Zeitschrift: Swiss bulletin für angewandte Geologie = Swiss bulletin pour la géologie appliquée = Swiss bulletin per la geologia applicata = Swiss bulletin for applied geology

Herausgeber: Schweizerische Vereinigung von Energie-Geowissenschaftern; Schweizerische Fachgruppe für Ingenieurgeologie

Band: 15 (2010)

Heft: 2

Artikel: Unconventional hydrocarbons - from niche to mainstream : AAPG annual convention New Orleans, April 12-15, 2010

Autor: Burri, Peter

DOI: https://doi.org/10.5169/seals-227487

Swiss Bull. angew. Geol. Vol. 15/2, 2010 S. 45-52

Unconventional Hydrocarbons – from Niche to Mainstream. AAPG Annual Convention New Orleans, April 12 – 15, 2010

Selective highlights and comments Peter Burri[1]

Key Words: AAPG, unconventional gas, unconventional oil, climate change, sea-level rise, global warming, CO_2, Brazil, Mississippi Delta, Deltas.

1. AAPG

Information gleaned from the House of Delegates, where the author represents the ASP-VSP.

- AAPG abolished the Climate Committee, established a few years ago. The main reason was that «AAPG does not want to be seen as a political organization». *This is unfortunate because now AAPG has no longer a professional/factual voice in the climate discussion, leaving the ground to the believers on either side of the fence.*
- Membership has since 2005 increased from 22 000 to 33 000 as a result of a recruiting drive, especially at the universities (European membership is 3 200).
- Membership age distribution has two maxima: 21–25 and 51–56. There is a distinct low in the age group 30–46.
- Profit and loss for 2009 ends with a surplus of about 1 Mio USD on expenses of > 15 Mio USD.
- Assets of AAPG are 32.5 Mio USD (end 2009). A fundraising campaign in 2010 has provided an additional 27 Mio USD by April, target is 35 Mio USD.
- 50% of the normal revenues come from conventions *(that's why they cost so much!).*
- AAPG spent in 2009 over 215 000 USD on the Distinguished Lecture Programme, from which also VSP-ASP benefits.

2. Unconventional Hydrocarbons

In recent years, unconventional hydrocarbons, especially shale gas, were THE big new hype at AAPG conventions. This year unconventionals were still a very important topic, but now, shale gas, tight sandstone gas and coalbed methane were considered to be a part of the core business of US companies, belonging to the routine day-to-day activities. There was something new, however: unconventional gas used to be the niche of small and medium sized companies; in the last year the Majors have been catching up, largely through multi-billion dollar corporate acquisitions of specialized smaller firms.

2.1 Unconventional gas

Unconventional gas and in particular shale gas are having a dramatic impact on the US energy balance and on world energy supplies. Some 15% of the domestic US gas production is now provided by shale gas alone and this

[1] President Swiss Association of Petroleum Geologists and -Engineers, Holbeinstrasse 7, CH-4051 Basel, Switzerland. Comments and additions by the author in italics.

share is rapidly rising. Unconventional gas technology, mainly the progress in horizontal and multilateral drilling and multi-fraccing is undoubtedly the biggest innovation step in energy in decades. Technology has at last allowed the industry to start to access the enormous amounts of hydrocarbons that so far have been stuck in the «wastezones». The dramatic rise of proven US domestic gas reserves of 35% within five years, also demonstrates how unrealiable reserve forecasts are. None of the analysts of the Industry or the peak-oil scenarios have anticipated this revolution. Peak gas predictions were announcing a worldwide decline in gas production as from 2020 – 2030 onwards. It might well be that the gas peak production does not occur until very late in this century.

