

July/August  
2020

# **SPE** Review London

The official e-magazine of the Society of Petroleum Engineers' London branch

## **Virtual rocks: Imaginary field trips for invisible students**



**PLUS:  
London section  
recognized  
for excellence!**

- \* **Machine learning and AI: Part two**
- \* **C-level talks: Philip Whittaker, BCG Partner**
- \* **Book Review: Disentangling the economics of oil & gas**



**BEHIND THE SCENES**

**LETTER FROM THE NEW CHAIR**



# SPE Review London

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## ABOUT US

The Society of Petroleum Engineers (SPE) is a not-for-profit professional association whose members are engaged in energy resources, development and production. SPE is a non-profit professional society with more than 156,000 members in 154 countries, who participate in 203 sections and 383 student chapters. SPE's membership includes 72,000 student members. SPE is a key resource for technical knowledge related to the oil and gas exploration and production industry and provides services through its global events, publications, events, training courses and online resources at [www.spe.org](http://www.spe.org). SPE London section publishes SPE Review London, an online newsletter, 10 times a year, which is digitally sent to its 3000+ members. If you have read this issue and would like to join the SPE and receive your own copy of SPE Review London, as well as many other benefits – or you know a friend or colleague who would like to join – please visit [www.spe.org](http://www.spe.org) for an application form.

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## CONTACTS

Communications: [spelondon@spemail.org](mailto:spelondon@spemail.org)

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## Behind the Scenes: SPE Review Editorial Board



### Elizaveta Poliakova, Editor in Chief

Elizaveta is a Reservoir Engineer at Trident Energy Management Limited. She has a Master's of Science in Petroleum Engineering from Imperial College London and a Bachelor's in Petroleum Engineering from the University of Leeds.

Elizaveta has been with SPE for more than five years. She was the President of SPE Imperial College Chapter and the President of SPE Leeds Chapter. Previously, she was also on the committee of SPE YP.



### Josh Beinke

Graduated from University of Adelaide in 2008 with a Petroleum Engineering degree. Moved to Europe in 2016, and working as a Production/Exploitation Engineer with Vermilion Energy.



### Mark Beleski

Experienced engineer, with deep understanding of industry practices, trends and challenges. Energy Loss Adjuster with AqualisBraemar, in London.



### Ffion Llwyd-Jones

Business editor and writer. Finding, explaining and sharing stories that people can understand and relate to. International experience in technology, environment, and animals as therapy.



### Justin Reynolds

Business writer focused on the energy and finance sectors. Currently writes for financial journals, has worked as communications officer for an oil & gas start-up, and features writer for The New European.

**A big Thank You! to all the organisations that support the SPE London section**



## Letter from the NEW SPE London Chair



Dear SPE London members and colleagues,

Welcome to the August issue of the SPE Review. I hope that you are all remaining safe and well as the Covid19 pandemic continues to affect our daily lives.

I want to introduce myself to you as I am the new Chair of section and will hold the position until June next year. I'm Adrian Southworth and have been an SPE member for over 30 years. Not surprisingly, much has happened over that time, some good and some not so good. My background is one of broad subsurface engineering coupled with an early stint in drilling. I've held technical leadership positions as well as being a single practitioner. I left my last employer, BP, during 2016 post the oil price fall of 2014 where I was leading efforts in unconventional development and supporting development of graduate engineering talent. I am currently running my own business which focuses on offering engineering services to support gas developments worldwide with a more recent focus on establishing a fugitive gas emissions management offer to the industry.

I'm grateful that many of the existing board members and committee leads are remaining in place and I look forward in working with them in what will be a challenging year. I would also like to recognise Adam Zalewski who will be acting as Chair elect. It is one of my goals to ensure that Adam is fully involved this year so that our initiatives can be continued into his chairmanship.

The last SPE year has been one of considerable volatility where we have seen the impact of over supply and curtailment in demand of oil due to the worldwide impact of Covid 19 both of which have contributed to a significant reduction in oil price both early in 2020 and potentially into 2021.

Despite this negative backdrop the section has remained resilient and has had to adjust its behaviour like so many businesses. That resilience was recognised by SPE International in awarding an excellence award to the section. You will see the award logo appearing on the section website, in the SPE Review London and in social media communications. My thanks go out to the outgoing Chair Maxim Kotenev for his leadership during these difficult times.

Turning now to the new SPE year. The volatility seen in the first half of 2020 has lessened, nevertheless significant challenges remain. Like many other organisations we are becoming much more familiar with communicating via web enabled systems such as Zoom and Teams. We will be continuing in this manner until the board is assured that running physical events poses little or no danger to participants. As an example you will be seeing promotional material for the forthcoming Virtual Upstream Finance and Investments Conference scheduled for 11 -12 November which is being organised as a joint event between the London Section and SPE International. There will be more information about this event in the coming weeks so check out the section website [www.spe-london.org](http://www.spe-london.org) and watch out for more social media communications. Additionally, the Distinguished Lecturer program remains in place, however presented virtually. There are a number of events across the European Region starting early September and running through into December. The first DL event for the London section is on 27th October so please watch out for how to access this and other DL events as they are SPE specific and not available through commercial communication platforms.

As I'm embarking on a new SPE chapter I thought it useful to review the comments of the outgoing SPE President on what themes she thought the organisation should address. Her thoughts are in the latest edition of the JPT. Most SPE London members could relate to her comments, however the one that resonated with me the most was how to strengthen the feedstock of incoming talent to our industry.



## Letter from the NEW Chair continued

For me this is our most pressing and difficult challenge and we are meeting this by two initiatives that I hope the membership will actively support.

A new committee section has been established, currently titled NetZero, led by Alison Isherwood that will reinvigorate the section's schools out-reach program with a focus on creating an engaging message around industry efforts to reduce carbon dioxide and methane emissions – the so called Net Zero aspiration voiced by many leaders within the oil and gas industry. Alison and her team will be providing material to share with the membership on this very topical issue in the coming months through the SPE Review, website resources and social media communications.

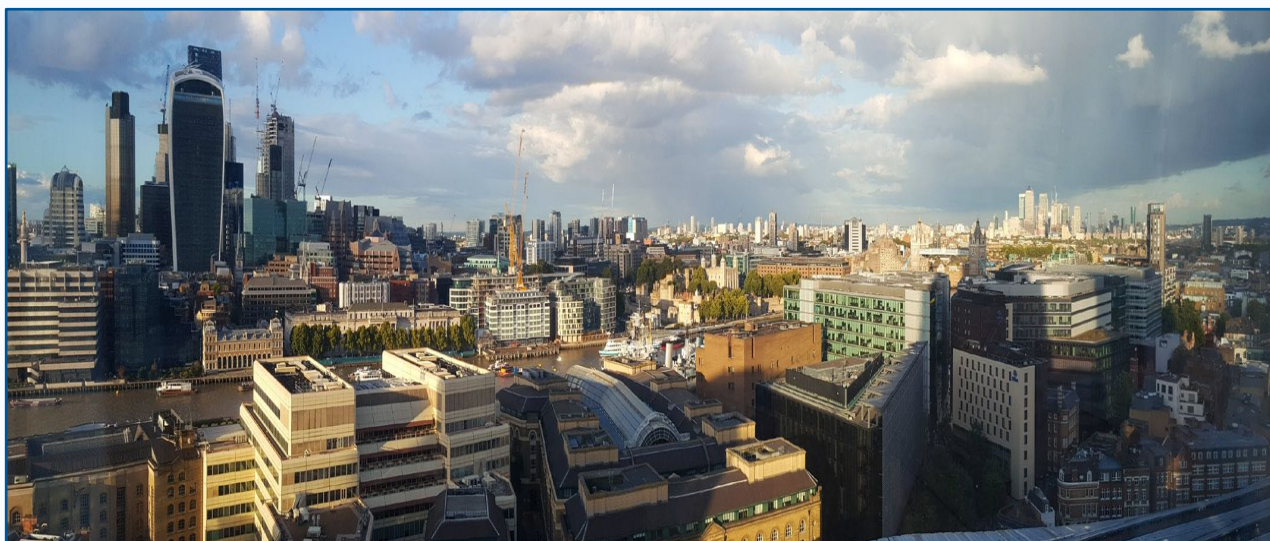
The section continues to support the Arkwright Engineering Scholarship program for upcoming talented A level students. We have endorsed our second scholar this year and have made a commitment in future years to ensure that there are more candidates from a broader ethnic mix and studying in less fortunate circumstances.

