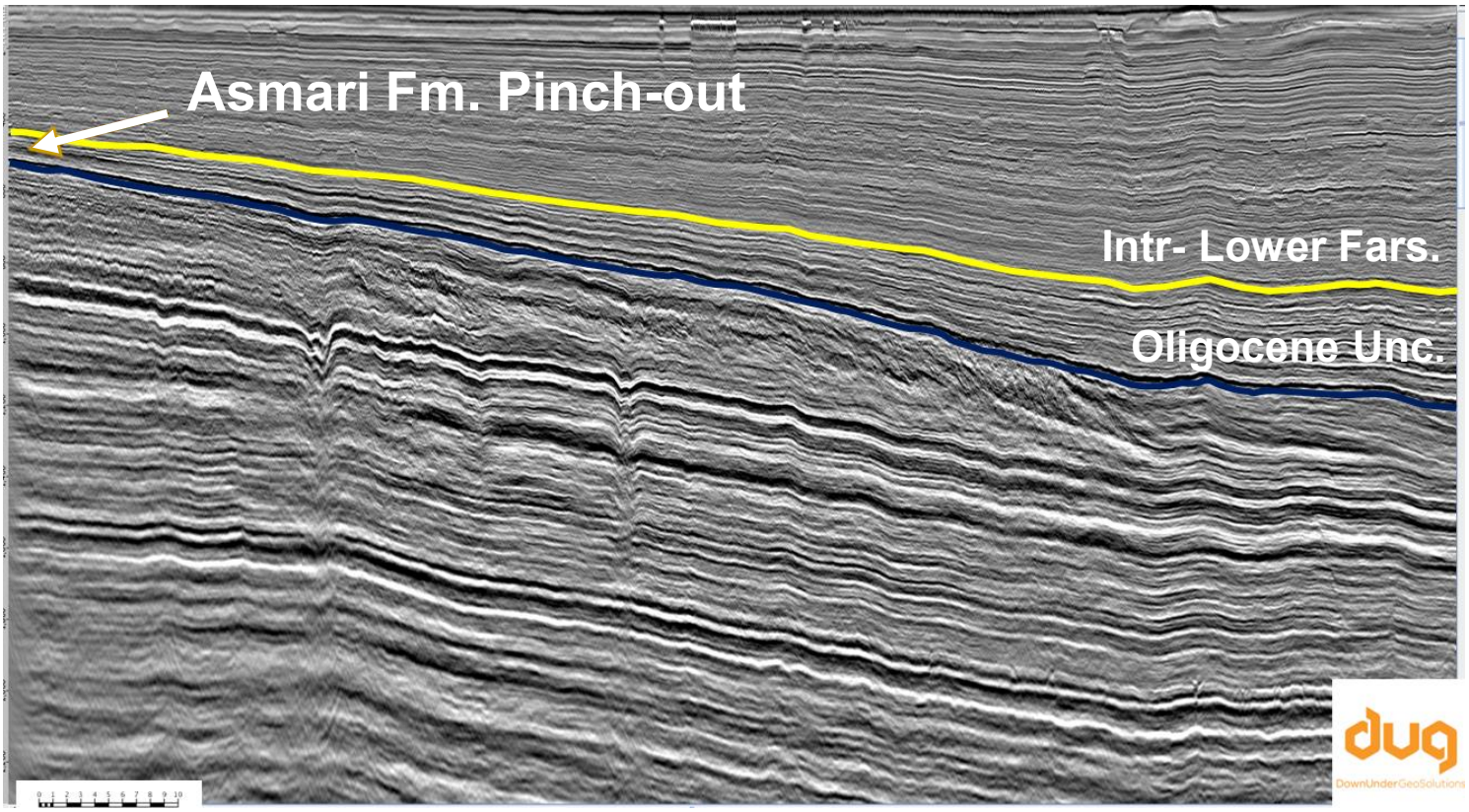

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Finding Petroleum opportunities in the Middle East

Our Finding Petroleum forum in London on May 26 2017, "Finding Petroleum Opportunities in the Middle East", looked in particular at how to get a better understanding of fractured carbonate reservoirs. A number of investors have lost their shirts due to reservoirs in Kurdistan proving to hold less than expected. We also looked at the best exploration opportunities in the region, and a review of security and political risk

There have been a few well publicised investor disappointments in carbonate reservoirs in Kurdistan, said David Bamford of Finding Petroleum, and a former lead for exploration with BP, in his opening remarks to the Finding Petroleum forum in London on May 26 2017, "Finding Petroleum Opportunities in the Middle East".

The typical story is that companies make a fairly bullish estimate of reserves, and after drilling a couple of appraisal wells, it has to be downgraded, he said.

Experience shows that predicting carbonate reservoir reserves is extremely hard. Mr Bamford cited a paper once published by Statoil's research centre in Bergen, which could be summarised as, 'if you've got a fractured carbonate reservoir - don't even try to predict the distribution of open fractures from seismic or the few wells logs you have, you can't do it," he said.

The paper also said that you can't use data from a small number of wells to estimate or generalise how the entire field will perform. The paper also said that it is very difficult to build a useful computer simulation covering porosity on both the rock matrix and the fractures.

"So when people started making discoveries in Kurdistan in 2010, they were being rather optimistic, to predict the likely reserves in fractured carbonate reservoirs after having drilled a small number of wells," he said.

"Everybody at that time was saying that Kirkuk (a very productive field) was an analogue to whatever they had discovered, despite the fact the size of the field was different, geological ages were different."

"They started looking at Kirkuk's reservoir, its perhaps unusual fracture porosity, and started making reserves predictions [for their own discoveries]."

Today's explorers might do well to learn from how the reservoirs were produced decades before. "The people who ran the Iraq Petroleum Corporation, which ceased to exist in the 70s, knew pretty well what they were doing, which was don't make promises, develop these things progressively, and learn about the field as you go," he said.

Carbonate reservoirs seem to typically have very different production profiles to reservoirs in (for example) the North Sea or Gulf of Mexico.

North Sea fields show a very distinct production profile, with a rapid rise over 3-6 years, something of a plateau, then a decline.

Gulf of Mexico fields can show the same shape production profile, even if the maximum production was much bigger.

So for these fields, it is possible to make an estimate about the reservoir size based on the well data, seismic data and analogues, and be "usually broadly right," he said.

Not much data is available about Middle East carbonate reservoirs, but we do know that Iraq's Kirkuk field, which was discovered in the early 1930s, reached its peak production in the late 1970s – so it took 40 years of working the field to get to full potential.

Similarly, Saudi Arabia's Ghawar field, with a fractured carbonate reservoir, was discovered in the late 1940s and had its first peak in 1980.

"With that sort of field, the message is, don't make any assumptions here about reserves - work them and you'll find out what the reserves are. Drill and produce. So quite a different world," he said.

"Reserves promises immediately after discovery in fractured carbonate reservoirs are not worth the paper they are written on."

This is a report from the Finding Petroleum conference "Finding Petroleum opportunities in the Middle East" held in London, in May 2017

Event website

www.findingpetroleum.com/event/a46c4.aspx

Some presentations and videos from the conference can be downloaded from the event website.

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Why fractured carbonate reservoirs are hard

Benoit Vincent, consultant geologist with Cambridge Carbonates, explained why fractured carbonate reservoirs are hard to understand – and how to give yourself the best odds for understanding them

If you need to understand a carbonate reservoir, you have to first identify your system, to decide what kind of fracture system you are dealing with (tectonic fractures or a Karstic system), then identify the type of structure.

You may need to analyse the fractures, to work out what kind of fractures formed before the other, in order to understand the distribution and density of the fractures.

You will also need to understand know the facies, texture and lithology of the reservoirs, to understand the distribution and intensity of the fracture inside your structure. With all of this, you can build a structural model, he said.

Benoit Vincent

An outcrop analogue, where the carbonates can be seen on the earth's surface which are similar to the subsurface carbonates you are studying, can be very helpful. You can use the outcrop to understand the fracture distribution, the fracture intensity, and how fractures are organised in the structure.

It cannot help if you aim to understand the direct impact of fracture systems on the reservoir, since outcrops are not a good petrophysical equivalent (different diagenesis to subsurface). Don't use outcrop analogues to try to understand if a fracture is open or closed, sealing or conductive, he said.