«Shale gas and America's energy future» McClendon, A. (CEO of Chesapeake Energy Corporation)

- Chesapeake Energy started with a capital of 100 000 USD in 1989 and is valued at 30 Billion USD today. It is now the largest US gas producer behind Exxon, employing over 8000 people (175 geologists).
- With the new shale gas resources, the US has enough gas supplies to cover the domestic gas needs for over a century. On a BOE basis there is more gas in the US than oil in Saudi Arabia.
- Gas is the cleanest fossil fuel: in comparison to coal gas has:
  – only 50% of CO_2,
  – only 4% of N_2,
  – no sulfur,
  – no particles.
- The future energy of the US is wind, solar, geothermal and gas.
- Gas will play an important role in US automotion: converting 10% of US vehicles to gas lowers US oil imports by some 1 million bbl a day and saves the US about 50 billion USD per year. The price of compressed natural gas (CNG) is now only 40–50% of the price of gasoline (energy equivalent).
- Fraccing of shales uses large quantities of sand and water but groundwater aquifers are always protected.
- Natural gas power plants have the lowest water use of any power generation process.

[Note Chesapeake entered in 2010 into a strategic cooperation with Statoil.]

«The future of gas in the US, a pathway to clean energy» Nummedal, Dag (Colorado School of Mines)

- US energy needs to shift from coal to gas. If one is taking the energy for production and transport into account, gas has - apart from its environmental advantage - 2–3 times the net energy contribution of coal.
- Energy is liberated by oxidizing H to H_2O and C to CO_2, The H/O ratio for gas is four times higher than for coal.
- In situ gasification of coal may allow coal to be produced at acceptable environmental standards. If 1% of the coal from the Powder River basin can be gasified this would amount to 30 TCF.
- Unconventional gas and gas from coal will contribute very large quantities to domestic supply. The US are likely to become a net gas exporter for many decades.
- Heavy oil conversion will be the biggest petroleum source for new oil in the US.
- Geothermal is the largest energy source on earth after the sun. It is the only renewable energy where AAPG and geologists can contribute.
- Fossil energy will play an equal role with renewable energy throughout this century.

«Marcellus shale gas play in Northeast US» Zagorsk, B.

- The latest of the major US shale-gas plays is a large over-pressured area, some 1000 km long and 100–200 km wide. Average porosity of these Devonian silty shales is 5–8%, permeability is 0.2–0.6 mD. Recoverable volumes are estimated at several 100 TCF (5–10 TCM).
- The Marcellus play contains more gas

than any other gas field worldwide, except possibly South Pars.

«Fossil fuels, energy policy and common sense» Smith, W. H. (Midland College)

- Global energy growth is estimated at min. 1.3% per year.
- 1.5 billion people do not have access to electricity, 2.5 billion people have no fuel except wood or dung.
- US energy demand is flat to 2030 (energy efficiency gain of 1.2% per year) but electricity demand is increasing steeply.
- Coal is still the cheapest and most used fuel for power generation in the US (50%) but gas will take over for environmental reasons (Carbon Tax).
- Gas can easily fill this role. Proven gas reserves of the US have increased 35% in 5 years from 1211 TCF in 2005 to 2075 TCF in 2010. Domestic gas supplies cover at least some 100 years but might last 200 years.
- Replacing all the present coal power plants would require:
  – 250 nuclear plants or
  – 500 large hydro dams or
  – gas power stations consuming 17 TCF/year.

«How enormous is the ‹enormous› US gas resource» Nehring, Richard (Nehring Associates)

- Gas reserves US 2009:

P1	237 TCF
P2	418 TCF
P3	744 TCF
Resources	428 TCF
Total	1830 TCF
- low estimate	1190 TCF
- high estimate	2850 TCF

- Of which unconventional gas:

Shale gas	444 TCF
Tight sands	209 TCF
Coalbed methane	28 TCF

- The US will not require any LNG imports for at least 20–30 years.