Many of our membership also have allegiances with other technical organisations such as IChemE and PESGB. These organisations are experiencing many of the same issues as we are and I would encourage you to share ideas and thoughts about how your partner organisations are coping with the significant changes (& opportunities) the oil and gas industry currently faces. One area I am particularly keen to hear about is skills and knowledge transfer. Attracting new and maintaining existing membership is an issue that each SPE section faces and is particularly prescient at this time. SPE International is offering a number of membership initiatives to reduce the financial burden of membership. To ensure that you get the best value from your subscription go to [www.spe.org](http://www.spe.org) and look for free webinars, discounts on learning events and subscription offers.

As you are aware the SPE London section is a volunteer run organisation. I'm proud of the commitment and efforts that many of our volunteers put into running the section. Notwithstanding that we are always pleased to hear from members wishing to contribute to building the section's success. 2020 was a great year and I hope that we can make 2021 equally as successful. Please feel free to contact me at [spelondon@spemail.org](mailto:spelondon@spemail.org) on how the section can remain relevant to the membership.

I look forward to sharing our 2021 SPE London journey together.

Adrian Southworth, SPE London Chair





## Letter from the Editor

Dear SPE members and colleagues,

Happy New SPE Year!

We are delighted to share that SPE London has won the Section Excellence award for 2020! This award is given to a section for achieving an admirable level of success and is the second highest honour that any SPE section can achieve. On this positive note, please give a warm welcome to Adrian Southworth, our new Chair, and Adam Zalewski, our Chair-Elect. Likewise, we would like to express our immense gratitude to Maxim Kotenev, our past Chair, for his enthusiasm and leadership.

In this publication, SPE London continues its trilogy on Machine Learning and Artificial Intelligence applied to Oil & Gas, written by Cameron Snow, co-founder at Danomics LLC. This month's C-Level Talks features an exclusive interview with Philip Whittaker, who is a Partner at Boston Consulting Group for the Oil and Gas sector, while the special book review focuses on 'The Economics of Oil & Gas', by Xiaoyi Mu. The book provides a good flavour to the upcoming SPE Upstream Finance and Investments Conference, which will be held online on the 11th and 12th of November.

Not only has COVID 19 nudged most O&G conferences to go digital, but it also affected the majority of schools and universities. In this issue, Professor Paul Glover shares his experience on delivering a Virtual Field Trip to the final year students of Petroleum Engineering, Geology and Geophysics at the University of Leeds. I have acted as a demonstrator on the same field trip a year ago – and it was already a challenge to do it in person!

Moreover, I would like to congratulate Adam Borushek and Adam Zalewski on holding a successful SPE networking event via Zoom using breakout rooms. You can find more information on page 13. All members are welcome to join our next session!

Finally, I would like to thank our Editorial Team at SPE Review London for their efforts, energy and support. Your dedication is the fuel behind our magazine!

Take care and stay safe!  
Elizaveta Poliakova



# NEWS DIGEST... NEWS DIGEST... NEWS DIGEST

## 15% of UK North Sea platforms could be re-used for CCS

A new study from Boston Consulting Group estimates that up to 15% of the UK's North Sea oil platforms could be re-used for carbon capture and storage to meet its target under the Climate change act.

According to the CCUS Cost Challenge Taskforce, the UK will need to capture and store between 60 and 180 metric tonnes of carbon dioxide (low-high case scenarios) to achieve net-zero goals.

[Link here for full story](#)

## Ahead of the US Presidential elections – Energy is pivotal

Ahead of the American Presidential elections this November, Joe Biden, Former Vice President of the United States, wants to appropriate \$2tn to “use climate policy to drag the economy out of its pandemic-era recession”.

With the current pandemic crisis

and diminishing green energy costs, the value seems feasible. The aim is to make the electricity sector ‘carbon-free’ by 2035 while scaling up carbon capture and storage facilities.

[Link here for full story](#)

## OGUK introduces initiative to support small businesses

The Oil and Gas UK introduced a forum launched by its Continuous Improvement team to support small to medium businesses during the offshore O&G downturn.

The forum allows OGUK's businesses to “support guidance and initiatives, and the opportunity to identify and address issues affecting SMEs and to collectively formulate solutions.”

The forum will also include political updates and their impact on the industry and its supply chain.

[Link here for full story](#)

## Oil & Gas Sector goes digital

The necessity to cut costs as a consequence of the current crisis has proved that the Oil and Gas industry functions efficiently when working from home.

Both operators and service companies reported that the majority of drilling activities are being supported remotely.

[Link here for full story](#)

[And here](#)

## Oil price hits five-month high

Oil prices rose to a five-month high, supported by recent stimulus from China's central bank. Hopes of an increase in fuel demand are justified due to expectations of economic recovery.

After a 10% cut of global supply due to demand contraction, OPEC + is planning to add back about 1.5 million barrels of daily production to the market this month.

[Link here for full story](#)

## Section excellence award



The London Section has been awarded the [Section Excellence Award](#) for 2020.

The award states:

"This prestigious award is the second highest honor a section may receive and is awarded to only 20% of eligible sections around the world.

The award is in recognition of your section's hard work and strong programs in industry engagement, operations and planning, community involvement, professional development, and innovation. We know the past year has been unique, and we thank you for continuing to fulfill SPE's mission and serve your members."



## NEWS In memorium: Professor P.F. Worthington



Paul Francis Worthington was born on 8 August 1945 in Preston, Lancashire. The son of a headteacher and an assistant headteacher, he attended St Mary's College, Blackburn, and remained proud of his northern English roots throughout his life.

After taking a Bachelor of Science degree in Maths and Physics from the University of Hull, UK, he taught for a year at Kilburn Polytechnic in London. A late-night conversation at a party introduced him to geophysics, and that chance encounter set him on the path that defined his academic and professional life.

Thereafter Paul's academic career took him first to an MSc. in Geophysics at Durham, then to the University of Birmingham, UK, where he both earned a PhD researching the petrophysics of the Sherwood Sandstone Group, and met Catherine, his wife of almost 50 years. He started his technical career in the water industry with five years in Pretoria, South Africa, during which he became Chief Research Officer with the South African Council for Scientific and Industrial Research and was awarded a D.Sc. by the University of Pretoria. After his return to the UK he spent two more years in the water industry with Howard Humphreys & Partners in Reading, before moving into the oil industry with BP in 1980.

Within BP, he rose to become Head of Formation Evaluation at the BP Research Centre in Sunbury-on-Thames, England, promoting study of both the theoretical side of petrophysics and the use of core data as an aid to integrated reservoir characterisation - especially in reservoir formations that contained appreciable amounts of clay. After BP he joined the petroleum engineering consulting firm, GaffneyCline, based in Hampshire, UK and Singapore, where he concentrated on matters of equity redetermination and reserves estimation.

Paul was devoted to the pursuit of excellence and to sharing his knowledge for the benefit of the industry. He published more than 100 peer-reviewed papers in the fields of engineering geoscience and petroleum unitization and coedited four books on core and log analysis. More than a few of Paul's papers are considered seminal within their subject areas and must be referenced in any relevant research. He served the Society of Petrophysicists and Well Log Analysts both locally in London and served on the main body of the SPWLA in many roles, including as its President (1985–1986). In addition, he co-chaired four topical conferences and the first Annual Symposium of the Society to be held outside of the USA, in London in 1987. Despite a downturn in the oil and gas industry, Paul's vision and drive ensured that the event was a technical, social, and financial success.

Paul was the recipient of numerous SPWLA Awards for technical achievement and service, including the society's top honour, the Gold Medal for Technical Achievement (2012).

Outside of SPWLA, from 1986–1992 he served as Chairman of the Downhole Measurements Panel of the International Ocean Drilling Program and was for 10 years a co-editor of Petroleum Geoscience for the Geological Society of London. He was also active in the London Section of the Society of Petroleum Engineers, being a guest speaker from time to time at their monthly meetings.