The physical changes that the outcrop has gone through, during its conversion from sediment to sedimentary rock, can be totally different to the physical changes which the subsurface rock has been through.

"I use the analogue to understand the carbonate architecture, the geometries of the position but never the petrophysics," he said. "A fracture system open in the subsurface can be sealed in outcrops or reversely."

Understanding the reservoir

To understand how the rock functions as a reservoir, you have to understand how fluids fill the holes in the carbonates at different scales at once. The carbonate can have a dual or even triple porosity system.

And over 50 per cent of carbonate reservoirs can be described as fractured. In comparison, under 10 per cent of siliciclastic (sandstone) reservoirs are fractured. The reason is that carbonates are more reactive than sandstone, he said, and are susceptible to karstification (a landscape formed by rocks dissolving forming for example caves). Karst fractures are related to collapse of caves or other kind of megapores, but their distribution to not follow "structural" rules.

"Using a pure structural model to understand the karst reservoir will give a wrong answer a significant percentage of time" he said. And "keep in mind that a lot of what are described as fractured reservoir are karstic or karstic fractured," he said.

Fractured carbonate reservoirs can have pores at many different scales at the same time, ranging from microscopic "micropores" to giant "vuggy" pores the size of a cave. There can be different associations between them – for example a very large "vuggy" pore surrounded by micropores.

Identifying your reservoir type

To identify what kind of tectonically fractured reservoir you have, you should first look at the main fracture indicators – such as open natural fractures.

If you don't have that, you can do permeability tests on a rock sample. If the permeability is higher than the matrix permeability suggests, it might indicate you have a fracture component.

If you have mud loss during drilling, it can give you some indication of fractures – but may also mean you have a Karst system (which dissolved rock, such as channels, sinkholes, caves). Usually bit drops and non LCM-cured mud-loss are more commonly associated with karst than tectonic fractures.

The well image logs can be "the most powerful tool to identify and quantify the fracture system," he said. "It gives you the fracture intensity, density, fracture orientation." But the well logs do not always provide enough information to build a structural model.

Classifying fractured reservoirs

There has been a classification system for fractured reservoirs proposed by Ronald A. Nelson in 2001.

With "Type 1" reservoirs, the fracture system has the biggest impact on rock properties – and almost all porosity and permeability is due to the fractures.

With "Type 2" reservoirs, most porosity is in the rock matrix (main rock body) but most permeability is in the fracture system.

With "Type 3", most of the porosity and permeability are in the matrix, and the fractures enhance the permeability.

With "Type 4", most of the porosity and permeability are in the matrix, and fractures only cause anisotropy (where a material has different properties in different axes).

The talk concentrates on Type 1 and 2 only, independently of their relative abundance in nature.

With type 1 reservoirs, the storage and productivity of hydrocarbons is mostly restricted to the fractures. Type 1 oil and gas reservoirs are mostly deepwater carbonates. The matrix has very low permeability and is usually "water wet".

An example is the Ain Zalah field in Northern Iraq, and the Ebano-Panuco fields in Mexico.

There can be some early water breakthrough when producing these reservoirs, which can usually be resolved by fine tuning the production, because it means that the water has found a flow path through the fracture system, he said.

The distribution and connectivity of fractures is not straightforward, it depends on the history and nature of the rock.

For oil production, you might want to drill into the part of the rock with the highest fracture density. This is often at the crest of an oil bearing structure when dealing with an anticline trap, but not always, he said. In the Ain Zalah field, the highest productivity is offset from the crest.

The overall fracture porosity (fraction of total volume containing fractures) is usually less than 1 per cent, he said.

Type 2 reservoirs, where most porosity is in the rock matrix (main rock body) but most permeability is in the fracture system, is mostly in shallow water carbonates, he said.

Although the porosity of the matrix can be high, the permeability of the matrix can be very low. So you need fractures to get good production.

The production can be heterogeneous (diverse in character), or homogenous (steady), depending on the distribution of the fractures. "It depends in every case," he said.

An example of this is the Kirkuk Field in Iraq, which is intensively fractured with well-connected fractures. If the pressure drops in one part of this reservoir, it is almost instantaneously detected elsewhere, although the structure is about 100km long.

Another example is the Masjed-e-Sulaiman field in Iran, which is very compartmentalised. Here, the fractures can be barriers, not conduits, to production. The fracture distribution is very heterogeneous (diverse).

In this kind of type 2 reservoir, the fracture porosity is commonly below 0.5 per cent, he said. The oil is stored within the matrix.

One specific kind of type 2 reservoir is fractured chalk. These can have a high overall porosity, of 30 to 40 per cent, but with pores on a micro scale and extremely small pore throats. So the matrix has very low permeability and it needs to be fractured to produce oil.

Some Middle East reservoirs have porosity and permeability values very similar to this, and show similar behaviours when they are oil reservoirs, he said.

In SW Iran, the most productive fields correspond to anticline structures aligned along a South East to North West direction, along the foreland fold and thrust belt of the Zagros Mountains. The Gachsaran field is one of these. In that field, the most producing wells in the Tertiary Asmari formation are aligned in a SW-NE direction, perpendicular to the main axis of the structure, and seems to follow inherited fracture zones.

However, paleo geographic reconstruction indicates that the facies belts are following this same SW-NE direction. It means that during deposition of the Asmari, the facies belt migrated parallel to this fracture direction. It is then hard to work out the relative weight (importance) of the facies and the fractures to the preferential production trend from the wells, he said.

But on type 1 reservoirs it is easier, there is not any matrix to consider.

In the Zagros field, type 1 reservoirs (with no significant matrix porosity) are mostly late cretaceous deepwater carbonates.

Permeability and porosity

To take some examples of fracture porosity for type 2 reservoirs, the Aghajari in the Zagros is 0.22 per cent. Sometimes it is a little higher, but it is usually very low.

With carbonates, you can have the fracture system enlarged by solution (rock dissolving), during freshwater water flows through the rock, or an aggressive fluid within the burial system.

"There is strong debate - if the burial fluids are able to dissolve huge amounts of carbonates or not," he said.

If you have a significant amount of clay in the carbonates affected by fractures, it tends to block or limit solution enlargement, he said.

An example of porosity in fractured carbonate reservoirs is from the Gachsaran structure in Iran, which has 0.17 per cent fracture porosity on the crest, which shows the highest density of fractures. This density decreases on the flanks of the structure, and fracture porosity decreases down to 0.03.

Studies show that fracture systems have a big impact on permeability (how fluids flow through the rock), but the matrix is more important for porosity (actually storing the fluid).

The width of the fractures and the spacing between them governs how much fluid they can hold, and how efficiently they can flow through. As an example, the Masjed e Sulaiman field, in the Zagros fold and Thrust Belt has fractures which are 0.1 to 0.5mm wide.

Usually, porosity will decrease with depth, for both type 1 (fracture system has biggest impact on both porosity and permeability) and type 2 reservoirs (matrix has the biggest impact on porosity, fracture system has the biggest impact on permeability).

Fracture distribution

When you deal with a geological structure, such as a fold, typically the orientations of the fractures depend on the stress directions, he said.

For symmetric or asymmetric folds, the fractures form in various directions, following a certain sequence during the development of the fold and the increase in stress.

In most cases, some pre-existing fractures may exist, their direction and distribution being independent of the actual structure. The carbonate may have suffered previous tectonic phases, he said.

There are usually two main types of fracture, "diffused" fractures, spread over a wide area, and fracture "swarms," concentrated in a smaller area, he said.
The diffused fractures are typically contained within the same mechanical units (rock layer). The important parameters are the thickness of the rock layer (typically, the thicker the beds the less dense the fractures and vice versa); the material properties of the rock itself (dolomite tend to develop fractures more readily than limestone); and

the strength of the interfaces between the units (accommodation of deformation at contacts).

Observed carbonate reservoirs

The Asmari formation of the Zagros basin, as studied by Van Berg et Al in 2007, can be split into the lower Asmari, a succession of thick to medium bedded limestone, and the upper Asmari, a succession of thin bedded dolostone (dolomite rock).

Usually, the thicker the beds, the lower the intensity of fracturation. An example of this is the Kuh e Asmari anticline in Iran. A number of other outcrops, from other anticlines in the Zagros foothills, show the same pattern.