«Shale Gas in the Posidonia Shale, Hils Area, Germany» Horsefield, Brian (GFZ Research Potsdam, Germany)

- Organic rich Toarcian shales exist in Paris Basin, Jura Mountains and Germany.
- In the Hils syncline of N-Germany 35 m of Liassic source rocks, the Posidonia Shales, are present over some 500 km^2 at shallow depth). This Posidonia source rock fulfils the criteria for a gas shale: Total organic carbon (TOC) can reach up to 12–13%. Lithology and mineralogy are similar to the US Barnett Shale, a prime target for shale gas exploration. Only part of the area has the high maturity required for the play (ideally >> 1.2 Vitrinite Reflectance).
- Large quantities of gas have been generated in these shales but only some 5% have been expelled.
- Assuming a 35 m source rock thickness, the yield is estimated at 2.5 TCF gas over an area of 250 km^2 *(a tiny area compared to the US shale gas plays that cover up to > 100 000 km^2).*

2.2 Unconventional oil

«The new strategic petroleum reserve – shale oil» Sewalk, Steven (Colorado School of Mines)

- Shale oil should be used as the new strategic petroleum reserve.
- Oil shales produce a very light product (diesel).
- The shale oil potential in the US could be in the order of 100 billion BBL and a production of 4 MM BBL/day could be reached within 9 years.
- These resources could be extracted through downhole processes with minimal carbon emissions in comparison to the tar sands of Canada or potentially even the oil fields of the Middle East (considering shipping emissions).
- Investments required would amount to

some 35 billion USD. The money for this could be raised by selling off the present strategic oil reserve (750 MM BBL).

3. Regional topics

Of the about 400 lectures given, many treat aspects of regional geology and it is virtually impossible to reflect this wealth of information. The author has therefore only selected two examples, both showing that imaginative geological thinking remains the key to unlocking new potential and that we are still far away from scraping the bottom of the barrel: a) a mega-regional view of Middle East and North Africa indicating a huge untapped unconventional potential and b) an intriguing new potential giant subsalt play in S-America.

3.1 Middle East and North Africa

«The petroleum endowment of the Middle East and North Africa» Ahlbrandt, T. (Falcon Oil)

- Four mega petroleum systems control the petroleum endowment of the area: the Infracambrian, the Silurian, the Jurassic and the Cretaceous. All four occur on the Arabian Pensinsula and partly North Africa.
- The same factors that make THE conventional hydrocarbon region of the world will also make it a dominant area for new unconventional plays.
- The area has also an enormous potential in unconventional gas, especially shale gas (resources are estimated at > 16 000 TCF). Silurian charged deep basin gas and shale gas may be the largest undiscovered hydrocarbon resource of the world. Given the vast remaining resource plays within the core conventional areas it is not unreasonable to assume that the world's unconventional oil and gas resources are likely to be much larger than all the presently known conventional resources.

3.2 Brazil

«The Giant to Super Giant Sub-Salt Onshore Hydrocarbon Province of the Solimões Basin in the Amazon» Mello, Marcio et al. (HRT Petroleum)

- The 480 000 km^2 Solimões Basin in the onshore Amazon area has been marginally explored for the post-salt and is unexplored in the pre-salt. 270 wells have been drilled in the post-salt and only one deep pre-salt test. One main field (Urucu) has produced some 200 MM BBL of light oil of 42° API; all wells drilled have gas shows. Petrobras has abandoned the area in the 90's, after priorities shifted to the offshore.
- The Solimões Basin contains a very promising pre-salt play, sourced by a Devonian-Silurian source rock which according to Mello could be the continuation of the prolific Palaeozoic SR of North Africa *(This is not too far fetched: although Silurian source rocks have not yet been reached by the drill in the Solimões Basin they are known further W in Brazil in the lower Amazon Basin and in the Paraaiba Basin).* A rich Devonian SR has been proven by the drill already (40–80 m of SR with 4-8% TOC).
- Reservoirs for the pre-salt play are Dune sandstones with 15–28% porosity and permeability of up to 2 Darcy *(it was not quite clear from what source Mello derived these reservoir data in a largely unexplored play!).*
- Large structures are proven and there is a regional salt seal.
- HRT Petroleum thinks that this onshore pre-salt play has as much potential as the very successful pre-salt play in the offshore. The company has secured over 100 000 km^2 of acreage. Mello: «This will change Brazil for a second time».

