Eco Atlantic Oil and Gas

Guyana: demystifying the heavy sour implications

Tertiary play: still a good chance that the Jethro discovery is commercial

Given the sharp share price sell off seen of the Guyana focused E&P companies last week, following the announcement that the Jethro discovery contained heavy and sour crude, we believe it is useful to provide some context around this. Our view is that Jethro still has a good chance of being a commercial discovery as there are positive factors such as the temperature of the crude, the over-pressured, high-quality reservoir sands and the crude viscosity that offset the fact it is heavy and sour. Eco highlighted that the crude tested to date appears not dissimilar to the commercial heavy crudes currently in production in the North Sea, Gulf of Mexico, the Campos Basin in Brazil, Venezuela and Angola. This is supported by the commentary from Hess on its Tertiary Hammerhead discovery, which is heavier than the Cretaceous discoveries on the Stabroek block.

Cretaceous play: low probability of heavy/high sulphur crude on Orinduik

We do not believe that the Tertiary results (shallower targets) have any significant bearing on the Cretaceous plays (deeper targets with 3bnboe of unrisked prospective resource) on the Orinduik block for a variety of reasons including: the likelihood of a different source rock, the deeper burial (the oil should be lighter) and the fact that the multitude of Cretaceous discoveries made by Exxon/Hess on the adjacent block are much lighter and sweeter than Joe. On the adjacent Kanuku block (Repsol, Tullow, Total) the Carapa well in the licence, is currently drilling a Cretaceous play. Success here would further derisk some of the large Cretaceous prospects on Orinduik. The well started at the end of October, with results expected before the year-end. Following this Eco is expected to release an update CPR in January 2020.

Hammerhead read across: commercial discovery that extends onto Eco's block

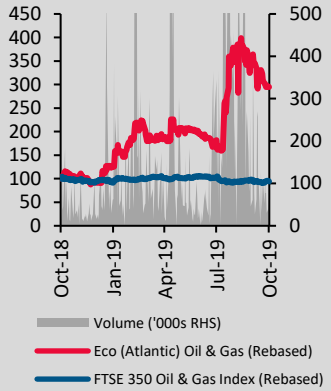
The Hammerhead discovery, like Jethro and Joe is also Tertiary in age. It is heavier than the Cretaceous discoveries and reportedly saw positive flow tests. Hess commented recently that they drilled three wells on the discovery and were unlikely to have done this if they didn't believe it was commercial. Hess and Exxon have already decided on the first 3 FPSOs on its Stabroek block and Hess commented that Hammerhead is highly likely to be the 4th or 5th FPSO development to be sanctioned.

Valuation update: we continue to see >300% upside to our risked NAV

We have cut our risked NAV to 216p/sh from 295p/sh as we have taken a 30% haircut to the NPV/bbl of the Tertiary discoveries and prospects and also decreased the chance of commerciality. Our NAV is based on a flat long-term oil price of US$70/bbl and a 12% discount rate. Eco remains well funded with a current cash position of US$21mm. The unrisked value of all the Guyana prospects and discoveries is >£15/sh. Eco also continues to advance exploration and value creation on its four Namibian offshore blocks, where it is seeing increased inbound interest and drilling activity in the region. A further update for drilling plans for next year on the Orinduik block will be made in January 2020.

GICS Sector	Materials
Ticker	AIM:ECO
Market cap 20-Nov-19 (US$m)	120
Share price 20-Nov-19 (GBp)	50

Risked NAV	p/sh
Core	15
Guyana discoveries	85
Guyana exploration	188
Namibia exploration	4
Total NAV	**295**



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Tertiary oil play in Guyana

Given the sharp share price sell off seen of the Guyana focused E&P companies last week, following the announcement that the Jethro discovery contained heavy and sour crude, we believe it is useful to provide some context around this. Our view is that Jethro has a good chance of being a commercial discovery still as there are positive factors such as the temperature of the crude, the over-pressured, high-quality reservoir sands and the crude viscosity that offset the fact it is heavy and sour. This is supported by the commentary from Hess on its Tertiary Hammerhead discovery.