Another study by Van Berg in 2007 shows that the fracture intensity is higher for mud-supported textures than grain-supported textures. The mudstone may be more brittle, and more homogenous.

For grainstone, there are many interfaces between the grains in the facies, which can accommodate some of the stress during deformation, preventing fracturing. "Less interfacing may explain the higher intensity of fracturing in the mud stone," he said.

Mudstone can have porosity of up to 30 per cent. "Obviously a tight mudstone will not behave in the same way as a porous mudstone," he said.

Another observation is that dolomites tend to develop fractures more readily than limestone, he said. "Here are many examples all around the world, you have limestone beds and dolomite beds, limestone is less fractured than dolomite," he said.

Diffuse fractures

"Diffuse" fractures, early developed structures which form a background network in the rock, can be very important in connecting the main fractures together. In the Asmari field, the diffuse fractures link the fault damage zones, he said.

Sometimes the oil water contact in the fracture system can correspond to the free water level, which can be some level below the oil water contact in the matrix.

In the Ebano-Panuco area in Mexico, most of the production is not coming from the matrix, although the matrix can be oil wet. But the wells cutting the main fracture systems are producing continuously, with recharged by a diffused fracture network draining the matrix.

Some wells, intersecting large fault corridors in water-wet matrix zones can also produce oil. "These kinds of wells are interesting, but difficult to properly identify" he said. "They were defined by Muir a long time ago as 'flank faulted pools'"

"These wells are producing oil. [However] They may produce oil for a short time period. You may have a very fast water cut there."

"The production rate may have to be very fine tuned in these kinds of targets," he said.

Fractures helping and hindering

Fractures can both connect the elements of reservoirs and act as barriers.

Mr Vincent showed two reservoir cross section examples from the Musandam region in the UAE, with some reverse faults and structures forming in front of the faults.

Studies showed that fluid flows during diagenesis differed on each sides of these faults, demonstrating that the faults zones acted more as barriers than preferential paths.

"This is totally compartmentalised," he said, and it is extremely difficult at the start of a reservoir study to know if a fault zone may act, or may have been a barrier or not during the burial history.

Modelling fluid flow in fractured carbonate fields

Reservoir engineers and geoscientists have put a great deal of effort into building computer models to try to predict hydrocarbon flows from carbonate reservoirs – but the additional complexity above that of sandstone reservoirs, especially if fracturing is significant, makes it very hard, said Kes Heffer

The test of whether any model is useful is whether it can skillfully predict new data, i.e. make an adequate prediction of what is going to happen before it actually happens, said Kes Heffer, director of Reservoir Dynamics Ltd.

But it isn't clear how many reservoir simulation models, especially among those for fractured carbonates, would pass this test, he said. Very little auditing of simulator predictions has been documented, but for a few carbonate fields that Mr Heffer has looked at, the error range turned out to be 3 x bigger than the predicted uncertainty.

Mr Heffer's talk was aimed at giving reservoir engineering reasons for the uncertainties. He emphasised that it was only a very brief overview.

Oil-in-place

For type 1 fractured reservoirs in particular, oil-in-place calculations depend upon estimates of fracture porosity; these are generally less than 1 per cent. Pre-development, fracture porosity is mainly estimated from cores, logs and analogue outcrops. With some production history available, estimates can also be obtained from material balances and well test analysis.

In a well test, a well is flowed, and then shut in, to see how the pressure builds up. The textbook shape of pressure build-up for an idealised 'sugar-cube' fractured reservoir is an S curve, with parallel rates of change in the early and late stages.

The shape of the curve is linked to the ratio of matrix to fracture permeabilities (permeability is the ability of rock to allow fluids to flow through it), and the proportion of storage in the reservoir which is attributed to fractures rather than the matrix.

Storage is porosity x compressibility: a big question mark is associated with the fracture compressibility – with fractures being usually more compressible than the matrix.

Another factor is that the early part of the well test pressure build-up can be dominated by the storage of fractures close to the well bore, rather than fluids flowing through the larger field.

This, and other departures from the idealised homogeneous model, mean that the iconic shape of build-up is rarely observed.

Material balance

Another way to determine fracture porosity is material balance, where you equate the volume of oil and gas in the fractures after some production to the initial volume plus the volume that has entered the fractures from the matrix minus that produced through the wells, minus any change in the pore volumes of fractures. There could also be gas or water flowing into the fractures, from a gas cap, aquifer, or injected.

The idea is that over time you can work out the oil-in-place in the matrix and fractures. But the errors can be large, especially if you don't have a long history of production.

Also, if the permeability isn't high, the pressures will be very non-uniform, as well as different in the matrix and the fractures, leading to uncertainties in the pressure-dependent fluid volumes. Complications can also arise from gas coming out of solution in the oil.

The material balance could be performed on a global scale for the whole reservoir, or for part of a reservoir, looking at horizontal or vertical segments.

Flow simulations to predict recoveries

Trying to incorporate all the complexities of geology and flow mechanisms into a practical flow simulator can be challenging.

Kes Heffer

The standard model for a type 2 or 3 fractured reservoir is a 'dual porosity' simulation, which tracks flow through the fractures incorporating how fluids are exchanged locally between the matrix and the fractures.

There are different factors governing how oil comes out of the matrix, including the pressure difference between the matrix and the fractures, the permeability of the matrix, and a 'shape factor' which is supposed to account for the geometry of the matrix blocks.

If the water level in the reservoir fractures has risen above the oil water level in the matrix blocks following oil production (either injected water or aquifer influx), then there is gravity driving water from the fractures into the matrix and driving oil out.

There are also capillary forces in the matrix, adding to gravity if the rock surface is 'water wet' (more attractive to water). Fluid and pore expansions also need to be taken into account. "Much literature has been devoted to the difference between co-current and counter-current flow," he said. In "co-current" flow, water is going from the fracture into the matrix, while oil is moving out of the matrix on the opposite face. In "counter-current flow" water is going in and oil is coming out on the same faces.

Sometimes you can have a "continuous capillary effect", where oil is able to drain down through a block continuously, or a "discontinuous" effect, where there are "some sort of barriers" holding up the oil. This will affect the overall transfer rate of oil coming out of the matrix.
Calculations involving the above mechanisms, or even experiments on core in the laboratory, lead to a relationship between the oil recovery and either cumulative water injected or time. Typically build-up of recovery is initially relatively rapid before levelling off.

In type 3 reservoirs there could also be longer-range flow directly between the matrix blocks themselves in addition to flow through fractures: in this case a "dual permeability" model might be deployed.

Assembling more realistic models

In contrast with the rudimentary 'sugar-cube' model, Discrete Fracture Network (DFN) models are populated with many individual fractures spatially configured according to either theoretical or locally derived rules. Fractures can range in size from micro fractures to large scale lineaments. You can use fractal or power law distributions to fill in the gaps between available data.

You need a conductivity assessment for each fracture (how easily fluid flows through it), although many studies assume that all fractures have the same conductivity. Fracture conductivities are governed by their apertures (openings). Relative aperture data can be gathered from core or log analysis, but fractures so measured are in stress states different from that acting in the wider reservoir, and the apertures should be calibrated against well test permeabilities.

Studies have indicated that permeability increases with the scale at which you measure it up to about 30m.

Another point is that the porosity and permeability interpreted from well tests, are generally only very weakly related to the fracture densities in the wells. "I think that is fairly commonly understood, but sometimes forgotten," he said.

Such phenomena are allied to the complexity of fracture connectivity, which is very important to large-scale fluid movement. Many people have looked at how fractures connect from a theoretical point of view. These have included studies again based on fractal concepts, which can incorporate clustering.

Probably no studies have included the full set of factors potentially influencing fracture distributions: structural histories, current stress state, stress interferences between fractures at all scales, induced stresses from production, heterogeneous mechanical properties, diagenetic histories etc.

Time-variable permeabilities

Typically, fractured reservoirs contain only a few very productive wells, and a large number of wells with much lower production.

The productivities can change in time (over and above change expected due to reservoir pressure decline by itself). Mr Heffer showed some data from a large carbonate field in the Middle East, in which 20 per cent of wells experienced rates of change of test permeability, either increasing or decreasing, of more than 10 per cent a year.