Paul's determination was legendary. As a young man, he was a football (soccer) goalkeeper of formidable reputation and became a lifelong fan of Manchester United. Wherever in the world he travelled, he would go to great lengths to do two things - watch the latest match of the 'Red Devils' and attend Mass. As both a scientist and a committed Christian, the Catholic faith played a huge role in Paul's life. He was an active parishioner in the parish of St Francis, Ascot, for almost 40 years, where he taught the children's liturgy, was a regular reader and edited the parish magazine. In later life he was honoured to be invited to become a Knight of the Holy Order of the Equestrian Sepulchre of Jerusalem.

Paul continued his pursuit of learning and education right until the end. His final academic achievement was consolidating the legal side of his unitization experience into an LLM by Research at the University of Reading, UK. This work is now published as his final legacy, 'The Law on Petroleum Unitization'.

Paul is survived by his loving wife Catherine, his children Michelle, Mark and Tim and his four grandchildren.



# Machine Learning and AI applications in Oil & Gas, Part 2



In the second of a three-part series, Cameron Snow (co-founder, Danomics), provides an overview of existing applications of machine learning and AI, and where opportunities are ready to be seized.

In my previous article, I outlined the broad potential that machine learning and AI have in the oil and gas space. In this article, I cover some of the steps that companies need to take to set the stage so that they can successfully utilize these technologies to drive their business.

The oil and gas industry has historically been data driven. From the earliest commercial seismic surveys to Schlumberger's first wireline logging jobs the industry has always sought to leverage data to drive their business. In the age of machine learning and AI, data has never been more important. However, for many companies data management has focused on data preservation instead of building and maintaining accessible databases of well-organized, consistent, and clean data.

Regardless of the state of your company's current data, it is never too late to make the transition to a data driven organization that treats data as an asset and source of competitive advantage.

## Becoming a Data Driven Organization

When evaluating the decision to move your company towards being data driven it is important to honestly assess the current state of your data management and consider the following:

- What will it take to get my historical data into the formats and systems required to use it effectively?
- What will it take to establish a system to capture data point forward?
- What cultural changes are required to ensure data is entered into those systems.

The first question is largely one of time, money, and manpower. Working through a company's network drives, staff computers, and even potentially email archives to find all the relevant data will be non-trivial for most companies. Outsourced solutions will typically provide the most consistent results, but in downturns such as the current one, there will rightly be a desire to preserve jobs and use existing internal resources. Whether the work is done by existing staff, new hires, or third-party contractors/vendors there is no free lunch – moving data from an old (potentially chaotic) system of data management into a new, modern system of data management will require a significant investment.

The final two questions are more of company culture and systems. Companies must have systems in place such that petro-technical employees can get their data into it without undue burden. In many cases this will require enforcing accountability and incentivizing compliance, as well as ensuring that management not only embraces, but actively champions, the process.

## Data's Value Proposition

Data management should create value. Multiple studies have shown that significant employee time is spent searching for and accessing the relevant data. The best answer to "Where can I find this data?" should never be "Let me search through my email."

*Value Proposition 1: More accessible and better organized data will reduce the amount of time spent searching for the required data.*

Time-pressure is a constant. Whether it is the race to complete an analysis before making FID, drill a well before concession expiry, or seizing first mover advantage in a new play we are all racing against the clock. In this race there is a tradeoff between completeness and timeliness, and in many cases this means utilizing the



## Machine Learning and AI applications in Oil & Gas, Part 2... continued

data that is currently in hand. A good data management system will minimize this tradeoff.

*Value Proposition 2: More accessible and better organized data will increase the completeness of the data set used for decision making.*

Many disciplines and processes within companies are driven by workflows, and in the early stage of many workflows there are myriad steps related to data QC, standardization, and basic processing. A good data management system will allow users to pull data that has already been cleaned and labelled as ready for use, allowing workers to move more directly into interpretations.

*Value Proposition 3: Good data management will reduce the duplication of effort related to data pre-conditioning.*

There are many additional value propositions for data, but in general they can be summed up as reducing the tradeoff between time and quality.

### Data Management for Machine Learning & AI

Data is the lifeblood of machine learning and AI applications. For many models there is a trend in which the quality of the result increases slowly until a certain amount of data is available for training at which point the quality will improve rapidly with more data. This means that capturing a large percentage of the available data early in the process will allow models to be trained, tuned, and deployed faster.

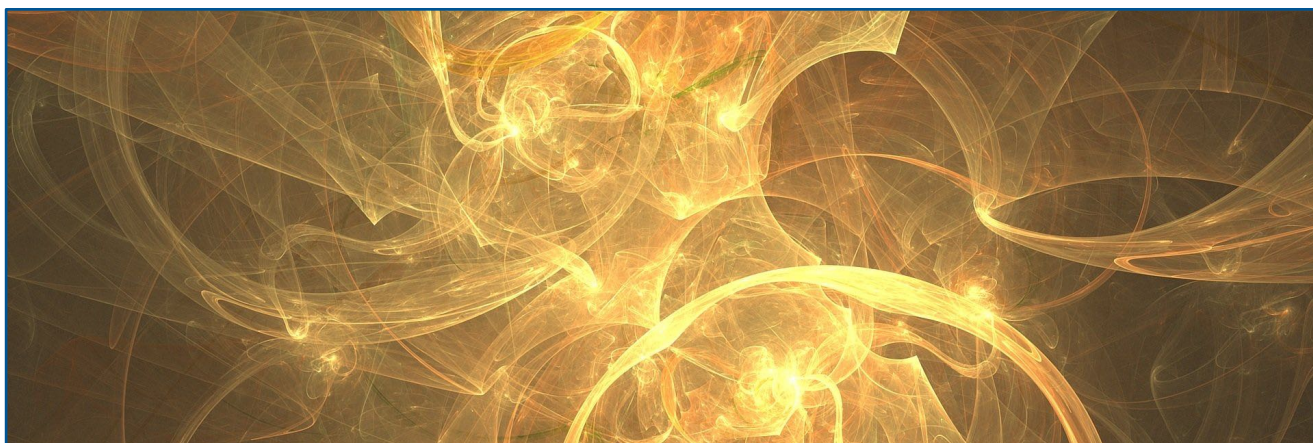
Well organized data is also critical to keeping projects within budgets. Within a data science team it is not uncommon to have 2-3 data engineers for every data scientist – and this is because the data is often in inaccessible and inconsistent formats. Having your data as close to user ready as possible will reduce this ratio and will mean lower overall spends on machine learning and AI model development.

Machine learning and AI models create value once they are productionized and deployed – until then they are simply science projects. Having good data management systems in place will facilitate building a data pipeline that feeds data directly from databases into predictive models so that insights can be acted on continuously.

### Conclusions

Good data management is good business practice. It should increase productivity and enable better decision making. Within the context of machine learning and AI, data management should ultimately lead to better models, faster timelines from project start to model deployment, and reduced costs. Becoming a data driven organization may not be easy if your company is behind the curve, but doing so will pay off in the long run.

**The third part of this three-part series by Cameron Snow will be in the September/October issue of SPE Review London.**





# Putting enjoyment high on the list of criteria against which to evaluate life and career choices



**Philip Whittaker is Partner & Director for O&G area at Boston Consulting Group (BCG).**

He joined BCG in 2007, and is a core member of the Energy practice, specializing in upstream oil and gas and oilfield services and equipment.

He has 25 years' experience in oil and gas exploration and production. As a consultant, he has worked with operators, national oil companies, service companies, and investors in more than 25 countries on a range of strategic and operational issues. He has led and supported over 100 projects in oil and gas covering strategy, growth, operating models, and post-merger integration. He also co-leads BCG's work on E&P Decommissioning. He has published extensively on E&P, and is regularly called upon as an oil industry commentator by sources including the BBC and The Economist.

## Who is Philip? Tell us about yourself.

I'm married with four children, two cats and a new puppy at home in London...the COVID lockdown raised the pressure to get a dog to unsustainable levels and I cracked. My older two kids are both now at University studying to be medical doctors, but the house is still pretty noisy most of the time.

I grew up in the Peak District, but always had a huge ambition to travel, which has shaped many of my choices. I was sponsored by the RAF at school and University, and they taught me to fly when I was 17. But as I finished University, defence spending cuts meant that there was very little flying available for the foreseeable future, and I started to look at other ways to see the world. That's where oil came in.