4. Climate change, CO_2 and impact on deltas

In a special Global Climate Change Forum there was extensive discussion on the ques-

tion whether global warming was affecting storm frequency and intensity. Physical modelling would suggest an increase of storms with increasing water temperature of the oceans and the most recent observations seem to support this. However, evidence in the sedimentary record over the last few 1000 years shows a rather constant frequency of storms, irrespective of climate oscillations.

Rapid sea-level rise due to global warming is now virtually undisputed among scientists. The new element is that a collapse of terrestrial ice sheets could lead to stepwise leaps in sea level increases in the order of several 10 cm. Such collapse of continental ice has not yet happened at a large, catastrophic scale, the main contribution having come so far from the melting of the arctic sea ice, leading to a rather gradual rise. The more rapid melting of sea ice is also a consequence of the fact that global warming is much more pronounced in the northern hemisphere.

A heated debate centred on the question of whether the enormous funds required for e. g. CO_2 sequestration and CO_2 avoidance should not better and more effectively be used to pay for worldwide adaptations to a warmer climate.

Interesting studies of the impact on storms on the sedimentary system of the Mississippi delta and the US coast are being done. They confirm once more that the sedimentary record that we study in rocks is primarily a record of exceptional, catastrophic events. The Hundred-year- or the Thousand-year-storm shape the geological record much more than the processes that we observe day to day.

4.1 Global Climate Change Forum

Anticipating and adapting to climate changes Burkett, V. (US Geological Survey)

- Temperature increase has been 0.74° C in the last 100 years of which 0.65° C in last 50 years.
- Arctic ice volume has shrunk by 7.4% since 1978. The surface of sea ice has shrunk by much more.
- Worldwide sea level rise has been in average 1.7 mm/y in the 20th century and 3.1 mm/y between 1993 and 2003.
- Sea level rise is not equal in all parts of the world. It is strongly influenced e.g. by currents and atmospheric pressure. Big differences exist, there is for example very little rise on the West side of North and South America.
- Global warming is expected to be 0.4° C over the next 20 years. Warming is higher over land, in high latitudes and in the northern hemisphere. This is why melting of arctic ice is much more advanced than melting in Antarctica.
- Disintegration of Greenland ice would lead to a sea level rise of 6–7 m.
- A seal level rise of 1–2 m is possible in this century. This would lead to enormous migration problems. With a rise of 1 m some 75% of the world population are affected.
- 70% of the world's deltas are deteriorating due to human activity (mainly reduced sediment supply due to damming of rivers and prevention of flooding). Building of further river dams should be prohibited.

Modelling and interpreting the impact of severe storms and their relation to climate
Soden, Brian (Professor of Meteorology and Physical Oceanography, Rosenstiel School for Marine and Atmospheric Sciences, Miami)

- 2005 was the most severe hurricane year in recorded history and Rita the most severe storm ever recorded. In 2005 four severe hurricanes struck the US causing > 100 billion USD damage. The question is whether this is an anomaly or the future norm.
- At present there are 0.75 severe hurricanes per year affecting the Gulf Coast. Forecast for 2100 is between 2–5 severe storms per year.
- Hurricanes are a direct response to sea warming. Sea surface temperature in the Gulf has increased by 0.8° C since 1970 and is likely to continue to rise.

- Modelling predicts more frequent storms in future but not a higher intensity.

Extreme Storms, Coastal Impacts Sallenger, Abby (Chief Scientist, US Gelogical Survey, Centre for Coastal Geology)

- The US Gulf Coast has seen the landfall of 14 hurricanes in the last 10 years.
- Relevant for the impact on the coast is the degree of coastal submergence. The coastal system was totally submerged during four storms in this decade.
- The largest storm impact is seen on barrier islands. The barrier islands in the Mississippi delta lost up to 80% of their surface during storm Katharina. Shorelines migrated inland by up to 250 m *(sic!)* in the time of days.
- If global sea-level rise accelerates as predicted, barrier islands worldwide (a major coastal protection factor) will be at risk.