The anomalies might be attributed to interpretation errors, but, for that field, you can plot out the wells showing high rates of change, and it does make "some sort of geomechanical sense" because they map lineations which possibly reflect strike slip movement on faults.

Anisotropy

Another issue is anisotropy, when rock properties are different in different directions. Oil recovery factors in waterfloods are very sensitive to the configuration of wells relative to any anisotropy in permeability.

For example, aligned fractures can lead water from injector wells directly towards only a subset of producers, at which you get early water breakthrough meaning loss of productivity and high water-cuts, while oil still remains to be recovered from the rest of the producers.

Evidence from a number of fractured reservoirs shows that the modern-day stress state can be a large factor in determining the anisotropy of the flooding.

Calibrating models with geomechanics and geophysics

An exciting way forward in understanding variations in productivity is to simulate the structural history of the field with a geomechanical model – including tectonic movements, such as strike slip, compression or extension.

This calculates the modern-day strain distribution in the rock which can be compared against well test permeabilities. Once calibrated, such a model can be used to predict fracturing "sweet spots" in new parts of the field.

You can also use geomechanics to try to predict how fracture permeability will change over time. One oil major devoted 10 man years of effort in a study of a carbonate field in the Middle East, which had experienced a breakthrough of injected water 7 years earlier than was initially predicted. The breakthrough was along a thin 'thief zone' that was found to have a high density of fractures due to mechanical stratigraphy.

Conventional reservoir modelling failed to provide a match to the history, and the only way the very fast breakthrough could be explained was if the permeabilities were somehow increasing while the field was being produced. Injecting cold, high-pressure water can make the fractures fatter; i.e. their apertures, and therefore conductivities, increase as the effective stresses acting on them reduce. Coupled modelling of flow and geomechanics supported this conjecture.

Another means of interrogating a reservoir in order to ascertain fracture distribution uses the fluctuations in routinely recorded well flow rates. These show strong geomechanical signals, an association that is consistent with the observation of changing permeabilities in well tests mentioned above.

"I spend a lot of time looking at fluctuations in flow rates between wells and their spatial correlations do seem to follow structural trends," he said. It is promising to be an extremely useful low cost way of identifying important structural features.

Seismic methods, both compressional and shear wave, can provide data on the spatial distribution and anisotropy of fractures. Satellite radar (InSAR) studies over onshore fields can reveal deformation of the land surface in response to production, potentially focussed on faults.

Such geophysical data, especially when gathered in repeated time-lapse fashion, can be used for calibration of reservoir simulation models, to complement production data. This appears to provide the best way forward to progressively enhance the skill of prediction as incremental field development continues.

Where are the Middle East exploration opportunities?

Richard Herbert, who retired as head of exploration with BP in December 2016, gave a talk at the Finding Petroleum forum in London on May 16 about where the likely emerging exploration areas and 'hotspots' will be in the Middle East over the next few years

The Middle East, defined for the purpose of this talk as the area from the Eastern Mediterranean to the Arab peninsula and Iran, contains "some real OPEC heavyweights with respect to petroleum reserves," said Mr Herbert.

There is also a second group of countries in the region not part of OPEEC which have much

Richard Herbert

smaller reserves, such as Israel and Lebanon.
In the recent past, it has been fairly difficult for outside companies to gain access to OPEC countries to explore, "with the exception of the Kurdistan region of Iraq," he said.

Also of course there are security issues in many countries in the region which has an impact on the ability to do exploration.

The Middle East could be described as "the most successful exploration province in the world by far," he said, with nearly half of the world's oil reserves and 43 per cent of the world's gas reserves. "I'm fairly certain that in conventional resources it will never be overtaken."

Based on current production rates, the known reserves can be produced for 73 years (oil) and 130 years (gas). "Both of which are longer than many people think that the petroleum era is going to last," he said.

This also means that any new exploration discoveries will be competing with the existing resources, many of which are already developed, and many of which are "very low cost".

"So new discoveries in some of these big OPEC countries may struggle in the short term to be developed," he said.

There is also a lot of stranded gas in the Middle East, especially in Iran. This could be targeted by companies who can see a way to take it to a market.
There are also some countries with a big gas demand and limited supply of gas, and Saudi Arabia is one of those, he said.

Why the Middle East?

It may be useful to begin by considering why there is so much oil and gas in the Middle East.

The region is on the North margin of the Arabian platform, an area which is 2 to 3,000km wide and over 5,000km long.

For most of the last 500m years, it was a passive margin (transition between ocean and land which is not an active plate margin). Up to 14km thick sediment was deposited on the margin.

Also, the closure of the Tethys Sea (previously between India and Asia) led to the closure of the Zagros fold and thrust belt, "which is by far the largest fold belt petroleum province in the world," he said.

There were also a number of important structural events during the long history, with uplifts, rifting, land breakup, subsidence (described in detail on the slides).

The sedimentary section also has evaporites (sedimentary rock) which act as petroleum seals and help in the formation traps.

"All of this, together with the salt tectonics, has led to the formation of a lot of enormous structures which were capable of holding giant accumulations," he said.

Opinions vary, but most experts agree there are five major petroleum systems in the region, and a number of minor ones, he said.

"We can all think of provinces around the world with a major petroleum system or two, possibly three. But the fact that there are five petroleum systems in the Middle East is unique in the world, I believe."
There are separate petroleum systems developed in the Palaeozoic, the Mid Jurassic, and Late Jurassic, Early Cretaceous and Mid-Cretaceous / Oligocene, he said.

Perhaps the most important of these is the Palaeozoic. The Palaeozoic petroleum system is linked to early Silurian "hot" (organic rich) shales, which extend from the Middle East to North Africa.

"These are a major source rock charging enormous amounts of gas in Iran and Qatar, and oil in Saudi Arabia and western part of Oman," he said.

"while we're talking about the Palaeozoic it is worth pointing out that it was during the Permian [the last period of the Palaeozoic era] that the Middle East actually drifted into the equatorial zone and it has stayed there ever since.

"This has provided ideal conditions for a lot of carbonate sedimentation."

The reservoirs are mostly carbonates, but not exclusively. There are sandstones, and giant structures linked to salt tectonics or thrust tectonics. "All of these provide conditions for an abundance of petroleum in the region," he said.

Also, the complexity "gives us scope for undiscovered resources in both existing plays and new plays," he said.

With many of the countries' oil industries under national oil company monopolies, busy producing reserves they already know about, "much of this region has not had the same intensity of exploration that we've seen in the rest of the world," he said.

In recent years there has been a lot of new technology available in exploration, which has not been applied.

"In particular, the Palaeozoic system looks to be very underexplored throughout the Middle East," he said.

Finding Petroleum opportunities in the Middle East

The past decade

Probably, the biggest area of exploration activity over the last 10 years has been focussed on the Kurdistan region of Iraq, where about 70 exploration wells have been drilled, of which a third resulted in commercial discoveries (according to data from Westwood Global Energy Group).

There is uncertainty because exploration data has not been made available by Saudi Arabia, the UAE, Kuwait and Iran.

The volumes in Kurdistan are split between oil (about 3bn barrels) and gas (about 2bn barrels equivalent).

However some reservoirs in the region have not performed as expected, so there is some uncertainty about these reserves.

There have been large discoveries offshore Israel, about 35 TCF, with Leviathan being the largest field.

However Oman, an important petroleum province, has not discovered anything over the past decade, he said.

Kurdistan

Looking in more detail at Kurdistan, Mr Herbert showed a slide of exploration in the region since the first production sharing contract in 2004.

At one time, Erbil, the capital of Iraqi Kurdistan, was called the "exploration capital of the world." And the government talked about having found 45bn barrels of oil, and producing 2m barrels of oil a day.

"There have been a lot of discoveries, mainly of oil, but the reality has disappointed somewhat," he said. "Today, the province is producing a bit less than 600,000 bopd.

"Abut 60 per cent of that is coming from Kurdistan-controlled part of the Kirkuk field, particularly the Khurmala Dome, which was discovered in the 1920s.

There are 2 new fields providing 50,000 bopd between them – Shaikan and Tawke. The Taq Taq field, expected to be one of the major producers, has seen production collapse, last month only producing 20,000 bopd.

Most of the oil in the region sits in fairly tight carbonate reservoirs, which can be very difficult to understand and to produce.