## Walk us through your career. How did you become a Partner at BCG for the O&G sector?

I began my career at Shell in front line drilling operations. It was, and remains, an exceptional place to start a life in E&P – the investment in structured training was extraordinary, and I spent my early years in wellsite roles from roughneck to derrickman and then on to supervisory positions. I went through the Round 1 and Round 2 well engineering programmes, and I guess will always feel a driller at heart.

I started in the Netherlands – where I met my wife, then a geophysicist at Shell – and went on to spend two years rotating to Peru working on a very remote jungle heli-rig appraisal programme, resupplied by a mix of Hercules aircraft, a Chinook helicopter and hovercraft on the Amazon. It was an incredible

adventure – an operationally and logistically challenging programme under intense scrutiny from environmental organisations in the wake of Brent Spar. I then spent a couple of years rotating as a company man in PDO, Shell's Omani affiliate, running high speed, low cost desert drilling operations – a wonderful country and people. By that time I had a young family, and being away from home for 4 or 5 weeks at a stretch was no longer how I wanted to live. I had also become a bit impatient at the pace of progression in a major operator, so I moved into management consulting – but always with a focus on Upstream. I joined BCG as a Project Manager 13 years ago, initially in Madrid for a couple of years and since then I've been based in London, but always travelled globally. Consulting is heavily based on apprenticeship, and I've learned under and alongside some incredible mentors. You build a broad skill set ranging from strategy, organisation, operational improvement, due diligence and merger integration work. But the great thing about working in a global consultancy is that you also have the chance to get involved in a lot of adjacent topics – from talking oil prices with the CFO of a global airline to working with a Finance Ministry to think about decommissioning liabilities. I've served all of the majors at some point, along with several independents, most of the leading NOCs, and many Private Equity groups. I've now worked with clients in around 30 countries, and I love having not just colleagues and clients but real friends in many of those geographies. And an element of my role is to ensure that we're relevant to the public debate on energy, which has given me opportunities with - for example - The Economist,



## Putting enjoyment high on the list... continued

the BBC and a lot of international media. I know at least my mum and dad tune in.

The career path in consulting is quite demanding, but what I love is that it's very transparent in terms of both pace and performance expectations – a very deep feedback culture means that you always know where you stand. I now co-lead BCG's Upstream business globally along with a close friend and colleague who's based in Paris.

**You've lived and worked in the Netherlands, Oman, Peru, Madrid, and London. What are the main cultural and work differences that you noticed?**

I've always found that many elements of the E&P and consulting cultures are quite consistent irrespective of geography, and then each new location adds a local twist. Wherever you go you'll always find practical people with a bias for action and unafraid to work hard. Sure, there are the cosmetic differences: approaches to hierarchy, trust, relationships and punctuality – but genuine curiosity and respect for people will always serve you well. To be honest the only real deal-breaker I've ever faced was sometimes having to wait until 4pm for lunch in Madrid...

**The standard route to consulting is typically through an MBA, but you transitioned from a technical background. Tell us a little bit more about that.**

The MBA pathway into strategic consulting used to dominate, but the entry routes are more varied these days. I'd guess around half of our senior team has an MBA – but we also have former soldiers, doctors and even drillers. For many people an MBA can be a great way to pivot, build a new skill set and reposition themselves. But it isn't essential. However, if you do enter from a non-MBA background, it takes very focused preparation to succeed in what is a quite specialised recruitment process. Once you arrive the learning curve is steep for everyone, irrespective of where you've come from.

My operational E&P experience gives me, I suppose, a certain level of credibility and empathy with the challenges that my clients are facing, but also - and this is key – a very deep connection with the HSE risks that can be involved. I saw colleagues – tragically - killed and seriously injured early in my

career, so the risks and change management implications of our work are always at the top of my mind.

**What is the difference between working with an O&G operator and serving O&G firms as a consultant?**

The most fundamental difference is that as a consultant you're a service provider - your mission is to serve your client, their Board and their shareholders; it's their business, not yours. You have to be humble and recognise that it's a privilege when clients open their doors and share their challenges with you. And if you aren't committed to making others successful, it isn't the right profession for you. "Clients come first" is one of our core values, and most of us spend 90% of our lives thinking about our clients' businesses, not our own.

Secondly we don't have any assets other than our people, so our people development processes are very, very strong – you can expect to have a meaty performance conversation at least every couple of weeks as a consultant, which is very different from my industry career. As you become more senior, your ability to grow others is just as important as what you can do yourself.

Finally – and this isn't unique to consulting - working in a privately-owned Partnership creates a very special culture, and it's something that I've always loved. It creates enormous mutual accountability, a culture of sharing and very high internal standards. We're harder on ourselves than our toughest clients.

**Looking back to when you graduated from the University of Leeds, what advice would you wish to give to your younger self? Would it be the same advice to those who are about to start their careers in O&G?**

Three things that I lived by then and which have served me well.

Firstly, surround yourself with smart, energetic people. Their energy and behaviours will rub off on you. Second, demand a really steep curve of learning and progression – both of yourself and your employer. Particularly in your early years, if your pace of learning – and capacity to change – slip, you'll never catch up, and you'll lose the ability to learn fast. **And finally, put enjoyment high on the list of criteria against which you evaluate your choices – otherwise what's the point?**



# Online networking: Meet, network, and chat!

Thank you to those who joined SPE London's first online networking and discussion event.

In turbulent times we all need to hear opinions and ideas from each other, but COVID put a stop to that!

We hosted an event to give like-minded people a new type of opportunity to meet, network and make new connections.

Zoom's breakout rooms were used for small group discussions, as feedback showed people feel more comfortable talking in a group of 4 instead of 30. We randomly assigned people into small breakout groups, several times during the event. We hoped to replicate the face-to-face chats we all have during SPE events over drinks, or informal discussions during breaks at conferences.

Several broad topics were selected as a basis for the conversations including:

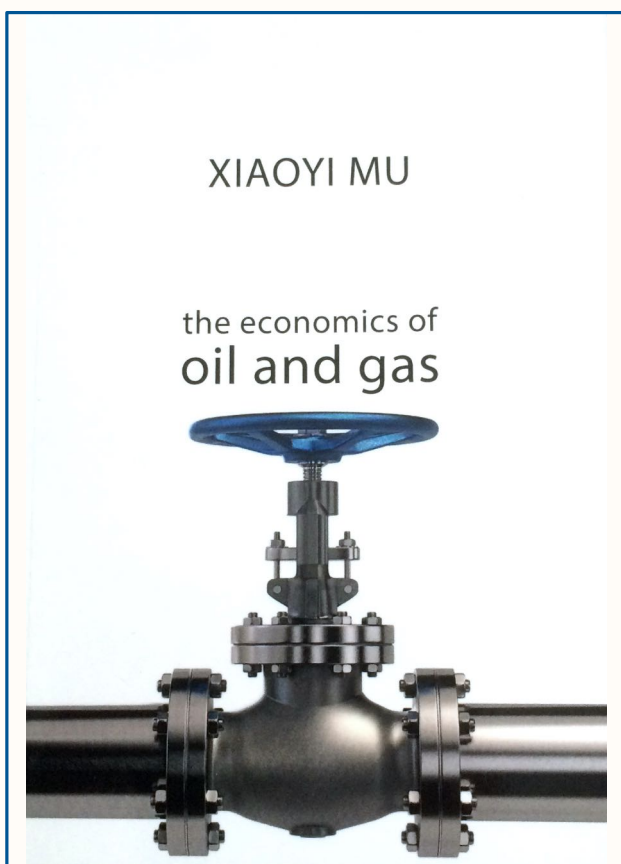
- Oil price predictions
- Experiences and advice on working from home
- Our favourite webinars, recorded lectures and online learning
- Thoughts on career transitions for petroleum engineering skills

Thanks to the organisers, Adam Borushek (RISC Advisory) and Adam Zalewski (BP).



# Disentangling the Economics of Oil and Gas

*Editorial Board member Justin Reynolds reviews The Economics of Oil and Gas by Xiaoyi Mu of the University of Dundee's Centre for Energy, Petroleum and Mineral Law and Policy. Published by Agenda Publishing.*



**The byzantine economics of oil and gas can baffle even industry professionals.**

Just how do companies calculate the risk of committing substantial resources to testing a possible petroleum find amid so many uncertainties? How, given those unknowns, can exploration licences be designed respecting the interests of all parties? How can the security of oil and gas travelling through pipelines and shipping channels that cross volatile borders be assured? Why have so many countries found the presence of significant oil and gas resources to be a curse as much as a blessing? What on earth are hydrocracking, alkylation, isomerisation, delayed coking, and crack spread? Why is the oil price so volatile?