Past, present, future sea-level change Anderson, J. B. (Professor of Oceanography, Rice University)

- Eustatic seal-level rise has been 0.4–0.6 mm/y over the past 4000 years. After the last major glaciation, between 7000 and 10 000 years ago the average rise was about 10 times higher (4.2 mm/y). The rise has doubled over the last 100 years and will reach some 5 mm/y at the end of this century.
- Relative sea-level rise varies strongly along the coast due to variable subsidence rates. Subsidence is mainly due to compaction and has a strong positive correlation with the thickness of post-Pleistocene sediments.
- Ice sheet melting contribution is the largest uncertainty in the forecast of sea-level rise. Presently 80% of the world's glaciers are in retreat or unstable.
- The sea level rise could go in leaps due to ice sheet collapse in Greenland or Antarctica, which could add several 10 cm in few years.
- The Gulf Coast shows accretion until 1800 and is retreating since then. Current coastal erosion is 3 m per year! Estuaries are the most vulnerable. This is almost entirely due to the global sea level rise, as subsidence along the Gulf Coast is presently minimal (< 1 mm/y).
- Frequency of storm impacts, as derived from the sedimentary record, has been almost constant over the past few 1000 years, even though the climate did vary considerably.

Petroleum Industry response to storm and sea-level change Patterson, R. (VP Shell for major projects Americas)

- Some 190 offshore platforms in the Gulf of Mexico (GOM) have been destroyed or were severely damaged by storms Katarina and Rita but there were no fatalities.
- 211 production platforms had to be shut in (about 1 MM bbl/day and > 5 BCF/day or > 50% of GOM production).
- Mooring failures at drilling rigs resulted in 24 rigs blown off location (with distances of up to 120 miles).
- Wave loads, peak wave heights and wind speeds exceeded design criteria (the «Hundred Year Storm»). As a result, design criteria for the GOM have now been upgraded. Existing platforms are being modified to the new standards. This strongly impacts profitability.

4.2 Mississippi Delta drowning

Several very alarming talks were held on the future of the drowning Mississippi delta. There are at the moment many politically inspired corrective measures and many plans for the saving of the delta. Many of these expensive exercises are a waste in the eyes of scientists since the main causes of the drowning - global sea level rise and insufficient sediment supply - cannot be rectified. In the longer term the drowning of the delta appears unavoidable and money should rather be spent on relocation of important industries and facilities. Note: the data given by different authors on e. g. subsidence or sea-level rise may vary but are generally of similar order of magnitude.

«The inevitable drowning of the Mississippi Delta region» Blum, M. and Roberts, H. (Exxon-Mobil)

- The Mississippi Delta is rapidly shrinking, 25% of the delta wetlands have been lost in the last 100 years and about 100 km^2 are now disappearing every year. Some 7000 km^2 of the delta land surface is below sea level. The cause is a combination of sea level rise and low sediment supply.
- 18–24 billion tons of sediment would be required until 2100 to stabilize the delta, which is 4–6 times more than the present sediment supply. The reason for the shortfall: over 40 000 *(sic.)* dams have been built on the Mississippi and its tributaries, so that present sediment load is only a fraction of the historic sediment supply. Until the 20^{th} century the delta was regularly flooded, spreading the sediment over large areas; now artificial levies and dams prevent such sediment supply to the inner delta.
- Sea level rise is now three times faster than any time in the past 6000 years. The present rise is 3 mm/y and amounts to 200 mm since 1920. Subsidence adds another 3 mm/y, giving an aggregate of 6 mm/y total relative rise annually.
- The combination of insufficient sediment supply and accelerated sea level rise will make the drowning of the Mississippi Delta in the next 100–200 years inevitable. The total rise will amount to 40–180 cm by the year 2100, depending on ice melting rates. Some 10 000 km^2 of the delta will be lost to the sea by 2100. By then New Orleans will be located in the outermost delta on a levy!
- Restoration measures, through deliberate diversion of the sediment flow, may protect, at best, some 20 to 30% of the present delta.