The carbonates are mainly Late Cretaceous in age, with some from the Jurassic and Triassic. "These have very low permeability, and rely on fractures to enhance it," he said.

But "if these fractures connect with the underlying aquifer there's a risk that the oil that lies in the matrix is bypassed," he said. "This seems to be one of the problems with fields like Taq Taq."

As a consequence, "the reserves have been downgraded. The remaining reserves are less than 60m barrels."

Several other fields have seen the reserves downgraded.

There has also been quite a lot of heavy oil in Kurdistan which has proved difficult to develop. Much of the gas in the province is stranded.

Another factor is a difficult political relationship between Erbil and Baghdad, which has made it hard for the Kurdistan government to make payments to operators.

"There have been indications the situation is improving, [but] it is a far cry from the "exploration centre of the world" just a few years ago," he said.

"Although there are a few good exploration opportunities in Kurdistan, it is not really a province for the faint hearted."

"The fold and thrust belt appears to offer better prospects, for higher quality oil and associated gas, and for better quality reservoirs.

"The Kirkuk reservoirs which is a very narrow facies belt along the paleo (prehistoric) shoreline could offer scope for stratigraphic traps," he said.

Mr Herbert also showed a picture of the Iraqi Oil Minister speaking to a group of people.

"The oil minister is requesting that the National oil company direct its efforts at offshore exploration in Iraq," he said. "It's not a very large offshore sector but it's actually sitting in a good location. So maybe there's

some good opportunities there. But I haven't seen any data."

Iran Zagros

The Zagros fold belt in Iran is much more productive than the Zagros fold belt in Kurdistan (excepting Kirkuk), he said. This is due to two factors – a favourable structural setting, and the shallow Miocene Asmari fractured reservoir.

The fold belt can be seen as three different zones, with a different stratigraphy and structural style.

In the North West Zone, there are "relatively tight folds and complicated structuring."

"We're going to rely on some of the same reservoirs that have proved problematic in Kurdistan, potentially in Jurassic and Cretaceous carbonates," he said. "There's probably been quite a lot of oil generated there but field size and commerciality is going to be quite challenging."

The central zone, the "Dezful Embayment," has been well explored for over 100 years. "The largest fields have likely been found," he said.

The region contains the thick Oligocene foreland basin, and the Zagros fault, which extends back to the Zagros mountain front. "So potentially, a combination of modern exploration techniques combined with modern seismic data could result in some new discoveries," he said. "There are likely to be some undrilled subthrusts, and some potential for stratigraphic traps."

In the Southeast Fars region, the Tertiary petroleum system is "either too shallow or absent," he said. "There are some hints of a Jurassic-Cretaceous oil play.

"There are lots of anticlines in this area, and likely to be lots and lots of Permo-Triassic gas to be found if anyone knows of a market."

Offshore Persian Gulf

The Offshore Persian Gulf of Iran is an "interesting exploration objective for both oil and gas," he said.

In the year 2000, it was covered by the world's largest multiclient seismic project at the time, "Persian Carpet", and this "remains the key data set for understanding this area," he said.

Iran has an offshore rig in operations in the region, and has made a number of "significant discoveries of both gas and oil," he said.

It is likely that most of the offshore structures associated with salt tectonics have been drilled, he said. But there could be good possibilities for stratigraphic traps within the Cretaceous section.

There is another "important prolific basin" in Iran, the South Caspian Sea. (The Caspian Sea is North of Iran).

There is some dispute over the international boundaries within the Caspian.

There is some 2D seismic being planned for acquisition in summer 2017

"The South Caspian basin has been called the deepest sedimentary basin in the world, with up to 28 km of sediment, of which 10km has been deposited just in the last 5 million years," he said.

The source rocks for the South Caspian are probably the same Oligocene Maikop Shales which have proven prolific in Azerbaijan waters of the South and Central Caspian Sea.

"Probably the most likely source of sediments is the very sandy system coming from Turkmenistan, and the deepwater sediments associated with that system," he said.

There was a significant discovery announced in the South Caspian of Iran in 2011 at Sadar-e-Jangal, at 700m water depth, drilled by an Iranian built semi-submersible rig. "It may be in disputed territory with Azerbaijan, I don't know," he said.

There was a claim of 500m barrels of 38 API oil and 2-5 TCF of gas. But "I think there's a big health warning on what the reserves really are," he said.

KEPCO, a subsidiary of the National Iranian Oil Company (NIOC), which operates in the Caspian, has offered this discovery, plus 3 other blocks, for international co-operation. "

"They have mapped almost 50 leads in this part of the Caspian Sea. Some are large structures, one is recorded to be up to 750km2, with vertical closure of hundreds of metres," he said.

"I think exploration here is likely to lead to some discovery of some giant fields. Although the fluid type and reservoir quality and ability to develop these obviously still big uncertainties going forward."

Lebanon

Deepwater offshore Lebanon is another frontier area now being offered for exploration. There is a "much delayed" licensing round taking place during 2017, with 5 blocks on offer, and bids due in September. Exploration interest has been sparked by recent success in the Eastern Mediterranean, in Israel, Cyprus and Egypt, with the Zohr field.

"Offshore Lebanon is more structured than the surrounding areas, largely due to the strike slip tectonics along this margin," he said.

The seismic data for Lebanon shows a lot of faulting in the Miocene section. "There are undoubtedly going to be traps, the question is how big are they and how commercial are the discoveries going to be," he said.

Looking at other areas of the Middle East:

Israel is planning to offer 24 blocks in its first licensing round. "The Israeli oil ministry thinks there's large volumes of oil to find offshore Israel, not just gas," he said.

"Yemen may not look very attractive today while there's a civil war raging, but eventually things will calm down and exploration could come back."

There were two discoveries in Yemen in the 1980s and 1990s, by oil companies Hunt and CanOxy, "These 2 basins are fairly well explored.

There are a number of other rift basins in the country, both Mesozoic and tertiary, which have had very limited exploration."

"In terms of scale, [Yemen] will never compete with the big production areas west of there on the Arabian Platform," he said. "The geology is different, we're seeing Mesozoic rift systems and Tertiary systems linked to some of the systems from East Africa (like Ethiopia)."

"Only a small part of Yemen, in the North East, you might start to see some of the same systems that are operating in Saudi Arabia. I would have modest expectations but certainly think it is still prospective."

There could be oil in "some of the interior basins in Iran," he said.

There could be unconventional plays in the Middle East. ADNOC (the national oil company of Abu Dhabi) has shown a lot of interest in shale gas technology coming from North America. There are significant tight gas resources in the Middle East including BP's Khazzan field in Oman.

"There's likely to be a lot more tight gas in the Middle East," he said.

"There's a potential 600 TCF of shale gas in Saudi Arabia just in the Silurian hot shales. There are Upper Cretaceous oil shales in Jordan if you are interested in them."

"The question is not 'are there unconventional plays' - there clearly are - but the real question is do they compete commercially." Also "is there, or could there be, an operational infrastructure to allow them to be developed and a market for the products."

Conclusion

"The region really needs some new data and some new ideas - particularly I think around stratigraphic traps," he concluded.

But "the main barriers don't really appear to be technical - they feel more political, commercial, increasingly worries about insecurity."

It should be worth looking harder at some of the established plays, and looking for new plays in some of the core areas such as stratigraphic traps, applying new data and concepts.

The low cost of developing oil and gas fields in the Middle East could be reason for investor interest, for example, one Alternative Investment Market (AIM) listed company in Kurdistan has stated that its operating costs are $4 a barrel, he said.

"I think if access is opened up there will be definite international interest in the region."

GGS-Interica's seismic data offshore Iran

GGS-Interica has an integrated subsurface data set offshore Iran, called PC2000. Sales director Katya Krylova explained

GGS-Interica, a joint venture between geoscience company GGS and data management company Interica, has a subsurface data set available for offshore Iran, including reprocessed 2D and pseudo 3D seismic data, gravity and wells.

The work is "the biggest multiclient data set ever taken for quite a long time," said Katya Krylova, sales director of GGS-Interica. "This is the only one multiclient data set available in Iran. We believe it is going to be the case for a few years."

There are still some limitations on seismic data acquisition, which will make it harder for international companies, to gather data, she said.

"So, we are definitely well positioned on the market for the time being."

The seismic survey name is "PC2000". The seismic data was acquired in early 2000.