The Economics of Oil and Gas offers a guide to the vexing commercial judgements that accompany each stage of the process of getting oil and gas out of the ground and bringing it to market. Mu's survey seeks to untangle the knotty intricacies of the sinuous network of laws, markets and pricing mechanisms that have evolved through reason, custom, chance and political expediency.

## Filling a gap

The book, which will be of interest to engineers, managers, business writers, marketers and others seeking a bird's eye view of the industry, fills a gap in the literature on oil and gas. There are several fine popular histories that tell the bracing and often brutal story of the industry's development, notably Daniel Yergin's classic *The Prize*, perhaps now superseded by Matthieu Auzanneau's eloquent *Oil, Power and War*. There is a growing library of more theoretical works assessing the industry's profound social, cultural and ecological significance, including *Carbon Democracy: Political Power in the Age of Oil* by Timothy Mitchell, *Fossil Capital* by Andrea Malm, and *On Petrocultures* by Imre Szeman. And there are a few useful introductions to the science and technology of oil and gas, such as Morgan Downey's *Oil 101* and Vaclav Smil's *Oil*.

Mu's book focuses squarely on economics, referring to the industry's history and politics while remaining scrupulously impartial. It is a dense book that crams a huge amount of information into 250 or so pages, and is perhaps better read as a reference than sequentially. And non-economists should be aware that there are mathematical equations here and there, and some rather forbidding diagrams and flowcharts. But the bulk of the book is written in clear prose requiring no technical expertise or prior knowledge. And it is not without a certain dry sense of humour, Mu observing that 'the demand for oil is a derived demand. It is hard to imagine that anyone really enjoys directly consuming gasoline, diesel, kerosene or LPG; doing so would be unpleasant at best and fatal at worst.'

## A mixed blessing?

The opening chapter makes clear how tightly oil and gas are stitched into the fabric of everyday life, even as the world seeks to make the painful transition to renewable energy. Oil and gas provide fuel, are crucial





## Disentangling the Economics of Oil and Gas... continued

constituents for plastics, chemicals, lubricants, solvents, waxes, tars, asphalts, textiles, paints, detergents, perfumes, pesticides and fertilisers, and power iron and steel foundries, aluminium and nickel smelters and many manufacturing industries.

Together, they still provide more than 50 per cent of world primary energy supply. Oil's high energy density and portability offer considerable economies of scale, made plain by the simple mathematics of a storage tank. The cost of a tank is determined by its surface area but the output by its volume, so when 'the size of the tank doubles, the surface area increases by four times but the volume increases by eight times. As a result, the unit cost of the materials used in the storage tank halves.'

And yet, though they remain such crucial lubricants for the world economy, oil-and-gas exporting countries have not necessarily prospered from their seeming windfall. Mu discusses the tendency for an oil-rich country's total exports to fall, the so-called 'Dutch disease' that takes its name from the decline of the Netherlands' manufacturing after the discovery of the Groningen gas field in 1959. The discovery of oil often leads to currency appreciation that makes exports more expensive. Then there is the 'resource curse' that can overwhelm countries with weak political institutions, opening opportunities for patronage, bribery and entrenchment of authoritarian regimes.



### Mapping uncertainty

One of the book's most useful sections shines a light on the complex analytical tools exploration and production companies have evolved to quantify the risk of committing substantial resources to surveying and drilling prospects. There is a particularly clear breakdown of the decision tree methodology that seeks to map all contingencies in advance, peering for a route through dark forests of possibilities.

Another surveys the various regulations for licensing oil and gas exploration that apply across differing jurisdictions. Mu notes that production sharing contracts (PSCs) have emerged as useful solutions that go some way to addressing the inherent imbalance in power relations between stage agencies and oil companies. Before the decision to invest there is relative parity: companies spy an opportunity, and governments want to attract investment. But once firms have made their commitment, and incurred sunk costs, the bargaining power shifts to the state, opening the way for higher taxes, or even asset appropriation. By specifying the terms according to which investors can explore within a specified area for a limited time, a PSC can offer a blend of security and flexibility fair to both sides.

Mu goes on to discuss the licensing issues peculiar to the United States, where the 'rule of capture' grants subsurface property rights to landowners rather than the state. The rule has been rather too successful in stimulating exploration, tending to generate overproduction as landowners whose property runs over the same underground resource compete to deplete reservoirs before their neighbours. History's most famous example is perhaps the rapid exhaustion of the legendary Spindletop field in Texas, where production fell from 17.4m a year after its 1901 discovery in 1901 to just 1.6m in 1905.

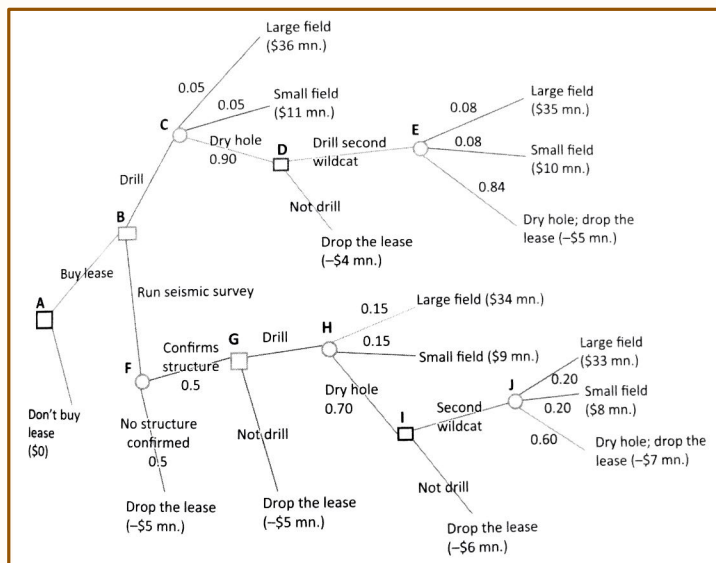
### Oil tankers for every occasion

A chapter on oil and gas transportation opens up the esoteric world of shipping and pipelines. There's some oil tanker spotting, identifying the 'Panamax' and 'Suezmax', designed to pass through the Panama and Suez Canals respectively, and the 'Aframax' mainly used in the basins of the Black Sea, the North Sea, the Mediterranean, and the South China Sea. The proverbial difficulty of turning an oil tanker around is true: a 250,000 tonnage tanker travelling at 16 knots takes three miles and 20 minutes to stop, and a 300,000

## Disentangling the Economics of Oil and Gas... continued

tonnage tanker travelling at less than five knots cannot be steered at all.

Then there is the curious balance of power attending the practice of ‘flags of convenience’, according to which tankers sail under the flags of their registered country not the home country of their owners nor charterers. The right of the country of registration to determine the laws under which the ship is required to operate accounts for the unusual power that small nations such as the Marshall Islands, Liberia and Panama exercise over the shipping of the world’s most valuable commodity. The delicacy of this transportation network is starkly illustrated by its dependence on the four-mile shipping lane of the Strait of Hormuz, connecting the Persian Gulf with the Gulf of Oman, the Arabian Sea and the Indian Ocean, through which 30 per cent of all seaborne-traded crude flows.



### Pricing oil and gas

There’s an extensive chapter on the increasing importance of the natural gas industry, in which Mu attempts to navigate the dense cloud of regional pricing mechanisms, and discusses the emerging alternatives for monetising gas that don’t rely on pipelines, liquefied natural gas and gas-to-liquids. He also covers the rapid growth of shale that has enabled the United States to break new ground as a net exporter in natural gas, and considers whether the blend of circumstances that have made it possible - such as mineral property rights, a robust pipeline infrastructure, and a supportive government - could be replicated elsewhere.

The book concludes with an analysis of the vagaries of the oil price, from the birth of the modern industry in mid-19th century Pennyslavania, through the ‘As-Is Agreement’ worked out by oil barons in the 1920s to limit excessive competition causing overproduction, to the price shocks of the 1970s and beyond. Mu argues that the role of OPEC in the latter has probably been overstated: the 1970s saw substantial increases in the price of all commodities, a trend that had little to do with Middle Eastern geopolitics.