«Coastal subsidence and accelerated sea-level rise, a dual threat for the Mississippi Delta» Tornquist et al. (University of New Orleans)

- Pre-industrial sea-level rise (up to 1800) was 0.55 mm/y, average 1920–2000 is 2.07 mm/y. Gulf of Mexico is 3.3 mm/y over the last 17 years.
- Subsidence: The impact of compaction is one order of magnitude larger than the one of the regional tectonic/lithostatic processes.

«Sedimentation patterns and transport pathways in the Ganges–Brahmaputra Delta» Rogers, V. and Goodbread, S. (Nashville University)

- The delta receives 1.2 billion tons of sediment per year (no dams, limited human interference, regular flooding), that is 10–12 times the sediment input in the Mississippi Delta. $^2/_3$ of the sediments are deposited in the delta, $^1/_3$ arrives in the offshore.
- The delta is much more stable than the Mississippi Delta. The Bengal delta managed to keep up with a 7 mm/y sea level rise at the end of the last ice age (9000–10 000 years ago). However, even in the Bengal delta, an accelerated sea level rise could outstrip sedimentation and lead to more submergence.
- Average sea level rise is presently 5.5 mm/y and increasing. A rise by 1.5 m would flood 22 000 km^2 and affect 18 million people.

4.3 CO_2 sequestration

CO_2 sequestration is still believed by many governments and a part of the scientific community to be an ideal measure to limit greenhouse gas accumulation in the atmosphere. The entire concept of CO_2 sequestration suffers, however, from a serious imbalance between the very limited dimensions of the capacity to inject gas for permanent storage into the subsurface and the enormous vol-

umes of the total CO_2 output. Australia, which is one of the most advanced countries in CO_2 sequestration, is able to store in its projects about 1/1000th of the country's CO_2 production of just one year (at costs of several 100 MM USD). CO_2 is also not ideal for disposal at depth; as from about 800 m depth onwards there is a sharp decrease in the compressibility of CO_2 gas. In addition, energy consumption for injection remains a severely limiting economic factor.

Storage capacity estimation and storage site selection Kaldi, John (CO_2 Capture Research Centre Adelaide)

- Most storage capacity estimates are imperfect today and comparisons between different projects are «apples and pears». Many of the factors controlling storage capacity are not yet fully understood. Estimates of sequestration have therefore to be taken with a large grain of salt. Basic research in these mechanisms is presently being undertaken by the CO2CRC in Adelaide.
- The main challenge for economics is the injectivity of the wells. Injection needs to be below fracture pressure (risk of leakage), this often requires more wells and thus more funds.

Fossil Fuels, Energy Policy and Common Sense Smith, W. H. (Petroleum Development Centre, Midland College, Texas)

- The US could recover some 70 billion bbl of presently stranded oil, by CO_2 enhanced recovery, 30 billion bbl in Texas alone.

Acronyms and terms

°API: Oil Gravity; B: Billion (10^9); BOE: Barrel Oil Equivalent; BBL: Barrel; BCF: Billion Cubic Feet (10^9); BCM: Billion Cubic Metres; E&P: Exploration and Production; Industry: here always meant as the Oil and Gas Industry; M: Thousand; MM: Million; Majors: The category of the largest multinational private oil and gas companies; mD: Millidarcy (permeability measure); P1: Proven Reserves; P2: Probable Reserves; P3: Possible Reserves; TCF: Trillion Cubic Feet (10^{12}); TCM: Trillion Cubic Metres; TOC: Total Organic Carbon; USD: US Dollar.