Bjørn Ursin-Holm, chairman and CEO of GGS, acquired the rights to license out the data to all interested parties.

Interica was contracted by GGS to take on the task of gathering all the field data from the different companies and different locations, which was stored on different media, and catalogue and transcribe it.

"As you can imagine it is a very challenging task to do," Ms Krylova said.

GGS-Interica then started re-processing the data, to create a single product which can be taken to market.

The data set covers all offshore oil and gas fields in Iran. 2D data (seismic lines) is available for the whole region.

The library also holds 3,250 km2 of pseudo 3D data, over structures with very high potential, eg the "F" and "G" structures Northwest of South Pars, the world's largest gas and condensate field.

The most dense 2D lines are in the Gulf Area, with a 2 x 2 km grid. This is the most explored area in the region, with many known oil and gas fields.

The lines are a little less dense in part of the Oman Sea, where it is a 2 x 4km grid, and the least dense in other areas of the Oman Sea, where the grid is 4 x 8km.

It is supported by a database of 120 wells, including well logs and tops, and tying wells to the seismic.

An atlas has been put together outlining the main areas of prospectivity in every single block, with a preliminary interpretation.

There are also gravity data, and a number of interpretation projects (carried out over the past years) available.

The seismic data is currently being reprocessed by DownUnder GeoSolutions, and this work should be completed in 2018. Many of the staff members doing the processing have previously worked on the data in former employment with Robertson.

The seismic processing has been challenging, with data acquired by different vessels with different acquisition parameters, she said. It covers transition zones (areas close to the coast) and deep / ultra-deep areas. Some individual lines are 400km long.

There is scope for further development of the data, using it in future interpretation or seismic inversion projects, she said.

About Iran

Iran has a tenth of the oil reserves in the world, and the fourth largest oil reserves by country. It has 18 per cent of global gas reserves, the second largest.

The National Iranian Oil Company has offered 52 upstream oil and gas development projects and 18 exploration blocks to foreign investors recently. Iran also has one of the cheapest operating costs of countries in the Gulf.

Katya Krylova

Total signed a contract together with China National Petroleum Company (CNPC) to enter Iran in November 2016.

It was soon followed by Shell, which signed a contact in December to study the Azadegan and Yadavaran oilfields in SW Iran and Kish gas fields in the Gulf.

In January 2017, the Iranian government and NIOC announced 29 more companies had been pre-qualified to bid for oil and gas projects in Iran.

Over 30 per cent of the companies are from Asia, including Japan, China and South Korea. There are companies from Russia and Europe. Iran and Russia has had reasonably good relations at senior government level, including with visits to the Kremlin by the President Rouhani administration and a number of memorandums of understanding, (MOU) agreed, including with Gazprom.

It seems fairly certain that this list of companies will grow, particularly after the re-election of president Rouhani, Ms Krylova said.

The 2D lines cover all of offshore Iran except the Caspian Sea.

Note: the presentation showed a few examples of how imaging has been improved through the re-processing. You can see these by watching the video online.

Cambridge Carbonates Ltd

Expertise in carbonate and evaporite systems

Tectonically Fractured Carbonate Reservoirs - A Synthesis of Analogues (2017)

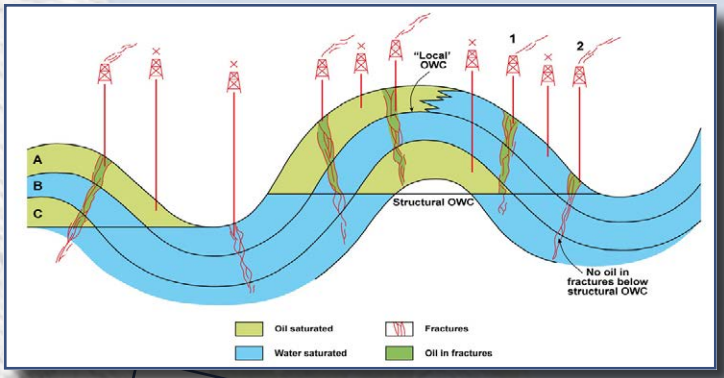
A comprehensive multiclient report providing detailed analogues and case histories of **tectonically fractured carbonate reservoirs.**

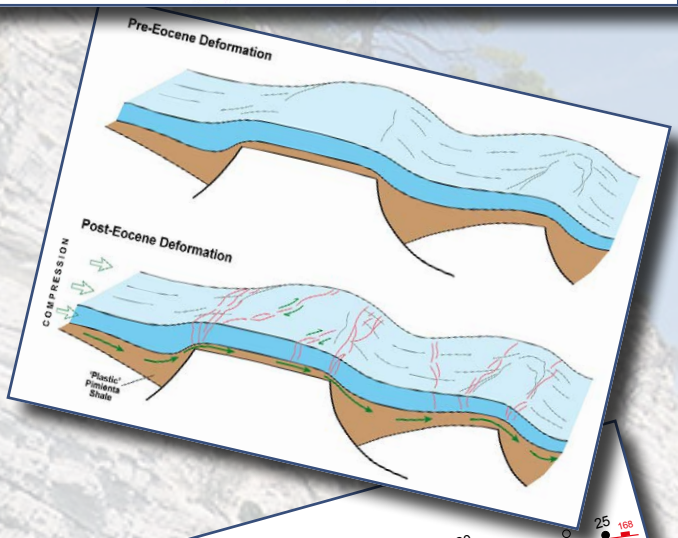
The report provides an overview of fractured carbonate fields which are **successfully producing at sustainable economic rates.** Approximately 50% of all carbonate-reservoired oil and gas fields worldwide are naturally fractured. This number is high compared to their siliciclastic counterparts. It is therefore important to not only be able to predict fractures in carbonates, but also to understand their impact on production.

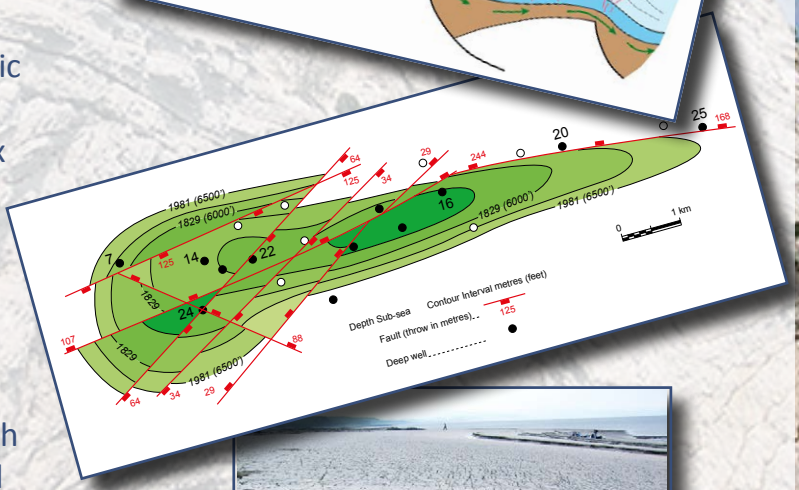
The report highlights two principal areas of economically sustainable fractured carbonate production: the **Zagros fold-and-thrust belt** of Arabia, and basinal reservoirs of **NE Mexico**. It also gives useful insights into fractured carbonate reservoirs from fields in the Adriatic area, USA and SE Asia. The report includes details of reservoir geology (facies and matrix porosity, fractures and permeability) and production trends and pitfalls.

A **detailed database** is also available, and comprises more than 50 naturally fractured carbonate reservoirs from around the World. Reservoir properties have been analysed, with data such as porosity, depth, permeability, oil gravity, recovery factor, STOOIP being plotted, and trends discussed.

This multiclient report is presented in pdf format, with an associated excel database of reservoir properties.







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PGI – a security assessment of the Middle East

Ryan Turner of security consultancy Protection Group International presented a risk assessment of Iran, Iraq, Saudi Arabia and the Eastern Med

Security consultancy Protection Group International loosely categorises Iran and Iraq as "high risk countries with high reward."

In contrast, Saudi Arabia has "more of a moderate risk but opportunities are quite limited". Similarly, the Eastern Mediterranean offers a moderate reward in terms of offshore gas, and has moderate risk both in security and regulatory issues, said Ryan Turner, lead political risk analyst with Protection Group International.