There’s also a look at the opaque world of energy derivatives - forward contracts, futures and options - that has evolved to help producers hedge decisions that depend on oil price horizons that are effectively unknowable, and at the state subsidies designed to keep domestic oil prices below market value. The provision of such subsidies, which according to IEA estimates can reach five per cent of the total GDP of the countries that provide them, is increasingly controversial as ecological sensitivities sharpen. But their removal can spark serious civil unrest, as in Yemen (2005) and Nigeria (2011).

### Managing the transition

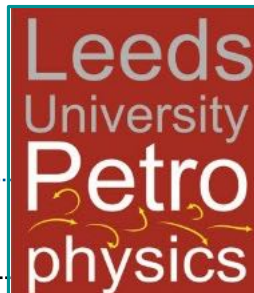
The challenge of managing an oil and gas business through the energy transition is perhaps the one major omission from the book. It predates the pandemic, so Mu could not have foreseen how suddenly the Covid-19 crisis would intensify pressure on the industry to plan for post-carbon futures, an increased urgency perhaps most clearly manifested in the recent restructuring announced by BP. But the complexities of managing investment in renewables while continuing to secure a return on oil and gas exploration and production have been pressing on the industry’s larger companies for some time, adding another layer of complexity to the commercial decision-making process.

**That, perhaps, is an issue that would require a book of its own. With *The Economics of Oil and Gas* Xiaoyi Mu has given us a useful guide that covers as much as we might hope for from an introduction to such a sprawling subject.**



# Virtual rocks: Imaginary field trips for invisible students

**Paul W.J. Glover, School of Earth and Environment, University of Leeds, UK discusses how virtual field trips offer a valid experience and a worthwhile discipline.**



Everything is Different.

The week running up to 11 March 2020 was spent fielding anxious requests from students about whether the field trip I lead to the Yorkshire Coast to look at Reservoir Analogues would go ahead. Certainly, all was booked and ready to go – hotels, coaches, material, safety stuff, spare socks. There were due to be 24 Petroleum Engineering students, 8 Geologists and Geophysicists, 4 staff and 3 demonstrators. Most students were from overseas, from all around the globe. What could possibly go wrong?! The long shadow of the Sino-European cough was beginning to loom. There was just over 10,000 cases in Italy and 148 cases in the UK. Despite requests to move the trip to a virtual field trip, permission to do it was not granted by the University until the 16th, by which time over 50% of my students had already left for their home countries.

Everything was going to be different. There would be no real students shown real rocks by real academics. There would be no real hotel, or coach trips, or packed lunches (which were not missed!). Warnings to always wear hard-hats were replaced by advice to wear pyjamas! An 8-day field trip with 2 pieces of assessment, would end up taking 25-days to run and a further four and a half weeks to mark.

The importance of high quality, dedicated staff and demonstrators was proven repeatedly. Yet, the best students submitted work that bettered all which had been submitted in previous years. It is true, you cannot feel, weigh, smell, lick or spit on a virtual rock, but the digital resources we currently enjoy resulted in some high quality observations, nevertheless.

## Focus and Preparation

It was clear at the very beginning that we would have to support students who were scattered around the world across all time zones and with extremely different access to digital communications. Some students



Figure 1. Flamborough Head in the days of conventional field trips (2019).

ended up doing two stints of quarantine; 14 days in the UK and a further 14 days in Saudi Arabia, just because their flight was turned back in mid-air. Staff and demonstrator numbers were boosted to 5 and 4, respectively.

The field trip, which was previously location-focussed immediately became exercise-focussed. It is extremely important that there is a very clear focus for the students. Visual engagement, which happens automatically when standing in front of an outcrop on real field trips, cannot occur in the same way virtually, so some



## Virtual rocks... continued

strong actuating focus needed to be present. You can lead a student to data, but you can't make it think. However, it is our job to try.

In our case two exercises were defined. The first was a PowerPoint presentation entitled "Static reservoir modelling of laterally-bedded and channelized sandstones: structure, scale, heterogeneity and anisotropy." As many students did not have recording capabilities or digital bandwidth sufficient to transmit an audio PowerPoint file, an 'as given' narration was required to be written in the notes boxes below each slide. The second was a poster in pdf A0 format (max. 20 Mb) entitled "Compare and contrast the sedimentological and stratigraphic characteristics of the clastic rocks and carbonate rocks encountered on the field trip with regard to their reservoir potential and production challenges." In each case the students were required to find, analyse, criticise and present data in a balanced way.

Pre-Covid-19, field trip documentation consisted solely of one 86 page spirally-bound full-colour field trip handbook which was provided in A5 format for the field and A4 for use in class in the evenings. By the end of the virtual field trip, this single document had been supplemented by 19 other significant support documents, including:

- A 26 page guide of how to carry out the two exercises, optimising use of the materials provided.
- An extensive set of scientific papers in pdf format, with a list of other papers and relevant websites.
- Schedules of videoconferencing meetings.
- A guide to the 8 field locations with extensive photographs and videos.
- Summary petrophysical observations collated from measurements made in previous years, including porosity, permeability, grain size and fracture measurements, provided by the demonstrators Ghinwa Yaghy and Ru Wang.
- High quality geological maps with accurate indications of the exact position of outcrops.
- Advice on field sketching with examples high quality websites and blogs (Markwick, 2020) and articles (Jude, 2018) about how to carry out sketching.
- Notes on sedimentary structures in chalks provided by Nick Shaw.
- Examples of matrix and fracture porosity calculations (Glover and Walker, 2009) together with permeability calculations through the matrix using the RGPZ equations (Glover et al., 2006; Rashid et al., 2015) and through fractures using the Hagen-Poiseuille plane flow equation.
- Notes on using Petrodiagenetic pathways on poroperm plots.
- 'How to' articles for using various pieces of software, including V3Geo, image analysis using ImageJ on thin sections obtained from scientific papers, narration handling in PowerPoint, viewing videos and pre-recorded video-call seminars.
- A set of 10-20 minutes videos that had been taken over the previous few years at each outcrop usually by Dr. Richard Collier (geological aspects), Nick Shaw (petroleum engineering), or myself (petrophysics and modelling). These are extremely useful in flagging-up the most important aspects at each location. They were available through the LectureCapture@Outcrop initiative, which involved making brief 10 min. summary lecturelets on different aspects (petroleum geology, petrophysics, petroleum engineering) at each outcrop over the previous years. Without these the virtual fieldtrip would have been a virtual non-starter.

One important aspect of developing a virtual field trip is the time required to work up adequate let alone high

## Virtual rocks... continued

quality extra material. However, effort here pays dividends. We were surprised (i) how quickly it could be done by a teaching team, where everyone contributed, (ii) how different staff expertise could be used effectively in broadening the student experience, and (iii) how some hurdles that need to be overcome for an effective student experience were extremely simple once recognised, for example, provision of an arrow on a map showing the student the exact location of a type outcrop to save them staring at a set of photos of a kilometre of cliff, wondering what to do.

### The Importance of High Quality Material

The list above gives an idea of the type and scope of material required for the virtual field trip. High quality students integrated all of these different sources and aspects. However, some of the material is critical.



Figure 2. An example view of Cloughton Wyke using V3Geo. This outcrop can be viewed at any location and direction and at any level of zoom with a smallest feature resolution of 5 cm, and linear or path length measurement in any direction.

The field trip depends critically upon access to reliable, relevant (location-based or analogue) and high quality data for each location. Years of high quality studies available in books, scientific and technical papers provide a remarkable resource in this respect. Access to them was provided by Scopus (<https://www.elsevier.com/solutions/scopus>) for academic papers, special issues and books, and OnePetro (<https://www.onepetro.org/>) for more industry-related material. Both of these were accessed by the students through the University of Leeds library's subscription, available globally.

The V3Geo website (<https://v3geo.com/search>) provides a gateway to 3D virtual models of geological outcrops around the world. At the present time it contains digital outcrops at over 171 locations, some of which coincided with the outcrops at our field locations (Burniston and Cloughton Wyke) while others provided analogue information. These digital models can be entered and move within just as if you were a drone flying around the real outcrop. Clearly, this experience is an improvement on a real field trip insofar as it is not normally possible to climb a cliff and look at it in detail, measuring the thickness of a bed with the measuring tool, or maybe measure the periphery of an inclusion (e.g., Fig. 2). There is a full 3D and zoom navigation so plan views are possible and the foreshore can be examined more effectively than when standing on it.