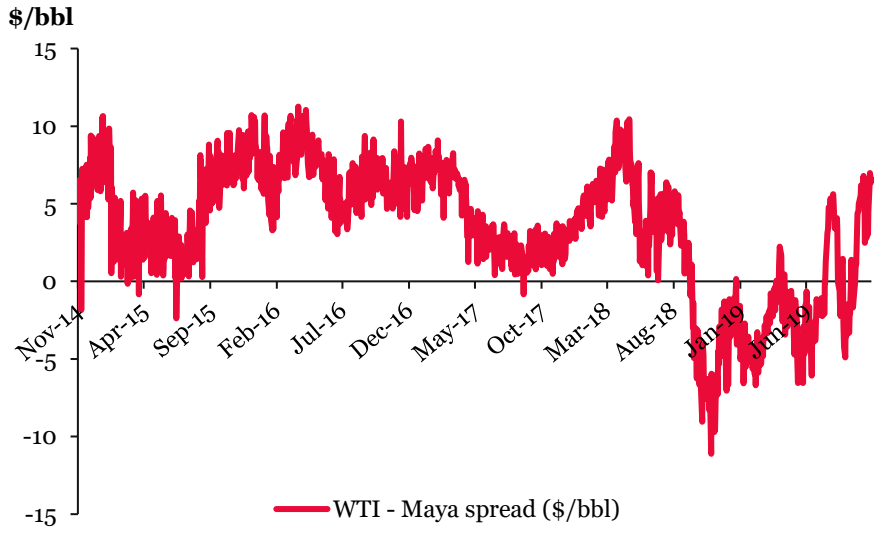
Secondly, we do not believe that this result has any significant bearing on the Cretaceous plays on the Orinduik block (3bnboe of gross unrisked prospective resources) for a variety of reasons including: the likelihood of a different source rock, the deeper burial meaning the oil should be lighter and the fact that the multitude of Cretaceous discoveries made by Exxon/Hess on the adjacent block are much lighter and sweeter than Joe.

We are taking a closer look at the factors that affect the commerciality of heavy and high sulphur oil. Heavy oil contains less of the light ends (e.g. gasoline and diesel) and more of the heavier compounds (e.g. fuel oil and bitumen). High sulphur crude is corrosive and needs to have the sulphur removed.

Pricing

Heavy, sour crude trades at a discount given less favourable yields of the more desirable light products. However, recently there has been a reduction in the discount for heavy sour crude as production has declined in the key producing regions of Mexico (e.g. Maya crude) and Venezuela (e.g. Boscan). Also, there has been dramatic growth in lighter crude production from the US, following the shale boom, where many of the refineries were geared to take in heavier crudes. There are a number of refineries that aren't designed to take lighter crude and so there is strong demand for the likes of Maya crude (22° API and 3.3% sulphur). Therefore, there have been times this year that Maya crude has traded at a premium to US WTI crude (40° API and 0.2% sulphur).

WTI and Maya crude price differential ($/bbl)



Source: H&P estimates, Bloomberg

High sulphur, heavy oil development

The Tambaredjo field in Suriname produces onshore oil of 14-16° API (albeit sweet) from the Tertiary. The Jethro discovery is estimated to have an API of ~13-15° and a sulphur content of 3.5-4%. This is heavy and high sulphur but there are grades of crude that are produced that are heavier and higher sulphur. Although there is focus on the crude being heavy (low API), the more important indicator of producibility is the oil viscosity.

For example, Venezuela's Boscan crude grade has an API of 10.1° and a sulphur content of 5.4%. The viscosity of Venezuela's Orinoco extra-heavy crude oil lies in the range 1000–5000 cP, which is quite high viscosity. The crude from the Joe discovery has a much lower viscosity of 125cp, which means it should have better flow characteristics.

There are numerous examples of heavy and/or sour offshore developments worldwide. In the UK a number of heavy oil fields have been developed with the benefit of horizontal wells. The Captain field with 88cp viscosity is a prolific producer. Also, for example, Equinor's Mariner field has crude in the Heimdal reservoir which has a lower API than Joe at 12.1° and a higher viscosity but is still producible.

The sulphur content of the crude is high but there are fields with significantly higher sulphur contents that are produced from globally. It is more difficult offshore given that the sulphur needs to be removed and reinjected from the offshore production facility, however this appears to be viable.

