rockflow
RESOURCES

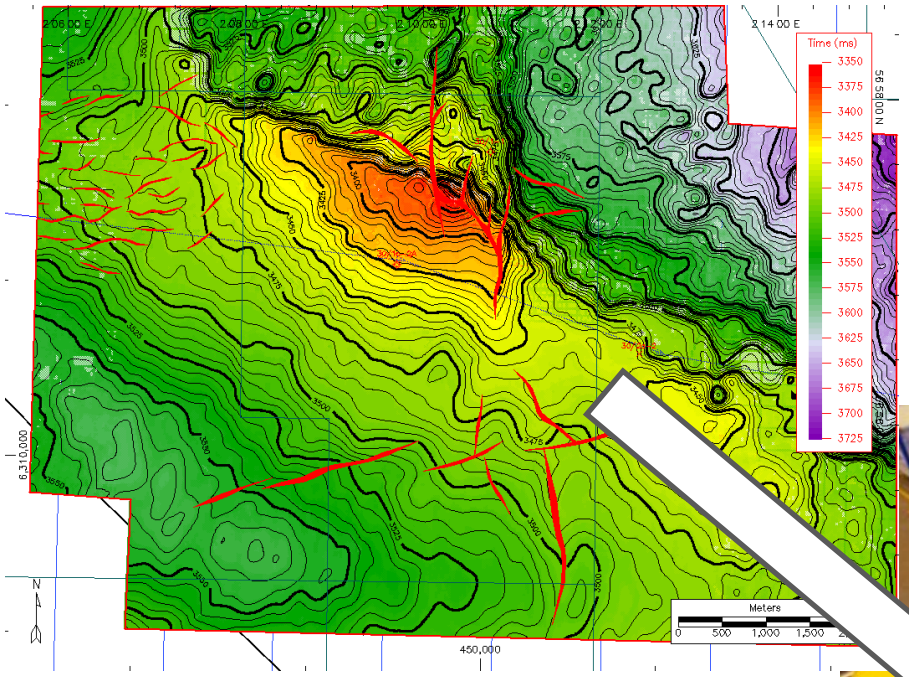
Petroleum Geoscience in 2017: A Contrarian's View

GWL

Date: March 2017

CONSULTANTS TO THE
PETROLEUM INDUSTRY

The Petroleum Journey



How do we get from here

To here

Phase One – Idea to Well Objective

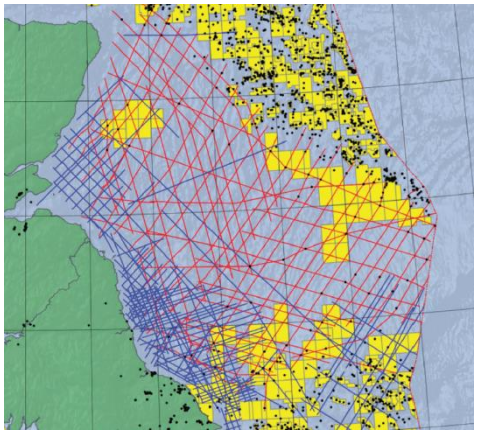
Knowledge + Idea + Data = Success?