## Virtual rocks... continued

Although not used this way in our 2020 field trip, the V3Geo functionality is sufficiently good for mini-field experience to be designed around a particular location. For example the Ainsa Quarry location is excellent for the study of turbidite sequences and could be used as a 3D virtual field experience if such a play.

One of the problems with a virtual field trip is that the rapport with the rock sample in one's hand is lost. It becomes difficult for an experienced earth scientist to judge composition, grain size and porosity, let alone a student. The use of scientific papers bridges the gap partially, but then not all of what one is interested in was studied by the authors of the paper. We often found that papers with a geological focus provided useful thin sections or other images, but not porosity and grain size data. In this case it was best to capture the image and image analyse it in ImageJ (Fig. 3), which is free to use, simple to operate (at least for the basic functions) and is supported by a plethora of YouTube 'How to' videos. We found that porosities and grain size distributions could be measured, from which pore and pore-throat size distributions and high quality estimated of permeability could be predicted using the RGPZ method (Glover et al., 2006; Glover and Walker, 2009; Rashid et al., 2015).

Access to high quality mapping was through Digimap (<https://digimap.edina.ac.uk>) which provides high quality Ordnance Survey mapping at all scales for individually chosen areas of any location in the UK, satellite imagery and geological maps (UKGS) as well as other services.

Finally, Google Earth should not be underestimated. The individual photographs uploaded to this site by users who have visited the field locations were used by the participants of the field trip to good effect.

### Sketching, Box Models and Reservoir Models

Perhaps the most important way to start understanding an outcrop is by sketching. In a pre-Covid-19 world this was always a problem for us because the petroleum engineers not only had no training in geological

sketching, but lacked the confidence to start, especially when they compared themselves with the earth scientists on the field trip. However, most would try, and those would improve enormously by the end of the field trip.

We made a conscious decision to promote the use of sketching from paused videos, V3Geo or photos as a start to understanding the structural complexities of each outcrop for all of the students. Support was provided through the video-conferencing meetings, by providing the students with two excellent introductions to this black-art (Markwick, 2020; Jude, 2018) and by badgering. The result was highly satisfactory, with many excellent field-sketches being produced. The isolated workspace provided by the lone working allowed the students to sketch without being self-conscious or shy about it. Not only did it provide extra texture and breadth to their submissions, but it proved to them how effective sketching is for observation, and how well they could do it with practice.

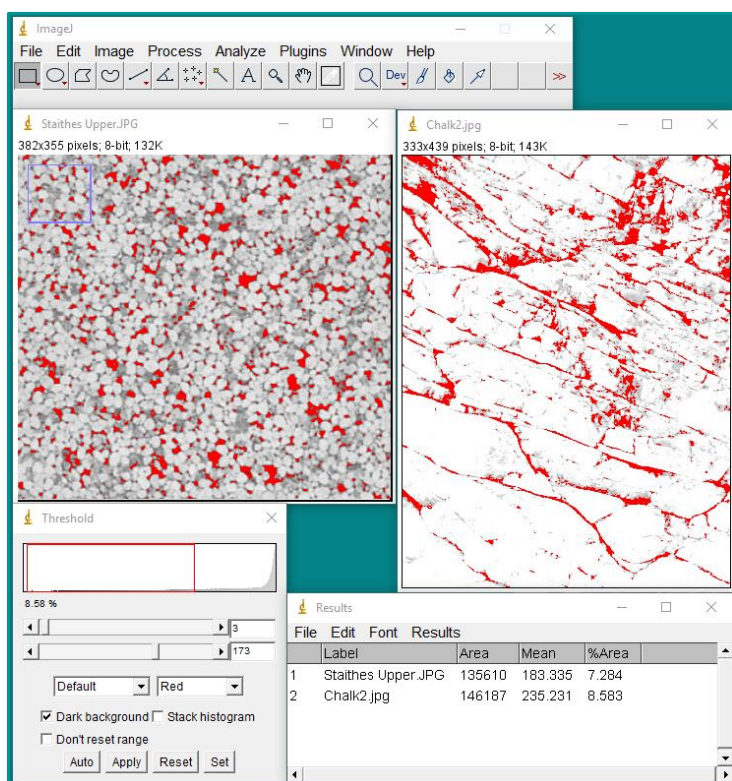


Figure 3. Examples of ImageJ applied for the calculation of porosity (7.284%) from a thin section from the Upper Member at Staithes (left) and the fracture porosity (8.583%) at Flamborough Head from a filtered photograph.

## Virtual rocks... continued

Once sketches were made, the students were encouraged to combine these essentially 2D studies into a 3D geological box model by reading around the depositional environment. The box models were then used as the infrastructure for a small reservoir model consisting of cells each of which was assigned a particular porosity and permeabilities depending on other information gathering associated with the outcrop.

### The Importance of Visual Contact

Performance was found to depend strongly on personal engagement irrespective of the quality of the student. Some students asked many questions in video-calls, while others were essentially mute. Nevertheless, both cohorts benefitted hugely from these sessions. It kept the students engaged and interested in a way that lone-working could never have done.

Sometimes the sessions were like miniature lectures, using shared files, such as images of rock samples (I had luckily kept a selection of samples and fossils in my garden, which I retrieved), thin sections, maps, images, geological box models, calculations in Excel, or just using diagrams using the integrated white-board feature of the video-conferencing software we used. Sometimes, we hosted navigated 3D trips at particular locations using V3Geo. Often the session was devoted to answering questions from the attendees.

There are a number of video-conferencing applications which offer potentiality for field trips. A short, non-exhaustive list includes; MS Teams, Zoom, Blue Button, Skype, GoToMeeting and Blackboard Collaborate. We used the latter, which offers the following advantages, some of which are also available now from other providers; (i) full integration with the Blackboard Minerva system which we used to deliver all of the supporting material, (ii) associated discussion rooms, (iii) attendance monitoring, (iv) a chat line during the call for questions, (v) clear hand raising, (vi) polling, (vii) breakout groups, (viii) sharing of files, video and applications, and (ix) a whiteboard that is accessible to all.

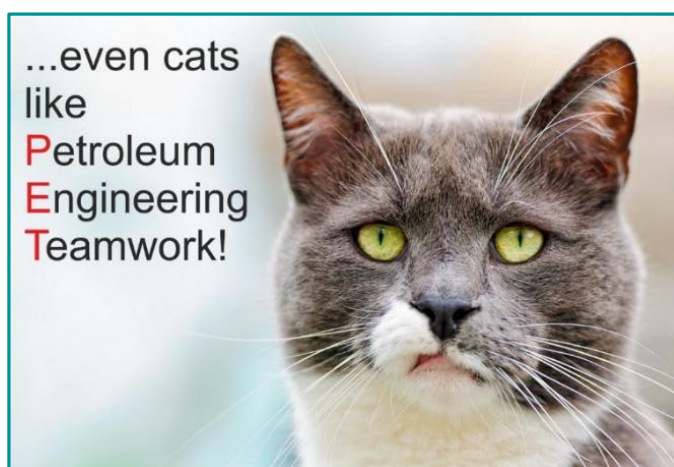


Figure 4. Encouragement to work in teams even when isolated increases efficiency, combats the loneliness of lone working and pushes back against the tendency not to ask for help if it requires communicating digitally rather than face to face.

Initially, 20 x 1.5 hour video-conferencing calls were envisaged, one in the morning and one in the late afternoon on each working day of a two-week period. The timings were set to allow access to everyone each day no matter in which time zone they were. All were recorded and immediately available to be reviewed irrespective of attendance. The significant wifi-less quarantine experienced by some of the students resulted us in adding 6 extra sessions, morning and afternoon for those who missed attending the previous 20. These supplementary sessions were used to flag up particular resources and pre-recorded sessions which would be useful to the affected students.