The partners on the Orinduik block have used a specialist consultancy to scope out different potential development scenarios for Jethro. They looked at nine different scenarios with different equipment on the topsides and in all scenarios the developments screened as economically viable.

There are a number of things that the Jethro discovery has going in its favour. First the reservoirs have high porosity and high permeability, which is positive with regards to potential flow rates. This is enhanced by the fact that the reservoir is significantly over-pressured and thick. The high reservoir temperature of 940C should also help with producibility. Finally, the attractive fiscal terms and PSC cost recovery mechanism helps with the economics in the case of higher capex. For example, even if we increase the capex by 50% versus the base case developments in Guyana, the oil price break-even is still <US$40/bbl.

Hammerhead: a commercial discovery

Hammerhead is a major discovery made by Exxon/Hess on the Stabroek Block, which extends onto the Orinduik Block. Eco believes ~10% of Hammerhead could lie on its block and Hammerhead could be 400-800mmboe gross (Hess has talked about "a pretty big tank of oil"). EcoAtlantic's last CPR (prior to the appraisal wells) only gave credit for 2mmboe net to Eco and we recently increased this to 13mmboe based on 600mmboe gross, with 10% on the Orinduik block. This gives a risked value of 12p/sh or 19p/sh unrisked. The Hammerhead discovery has also de-risked Eco's Iatuk prospect, which ties into Hammerhead based on the seismic interpretation.

The Hammerhead discovery is also Tertiary in age, and is heavier than the Cretaceous discoveries and reportedly saw positive flow tests. Hess commented recently that they drilled three wells on the discovery and were unlikely to have done this if they didn't believe it was commercial. Hess and Exxon have already decided on the first 3 FPSOs on its Stabroek block; Hess said that Hammerhead is highly likely to be the 4th or 5th FPSO development to be sanctioned.

Previously, Hess confirmed at its Q3'19 results that drilling and appraisal activities were completed at Hammerhead with encouraging results, including a successful drill stem test. These results are being evaluated for a potential future development. Well results for both Hammerhead-2 and Hammerhead-3 demonstrated three things that bode well for development. First both had high-quality reservoirs. The DST on Hammerhead-3 showed very good mobility. Finally, very good connectivity between all 3 wells (i.e. all 3 wells are in pressure communication).

Valuation

Asset	Country	Interest	Net Mmboe	US$/boe	Unrisked US$m	Unrisked p/sh	eologic CoS	Commerical CoS	Risked US$m	Risked p/sh
2019 G&A					-$1.4	-0.6p			-$1.4	-0.6p
Warrants and options					$2.4	1.0p			$2.4	1.0p
Apr '19 equity raise					$16.2	6.7p			$16.2	6.7p
End '18 cash					$19.8	8.3p			$19.8	8.3p
End '18 w/c					$0.1	0.0p			$0.1	0.0p
Core NAV					**$37.1**	**15.5p**			**$37.1**	**15p**
Hammerhead/Aurituk	Guyana	15%	9	$5.2	$46	19p	81%	75%	$28	12p
Jethroe	Guyana	15%	38	$3.6	$135	56p	80%	50%	$47	20p
Joe	Guyana	15%	22	$3.6	$80	33p	80%	50%	$29	12p
Discovered NAV					**$261.7**	**109.1p**			**$104.6**	**44p**
Exploration										
Jethro Ext	Guyana	15%	7	$3.6	$25	10p	60%	50%	$3	1.2p
Jimmy/MJ-4	Guyana	15%	5	$5.2	$27	11p	60%	50%	$4	1.6p
Iatuk	Guyana	15%	94	$5.2	$485	202p	22%	66%	$66	27p
KD	Guyana	15%	100	$5.2	$516	215p	22%	66%	$70	29p
KB	Guyana	15%	36	$5.2	$188	78p	21%	66%	$20	8.4p
KG	Guyana	15%	95	$5.2	$490	204p	22%	66%	$66	28p
Rappu	Guyana	15%	80	$5.2	$414	173p	25%	66%	$63	26p
Mako	Guyana	15%	38	$3.6	$135	56p	30%	50%	$16	7p
Tuktuk downdip	Guyana	15%	30	$3.6	$108	45p	30%	50%	$12	5p
Tuktuk updip	Guyana	15%	30	$3.6	$108	45p	30%	50%	$12	5p
Malone	Guyana	15%	30	$3.6	$108	45p	30%	50%	$12	5p
Amaila	Guyana	15%	38	$3.6	$135	56p	30%	50%	$16	7p
Osprey	Namibia	58%	164	$4.7	$764	318p	18%	20%	$7	3.1p
Guy, Sharon, Tamar	Namibia	Varies							$10	4.2p
Exploration NAV					**$3,503**	**1460p**			**$376**	**157p**
Total NAV					**$3,801**	**1585p**			**$518**	**216p**