Ryan Turner

Iran

Iran is currently a very exciting country, with a great deal of interest. However the operating environment is "highly uncertain".

Since the Iranian revolution in 1979 there has been competition for power between the moderates (which include the current president) – which is open to foreign investment and better relationships with the rest of the world. Then there is a "kind of conservative or hardliner faction", which is more hostile to foreign investment, and which rejects better relationships with the rest of the world.

"These two factions have meant Iran has waxed and waned between openness and hostility to foreign investment over the past few decades," he said.

The presidential election is not going to make the competition between these factions go away.

Another uncertainty comes from the Trump administration, and Iran's involvement in other conflicts in the region.

"There's a lot of dynamics on the horizon that can make Iran a more difficult place to do business."

PGI's security analysis of Iran assesses that the risks of civil unrest and kidnap are "pretty low relative to the rest of the region", but the bigger problem is on the business risk side, where there is a "highly uncertain regulatory environment."

President Rouhani's win in the presidential elections is good for the oil and gas industry, Mr Turner said.

However there is some scepticism in Iran about whether the nuclear deal Iran agreed with other countries has "lived up to expectations" of an improved economy.

The alternative political view is for Iran to become more self-sufficient, so it is less vulnerable to sanctions.

Oil companies have been pushing for a better petroleum contract, because they say it has been hard to make money with the current one. President Rouhani is willing to improve the terms, but there has been repeated resistance from hardliners to unveiling of the new contract. It was supposed to have been finalised in 2016, but was still under review as of April 2017.

For many years, Iran was on the blacklist of the Financial Action Task Force, an inter-governmental body to prevent money laundering and terrorist financing.

President Rouhani secured a deal in 2016 for the country to be removed from the blacklist for 12 months, while the country implements an action plan, and gets its regulations up to scratch. This will "hopefully make foreign investors feel a bit more comfortable going into Iran," he said.

This move was resisted by hardliners in parliament.

There have been some smaller European banks setting up business in Iran, but larger banks are staying away, because of fears of sanctions re-emerging, perhaps through the 'snapback' provisions of the nuclear deal.

"Domestically the banking sector is a mess - you don't know who you are doing business with sometimes."

Corruption is also a major issue, with Statoil and Total hit with fines.

The economy is "quite opaque", with something between a third and 80 per cent of the economy in the hands of the state.

President Rouhani is making efforts to liberalise the economy, "but that's a slow-moving process, there's lots of vested interests that he has to tackle," he said.

There are many people who have made money in Iran, even under the sanctions. "It is just a complex place to navigate," he said.

The environment in the Middle East around Iran is quite challenging.

Iran is "on the wrong side of proxy conflicts from Syria to Yemen in terms of neighbours in the region," he said.

Iran has been keen to gain access to the Sumed pipeline, which runs from the Red Sea to the Mediterranean and bypasses the Suez Canal, as a way to get Middle Eastern oil to market faster.

Iran has been trying to regain access to the pipeline after the nuclear deal was signed in 2015. But it is owned by Egypt, Saudi Arabia and "some other Gulf states", who have blocked Iran's participation.

That means that regional tensions have had an impact on Iran's oil industry.

There is still plenty of uncertainty and mixed messages coming from the US. Recently the US State department said that Iran was complying with the nuclear deal, then the White House declared it was doing a review of the nuclear deal.

Mr Turner said he thinks it is "very unlikely that the US would unilaterally withdraw - there's lots of consequences."

"But he [Trump] can definitely make Iran a less attractive place to do business."

"He can impose additional sanctions. He can designate the IOGC, which has huge interests throughout the economy, a terrorist organisation - and that can make it more difficult for banks and other companies to do business in Iran."

Technically the sanctions have been "waived", not lifted, which creates a bit of doubt about whether the "waiver" will be renewed.

Saudi Arabia

Saudi Arabia currently offers very limited opportunities in upstream oil investment, and "that's not likely to change".

However there is scope for foreign investment in downstream and in gas.

In April 2017, Saudi Aramco asked a number of international oil companies if there was interest in some upstream joint ventures.

This is a repeat of what happened in 2003 and 2004, when Saudi Arabia invited a handful of oil companies to invest in some upstream gas joint venture. But "within a decade they were all gone," he said.

The gas was high in sulphur, so more expensive to process. Also Saudi Arabia sets it gas price at an artificially low level. As a result, the country was seen as commercially unattractive and companies pulled out.

Saudi Arabia has now raised gas prices, but "I don't think it's at a level likely to raise much investment," he said.

The big news is the Saudi Aramco [5 per cent] privatisation, expected to happen by 2018, and be the largest IPO in world history.

"I don't think that will change much in terms of actual opportunities on the upstream side, [although] you could see some more privatisation on the downstream side," he said.

There are security issues in the oil and gas industry, with most of the oil and gas in the Eastern province, a predominantly Shia region, while the country is predominantly Sunni and its monarchy is Sunni.

"This hasn't really had a disruptive impact on O+G sector but is obviously something you would want to know before moving into the region," he said.

Also Islamic State is active in Saudi Arabia and has carried out a handful of attacks, including a failed attack at the US Consulate in July 2016, although no attacks at the oil and gas sector yet.

The conflict with Yemen is another emerging threat, with a failed suicide attack in April 2016 by Houthi rebels based in Yemen, rivals of the Saudi government.

Saudi Arabia also has an economic reform program, to try to raise funds to replace the drop in oil revenues in 2014. Saudi Arabia implemented austerity measures and a reform program, "Vision 2030".

"This isn't the first time Saudi Arabia said we're going to end our reliance on oil and diversity the economy. I think it's the third or fourth. It hasn't really panned out."

"So while this program is certainly more ambitious and has much more detail and has backing from the highest level of government it is unclear how effective it will be and how much they will be able to reform the economy."

The program is orientated around privatisation, reduced reliance on oil and gas, and developing new sectors.

"But even with that, I don't think there's going to be much opportunity for oil and gas on the upstream side."

Iraq

It makes sense to see Iraq as two separate oil producing regions, North and South, Mr Turner said.

In the North there is the Kirkuk field, which since 2014 has been under control of the Kurdish semi-autonomous authority.

The Kurdish government "faces less security challenges in its areas of control than the rest of the country," he said. But there are a few issues.

Erbil, which is sometimes referred to as the oil capital, has been hit by IS a "handful of times."

"There's obviously still a presence and continued intent by the group to target the region," he said.

Kirkuk, the other main oil hub in the region, has been hit repeatedly, including with a major attack in October 2016 with over 100 militants.

Even with IS gradually losing control, Kirkuk will still be vulnerable, he said.

Another issue is the conflict between Turkish rebel group PKK fighting the Kurdish government. It has strongholds in Northern Iraq, and carries out air strikes and armed raids, some of them near oilfields.

The pipelines can be both inadequate and in need of repair. During 2014-2015 there was regular sabotage of pipelines by oil groups and criminals, although "not too much in the past few months," he said.

There have been long running disputes with the Kurdish authorities and the Federal authorities in the South, "about who controls oil and what they can do with it." As a result, in 2014, Baghdad reduced the budget transfers to the Kurdish government by over $1bn a month, leaving the government with a huge hole in its revenues which it hasn't recovered.

Consequently, it has built up very large debts with international oil companies operating in Iraq and Kurdistan. This has led to many companies cutting investment, and the situation has not been resolved.

In Southern Iraq, IS is less of a threat, and IS has less of a base to launch attacks. But there has been crime, civil unrest and kidnap.

There are also regulatory issues. Iraq has paid oil companies on a fee per barrel basis, rather than production sharing. However, the fee

did not vary with the oil price, which was bad news for Iraq.

The conflict with IS has also damaged Iraq's finances. Iraq owed oil companies around $3.7bn last year. "They were supposed to have repaid this by the end of last year but I haven't seen any confirmation," he said. "I doubt that they had - they have bigger priorities in terms of fighting a war."

Iraq wants to develop a different type of contract, which could be positive, but there could be uncertainty during the migration.

Most of the oil producing regions in Iraq have always been outside the region of IS control, although IS managed to seize about a third of the country at one point. "The oil sector was remarkably resilient," he said.

There has been some disruption, but most production stayed online.