This third year undergraduate field trip was attended by students with a wide range of different backgrounds, from Petroleum Engineers whose only

previous field experience was a single day in their first year, to fourth year geologists who had been on many field trips in the UK and abroad, including long-term mapping work. The staff and demonstrators on the field trip reflect the huge range of student focus and experience, from subsurface characterisation (seismics, logging and core analysis) through modelling and simulation to clastic and carbonate sedimentology, stratigraphy and basin analysis, as well as in drilling, completion and production. Consequently, it was always important to balance the staff available in any given video-conferencing session to ensure that an appropriate expert was available in all relevant areas.

# Virtual rocks... continued

The Blackboard Collaborate system which we used allows the recording of video-conferencing sessions which are held on the system. The ability of whatever system has been used to record sessions and manage the resulting recordings effectively is a critical necessity in a number of different ways. It enables students who would otherwise miss the session due to illness, clashes or low bandwidth to still benefit from it. Second, Students can revisit a recording multiple times in order to pick up a single piece of advice or to understand the conversation better. Finally, we found that some students completely missed the entire series of initial sessions due to quarantine in accommodation with no digital connectivity. These students were able to complete the field trip by using the recorded sessions in order, only needing minimal extra help.

The assessed exercises were individual submissions and subject to all the usual plagiarism rules and checks. However, we actively encouraged team-working for the research of contributing information (Fig. 4) in order to maximise the efficiency of the digital information trawl that the students were encouraged to make, especially with regard to the search for relevant and analogue values of grain size, porosity and permeability.

## The Hunt for Treasure

While a central feature of the virtual field trip was to have students gather, analyse, critically evaluate and report data and observations that they had collected themselves, it was recognised that they would not be

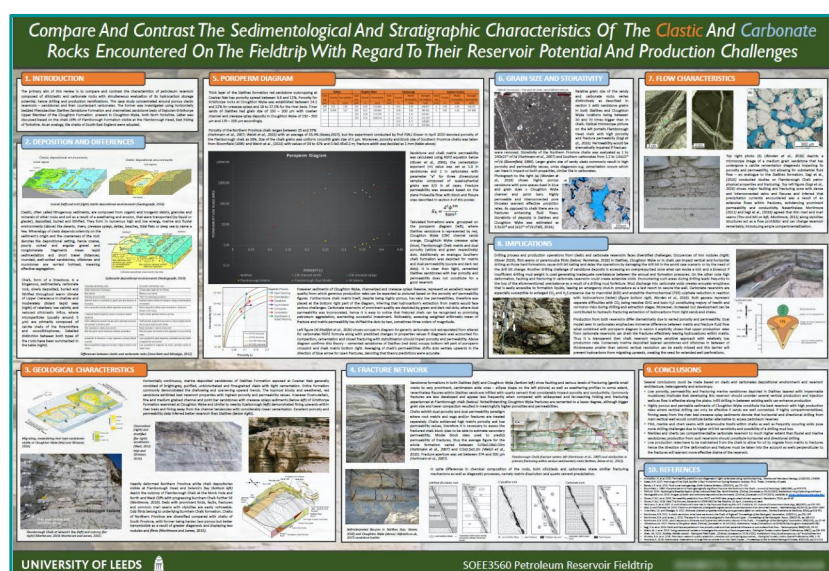


Figure 5. An example of a submitted poster. Irrespective of the professional presentation, the varied, accurate, detailed data content and analysis is of excellent quality.

able to start this in a vacuum. This was especially the case for the petroleum engineering students because of their sparse previous experience of fieldwork. After all, for a real field trip, the participants are at least taken to the location, provided with a field guide and told what to look for. For a virtual field trip, this seeding of the hunt for information becomes much more important. The provision of information must be sufficient to prime the pump of the most hesitant student, while allowing the more comfortable students to have to ask themselves valid questions during their quest for information. So, the design of the field trip becomes a little like designing a treasure hunt, where it is hoped the

clues are sufficiently challenging; not so straightforward as to be boring, but not so difficult as to be obtuse. Given the range of abilities within the student cohort, the release of data or provision of advice must needs be judged finely. I would say that I felt more in tune with the needs of the individually students in this regard than when in the field for real, when there may be the tendency to just point all of the students in the cohort at the rock face and say "Right, now get on with it!", without a differential judgement of their individual abilities and needs.

## Remote Judgements

University field trips are assessed and count towards final degree classifications. As such, the way we changed our assessments may not be of interest to all readers. However, I think that the efficacy with which the virtual field trip fulfilled its stated learning objectives can be judged by comparing results to those attained in previous, virus-free years.

Previous years were mainly assessed on two manually created posters, one group work and one individual,



## Virtual rocks... continued

made on the 6 field trip evenings. The virtual field trip retained the two pieces of work, with the same titles, but carried out individually and remotely. The first became a PowerPoint presentation with written narration, while the latter became a poster submitted as a pdf.

The critical differences are that this year students had digital tools to create more professional-looking submissions (Fig. 5) and more time in which to complete them. However, the quality of the raw observations and data was severely limited to that obtainable through the web

The overall marks from the virtual field trip had an arithmetic mean of  $63.48 \pm 10.16\%$  with extremes of 44% and 89%. This compares with the aggregated data from the previous 4 years of conventional field trips of  $64.15 \pm 7.14\%$  with extremes of 30% and 78%. Statistically, there is no difference at a level of significance of 1% (t-test,  $p=0.0062$ ). The spread is larger for the virtual field trip, which is hardly surprising given the multifarious nature of external pressures on the students, but also arises from the best ever submissions (from the same student) for the virtual field trip, when judged solely on content (i.e., deliberately ignoring the better presentation that digitally prepared submissions allow).

### Saw Rocks, Nobody Died!

Some years ago, when returning from leading a field trip at Easter but in the snow and with a fierce on-shore wind which played havoc with the tides, an experienced field geologist told me that the definition of a successful field trip was summed up by “Saw Rocks, Nobody Died!”. The sanguine assessment I now recognise as post-field trip relief expressed as gallows humour. There was a point where I had several students down with the virus, and I considered that the opposite of this phrase could actually occur. In the end the students did not see any rocks up close and personal, but no one died, and I am glad to say that, at least from the very high quality of some of the exercise submissions, that everyone had an experience which will not only live with them, but which they will be able to use actively in their future careers.

What have I learned? Well, that there is nothing that can replace loyal and hard-working colleagues and demonstrators; that there is no substitute for preparation, that students need flexibility and kindness but will repay you in that most rare of coinage, enthusiasm, and that virtual field trips represent valid experience, and if not a complete replacement of the real thing, they are a discipline which is very worthwhile.

### Acknowledgements

In perhaps the longest acknowledgement yet, I would like to thank sincerely field trip staff Richard Collier, Luca Colombera, Jacqui Houghton, Nick Shaw, Ghinwa Yaghy, Ru Wang, Mike Shotton and Dorothy Drayton as well as the 2020 cohorts of SPEE3560 and SOEE5616.

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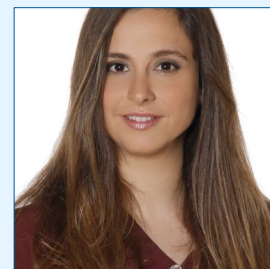
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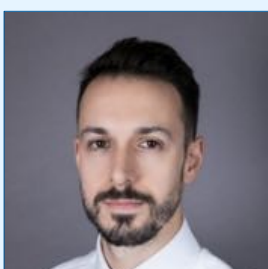
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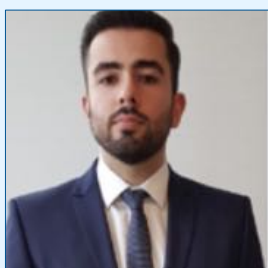
Big Data  
Kanad Kulkarni



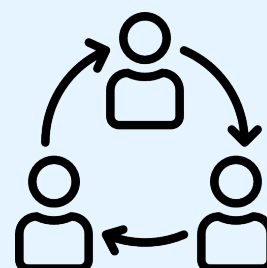
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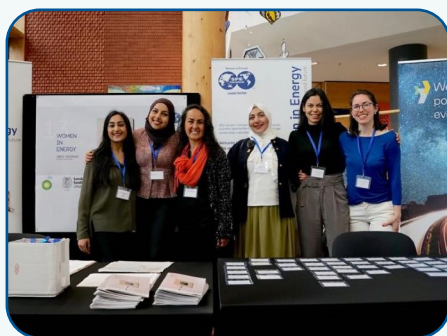
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