Source: H&P estimates, Company Data

Heavy oil and sulphur production mechanisms

Crude can be heavy or light and high (sour) or low (sweet) in sulphur. It is possible to have heavy sweet or light sour crude. Crude becomes 'heavy' as a result of biodegradation, in which lighter ends (e.g. gasoline) are preferentially consumed by bacterial activity in the reservoir, leaving heavier hydrocarbons (e.g. bitumen) behind. At greater depths, the bacteria do not tend to be present lowering the chance of biodegradation.

In terms of sulphur production, which causes the crude to be sour, it is important to understand that there are 4 mechanisms that can produce H_2S which we explain in detail below:

ONE: Microbial Sulfate Reduction (MSR): this is unlikely to have occurred

This is an aerobic reaction where bacteria eat the lighter hydrocarbon chains and produce H_2S as a waste product. Industry wisdom is that this doesn't occur above 70°C. Also, given the bacteria needs a source of oxygen, the reaction takes place at the oil water contact.

We know the reservoir temperature is 94°C (too hot). MSR typically is concentrated at the water contact – i.e. not the crestal location targeted by an exploration well. There is a chance the target formations were previously buried shallower (which would enable biodegradation and explain why the oil is heavy), but this seems unlikely given the reported strong overpressure.

TWO: Thermochemical Sulfate Reduction (TSR): most likely mechanism

An anaerobic reaction whereby Sulphur + Hydrocarbon => Methane + Water + CO_2. Main ingredient you need is a source of sulphur – either in the source rock, the migration pathway, or the reservoir. This occurs in the range of 20°C – 200°C. We discuss this in more detail on the next page.

THREE: Thermal Decomposition Reduction (TDR): least likely in our view

An anaerobic reaction whereby longer chain hydrocarbons containing naturally occurring sulphur "crack" at high temperatures emitting H_2S. Volumes of sulphur are small, so industry wisdom is can't produce above 5% H_2S (often much less). It needs temperatures in excess of 300°C for the reaction to occur in any meaningful quantity. Given the temperature window for this reaction to occur, you would have gas-condensate rather than an oil discovery. Therefore, this is the least likely explanation.

FOUR: Wild card

A "wildcard" is incompatibility of drilling mud – i.e. the reservoir isn't sour but fluid sampling indicates it is. External sources of gas such as secondary charges, volcanoes, or shallow gas. There are no igneous rocks at depths >4,000m to suggest volcanic activity. Could you have other sources in the gas window that generate H_2S? Maybe, but you would probably expect to see evidence of this in Stabroek too.

Thermochemical Sulfate Reduction

TSR is the most likely the mechanism – you need to establish the source of the sulphur to understand whether this has a read-through to other areas.

ONE: Source Rock (unlikely unless second source rock)

We know the Canje source rocks are marine shales which are not prolific producers of H_2S. The Stabroek block Cretaceous discoveries are (vertically) closer to the source rock (see diagram of stratigraphic column below) so would be more likely to be sour (which they are not). Eco believes that there may be a second source rock at play from the Venezuelan side where some of the crude has similar heavy/sour properties.