"While Iraq is in the headlines for a lot of bad news, the oil sector still presents an opportunity, if you can navigate the complexities and security challenge," he said

At the time of the conference, the government was trying to retake Mosul, the last stronghold of IS. Once that is done, "effectively IS will have lost their caliphate and most of the territory," he said.

However, when that happens it is important that Iraq addresses the grievances of the Sunni minority – and it was the failure to do this the previous time, after the fall of Al Qaeda in Iraq, which led to the last insurgency.

"You could potentially have the same thing that has happened before, the Sunni insurgents go dormant for a few years and again cause havoc in the country."

There is a wider issue about sectarian relationships in Iraq, with Sunni, Shia and Kurd all at odds with each other, he said.

Eastern Med

Looking at the Eastern Mediterranean, there is lots of offshore activity, but Israel is the only country which has been able to monetise its discoveries so far.

"Infrastructure and regulatory issues are very critical," he said.

"In Cyprus, there's a lot of questions - how are we going to get gas out of the ground. If it is cross border pipeline that makes it more difficult."

"With Israel - although they are monetising gas- it would be great if they can find an export market. The politics make it very difficult, even though economically it makes sense."

There are also regulatory issues in Israel and Lebanon. In 2014 in Israel the anti-trust regulator intervened to break up an alleged monopoly, which "kind of set up this cycle of instability" in Israel's regulatory regime, he said.

"This was only resolved in 2016 after a number of court cases. The situation appears to have stabilised. [but] the past precedence of government intervention is certainly something to be concerned about."

Lebanon has been in a state of [governmental] paralysis for a few years, with 3 years of caretaker government, which began to break in late 2016, with the election of a new prime minister.

This has enabled progress in the oil and gas sector. But the situation is still "pretty unstable".

What did you enjoy most about the event?

Venue, exploration opportunities discussion by Richard Herbert.

Varied programme and topics.

Opportunity to discuss my ideas with others.
Mike Simmons (Halliburton)

The talk on ME Carbonates by C&C.
(Petrofac)

PGI presentation.

The technical, regional and political presentations were a great compilation for the Middle East.

The well-planned order of the high quality presentations, which followed a logical flow, allowing speakers to build directly on what was said in previous talks, greatly enhancing the overall value.
Christian Bukovics (Cygnus Energy Ltd)

The useful historical information about Middle East exploration history.

Networking, and first presentation by Benoit Vincent on fractured carbonate reservoirs.
Mike Rego (Independent Consultant)

The talks and conversations with others.

Interesting technical presentations, chance to network.
Bryan Moseley (Geologist)

First session technical presentations - carbonates and reservoir engineering.

Very informative talks.

PGI & Finding Petroleum Post Conference Briefing Note

MENA Extractive Industry Monitor

This report summarises a selection of recent key events affecting the extractives sector in the MENA region. The report is part of PGI's broader country and sector coverage. For more information on any of the report or other PGI risk analysis services, please contact: riskanalysis@pgitl.com.

Egypt: Government to pay USD 1.5 bn to oil companies

The central bank said that Egypt had paid USD 750 mn to international oil companies on 16 May and would make an additional USD 750 mn payment on 1 June. Instability in Egypt following the 2011 revolution contributed to large unpaid debts to IOCs, which totalled USD 3.5 bn before the latest payment. Cairo has committed to repaying the debts by June 2019 and to avoid fresh arrears to IOCs as part of efforts to attract investment in the oil and gas sector.

Perceptions of improved stability, regulatory reforms, and major offshore discoveries have led to a steady recovery of interest and investment in Egypt under President Abdel Fattah el-Sisi. However, unpaid debts to IOCs are indicative of wider payment challenges in Egypt, where shortages of foreign currency have made it more difficult to do business and repatriate profits. Despite repeated promises to pay off the debts to IOCs, including one pledge to do so by 2016, the arrears have continued to rise, highlighting deeper structural imbalances in the Egyptian economy and reinforcing the need for a cautious approach from investors in the energy sector.

For more analysis of the economic climate and challenges for investors in Egypt, see PGI's Insight.

Tunisia: President deploys army to prevent unrest from disrupting industry

On 10 May President Beji Caid Essebsi ordered the deployment of military forces to ensure that protests over social issues and employment do not affect the operations of companies and industries. Essebsi highlighted the phosphate industry which has been repeatedly disrupted by demonstrations in recent years. The order comes amid ongoing protests in the Tataouine and Kebili governorates over employment opportunities that have impacted oil companies due to continued road blocks and sit-ins. Protest leaders in Kamour called for continued demonstrations and expressed a willingness to negotiate with the government.

Tunisia: Union calls three-day strike of petroleum employees in Tataouine on 17 May

On its Facebook page, the Tataouine Regional Labour Union called for a three-day strike of oil company employees with the Sitep oil company from 17-19 May. In an 8 May post, the union called for a protest in front of the company headquarters. Repeated attempts at negotiation with company officials failed to avert the industrial action. The strike comes amid a series of protests by unemployed groups in the region over development and job opportunities.

Libya: Assailants attack pipeline leading to Mellitah terminal

According to local media reports on 3 May, the Facebook page of the Petroleum Facilities Guard said that unidentified assailants attacked the pipeline connecting the el-Feel oil field to the Mellitah terminal at valve number 113 on the pipeline, around 50 km south of Zintan. Initial reports did not confirm whether pipeline operations were affected. The incident comes days after the el-Feel and Sharara oil fields resumed operations on 27 April.

PGI & Finding Petroleum Post Conference Briefing Note

MENA Extractive Industry Monitor

This report summarises a selection of recent key events affecting the extractives sector in the MENA region. The report is part of PGI's broader country and sector coverage. For more information on any of the report or other PGI risk analysis services, please contact: riskanalysis@pgitl.com.

Egypt: Government to pay USD 1.5 bn to oil companies
The central bank said that Egypt had paid USD 750 mn to international oil companies on 16 May and would make an additional USD 750 mn payment on 1 June. Instability in Egypt following the 2011 revolution contributed to large unpaid debts to IOCs, which totalled USD 3.5 bn before the latest payment. Cairo has committed to repaying the debts by June 2019 and to avoid fresh arrears to IOCs as part of efforts to attract investment in the oil and gas sector.

Perceptions of improved stability, regulatory reforms, and major offshore discoveries have led to a steady recovery of interest and investment in Egypt under President Abdel Fattah el-Sisi. However, unpaid debts to IOCs are indicative of wider payment challenges in Egypt, where shortages of foreign currency have made it more difficult to do business and repatriate profits. Despite repeated promises to pay off the debts to IOCs, including one pledge to do so by 2016, the arrears have continued to rise, highlighting deeper structural imbalances in the Egyptian economy and reinforcing the need for a cautious approach from investors in the energy sector.

For more analysis of the economic climate and challenges for investors in Egypt, see PGI's Insight.

Tunisia: President deploys army to prevent unrest from disrupting industry
On 10 May President Beji Caid Essebsi ordered the deployment of military forces to ensure that protests over social issues and employment do not affect the operations of companies and industries. Essebsi highlighted the phosphate industry which has been repeatedly disrupted by demonstrations in recent years. The order comes amid ongoing protests in the Tataouine and Kebili governorates over employment opportunities that have impacted oil companies due to continued road blocks and sit-ins. Protest leaders in Kamour called for continued demonstrations and expressed a willingness to negotiate with the government.

Tunisia: Union calls three-day strike of petroleum employees in Tataouine on 17 May
On its Facebook page, the Tataouine Regional Labour Union called for a three-day strike of oil company employees with the Sitep oil company from 17-19 May. In an 8 May post, the union called for a protest in front of the company headquarters. Repeated attempts at negotiation with company officials failed to avert the industrial action. The strike comes amid a series of protests by unemployed groups in the region over development and job opportunities.

Libya: Assailants attack pipeline leading to Mellitah terminal
According to local media reports on 3 May, the Facebook page of the Petroleum Facilities Guard said that unidentified assailants attacked the pipeline connecting the el-Feel oil field to the Mellitah terminal at valve number 113 on the pipeline, around 50 km south of Zintan. Initial reports did not confirm whether pipeline operations were affected. The incident comes days after the el-Feel and Sharara oil fields resumed operations on 27 April.

Finding Petroleum: Finding Petroleum Opportunities In The Middle East - The Geological Society, London, May 16 2017

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