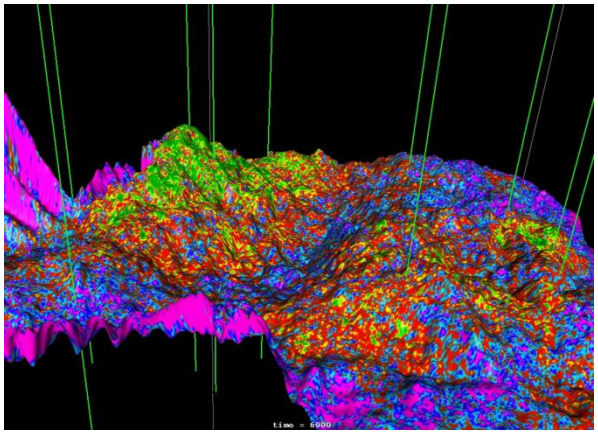
Charge

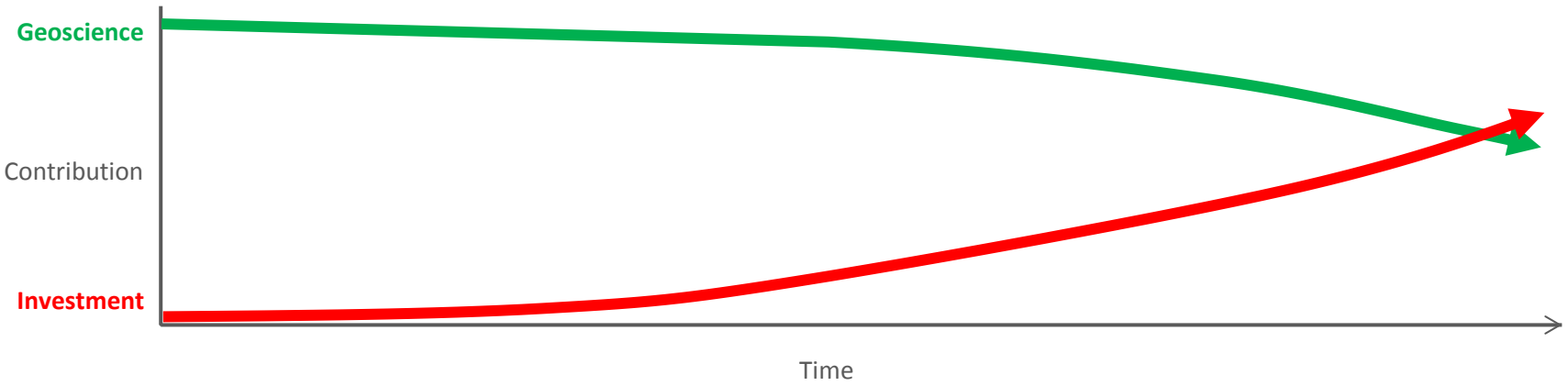
Reservoir

Trap

Seal

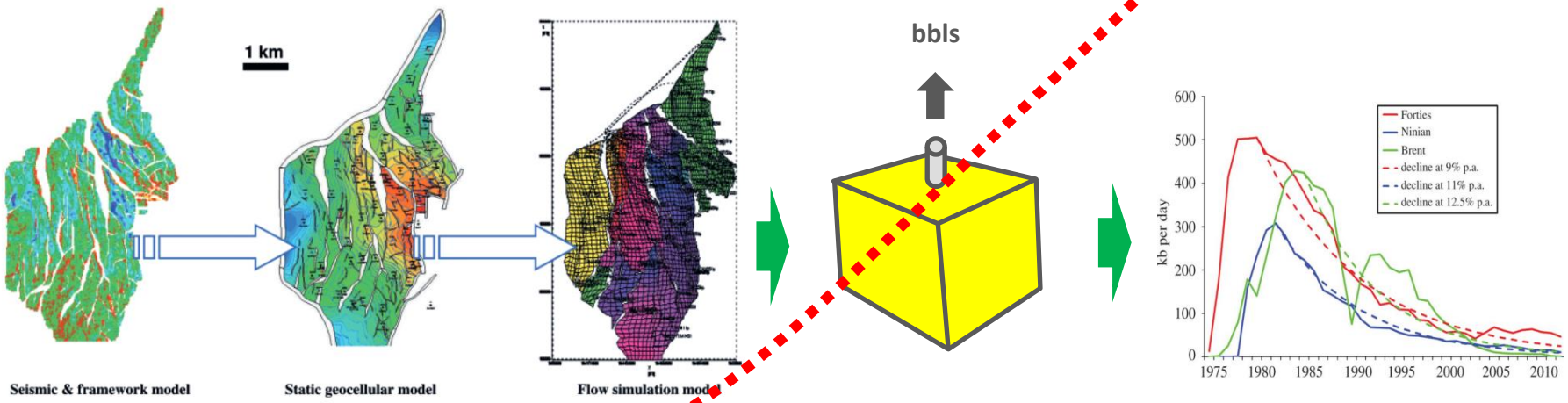


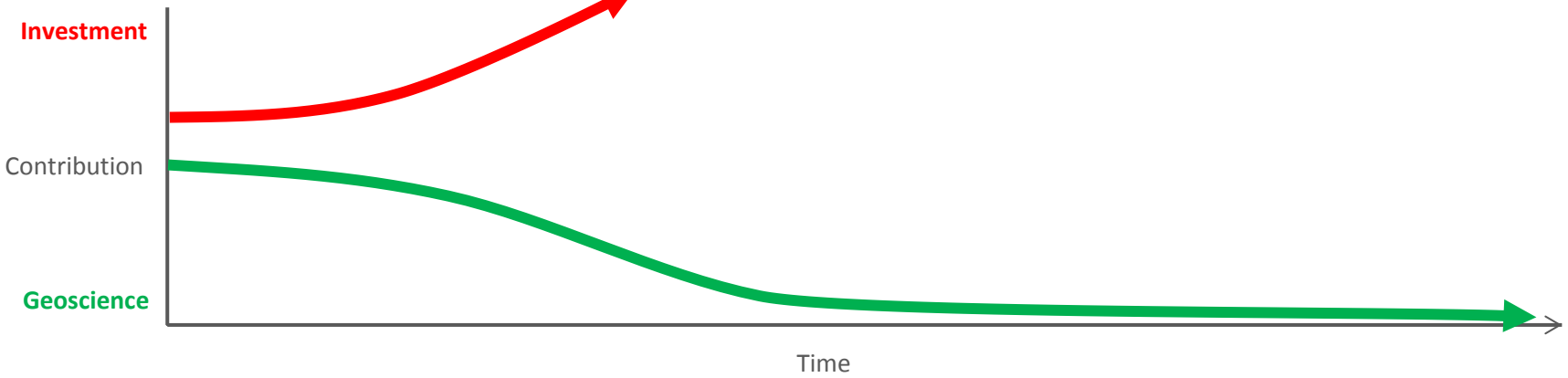




Phase Two – Discovery to Production Profile

Interpreter's view *Modeller's view* *Engineer's view* *CEO's view*

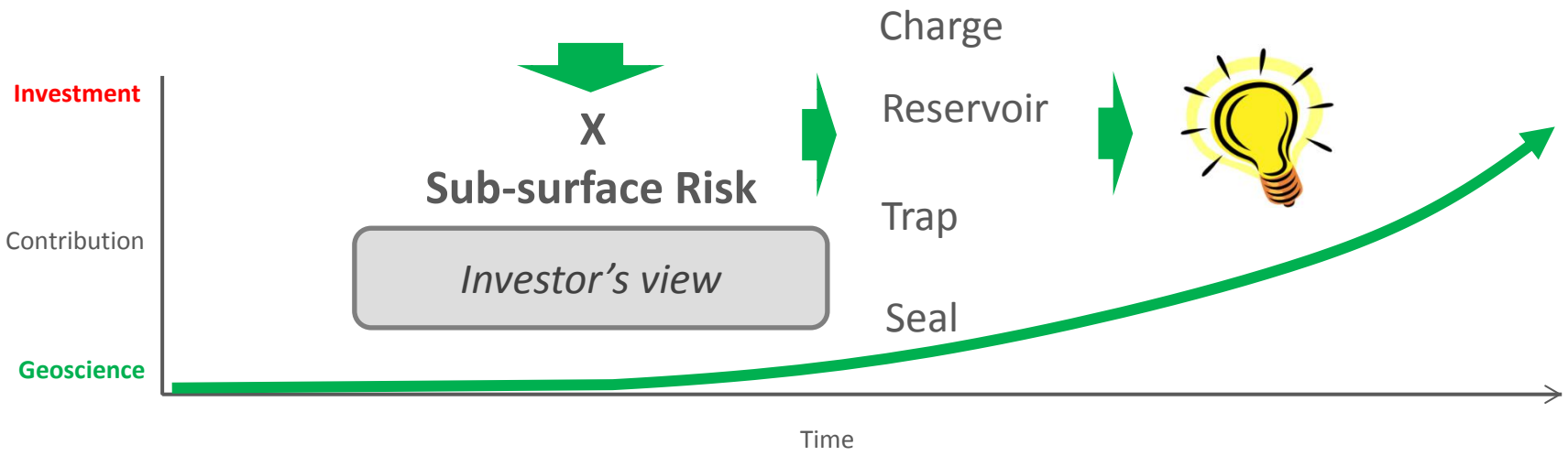




Phase Three – From Investor back to Idea

Banker's view

Indicative Cashflows		Jul-16	Jan-17	Jul-17	Jan-18	Jul-18	Jan-19	Jul-19	Jan-20	Jul-20	Jan-21	Jul-21	Jan-22	Jul-22	Jan-23	Jul-23	Jan-24	Jul-24
	Produced Gas - mmscfd	262.3	16.2	12.9	10.9	9.4	26.5	24.3	23.5	20.7	19.7	17.6	16	14.8	13.5	9.9	9.5	8.7	8.2