TWO: Migration Pathway (could go either way)

Sandstones tend to be higher in iron (which scrubs out H_2S) whereas carbonates are higher in sulphur (which adds H_2S). In the stratigraphic column below, sandstones are yellow whereas carbonates are indigo. As Orinduik and Kanuku are up-dip from Stabroek, there's a further distance to travel, which either allows H_2S to either be scrubbed out or added en-route. An important differentiator is that carbonate content reduces beyond the shelf (i.e. with depth), which may explain why the deeper Exxon Tertiary discoveries appear not to have H_2S. This is illustrated spatially (see map below) where only Hammerhead 13,682' to Tertiary was drilled near the shelf. Jethro was 14,000' deep to the Tertiary compared to 16,500-18,800' for the rest of the Exxon Tertiary targets (Pluma, Tilapia, and Yellowtail)

THREE: Reservoir (likely)

It is clear from the stratigraphic column below that the Joe and Jethro targets sit in sands in between interbedded carbonates – provides a plentiful source of sulphur. This may also explain why the oil is heavy – the reaction with sulphur strips the lighter ends of the oil, which together break the seal leaving only heavy oil behind. Given that both wells are apart and target different horizons, would imply this is not a reservoir-specific issue and is likely to be more widespread in the region.

Guyana stratigraphic column and acreage map

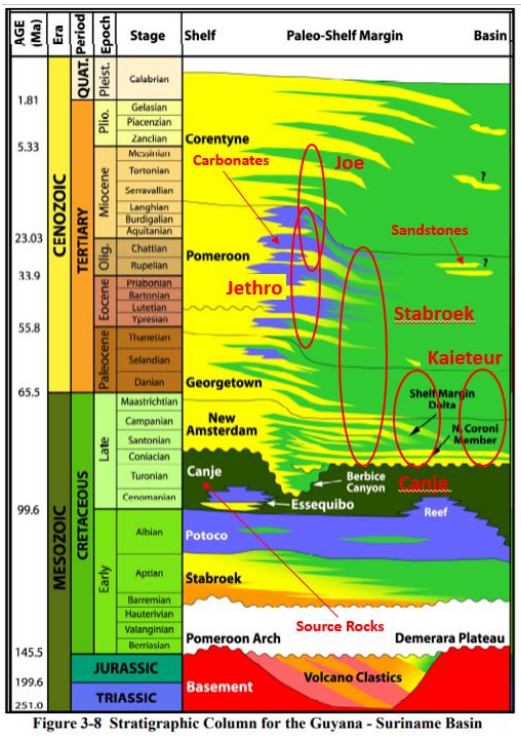
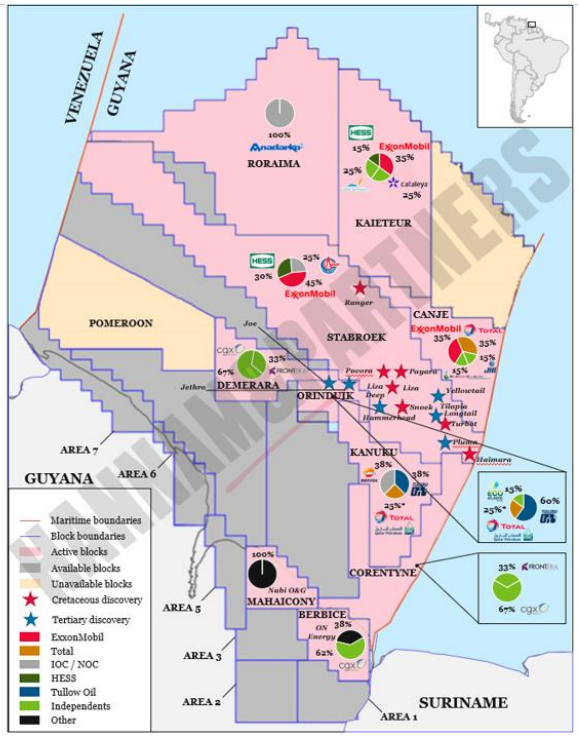


Figure 3-8 Stratigraphic Column for the Guyana - Suriname Basin



Source: H&P estimates

Conclusions

Our main takeaways about the source of the sulphur are that it is most likely to have occurred through Thermochemical Sulfate Reduction. This means that the high sulphur is likely to be widespread in the Tertiary plays in the Kanuku and Orinduik blocks. However, this explanation means that the Cretaceous plays on these blocks are unlikely to encounter high levels of sulphur. In terms of the heavy oil, this is more likely related to the depth of the reservoirs, so the Cretaceous plays should be significantly lighter.

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