	Flare & Fuel - mmscfd	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sales Gas - mmscfd	262.3	16.2	12.9	10.9	9.4	26.5	24.3	23.5	20.7	19.7	17.6	16	14.8	13.5	9.9	9.5	8.7	8.2
	Oil - mbopd	43.6	2.3	1.8	1.4	1.2	2.9	3	4.7	4.2	3.7	3.4	3	2.7	2.4	2	1.8	1.6	1.5
	NGL - mbopd	4.8	0.3	0.2	0.2	0.2	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
	Combined - mboepd	93.7	5.5	4.4	3.5	3	7.9	7.8	9.2	8.2	7.4	6.7	6	5.5	4.9	3.8	3.5	3.3	3.1
	Revenue	216.2	9.8	10.8	6.9	6.4	16.3	16.7	21.6	19.8	17.7	16.3	14.6	13.4	12.1	9.5	8.7	8.1	7.5
	Net Opex	59.9	3.1	2.3	2.1	2.4	4.8	4.8	5	4.6	4.4	4.2	3.9	3.5	3.5	2.9	2.8	2.8	2.8
	Operating Cashflow	156.4	6.8	8.5	4.8	4	11.5	11.9	16.6	15.2	13.3	12.1	10.7	9.8	8.7	6.6	5.9	5.3	4.7
	Total Capex	26.5	0.7	1	1	6	6	5.8	5.8	0.1	0.1	-	-	-	-	-	-	-	-
	Pre-Tax Cashflow	130	6.1	7.5	3.8	-2	5.5	6.1	10.9	15.1	13.2	12.1	10.7	9.8	8.7	6.6	5.9	5.3	4.7
	Tax	47.8	-	2.9	1.4	-1.2	1.8	2.1	4	6	5.3	4.8	4.3	3.9	3.5	2.6	2.4	2.1	1.9
	Post-Tax Cash Flow	57.2	6.1	4.6	2.3	-0.8	3.7	4	6.9	9.1	5.4	3.3	2.7	2.6	2.2	1.3	1.4	1.3	1.1



The Exploration Method

Geochem
Seismic mapping
Seismic inversion
Basin modelling
Petrophysics
Core logging
Lithostratigraphy
Play mapping
Biostratigraphy

Risk categories

Charge
Reservoir
Trap
Seal

Chance of Success (CoS)

Field economics

Investment decision

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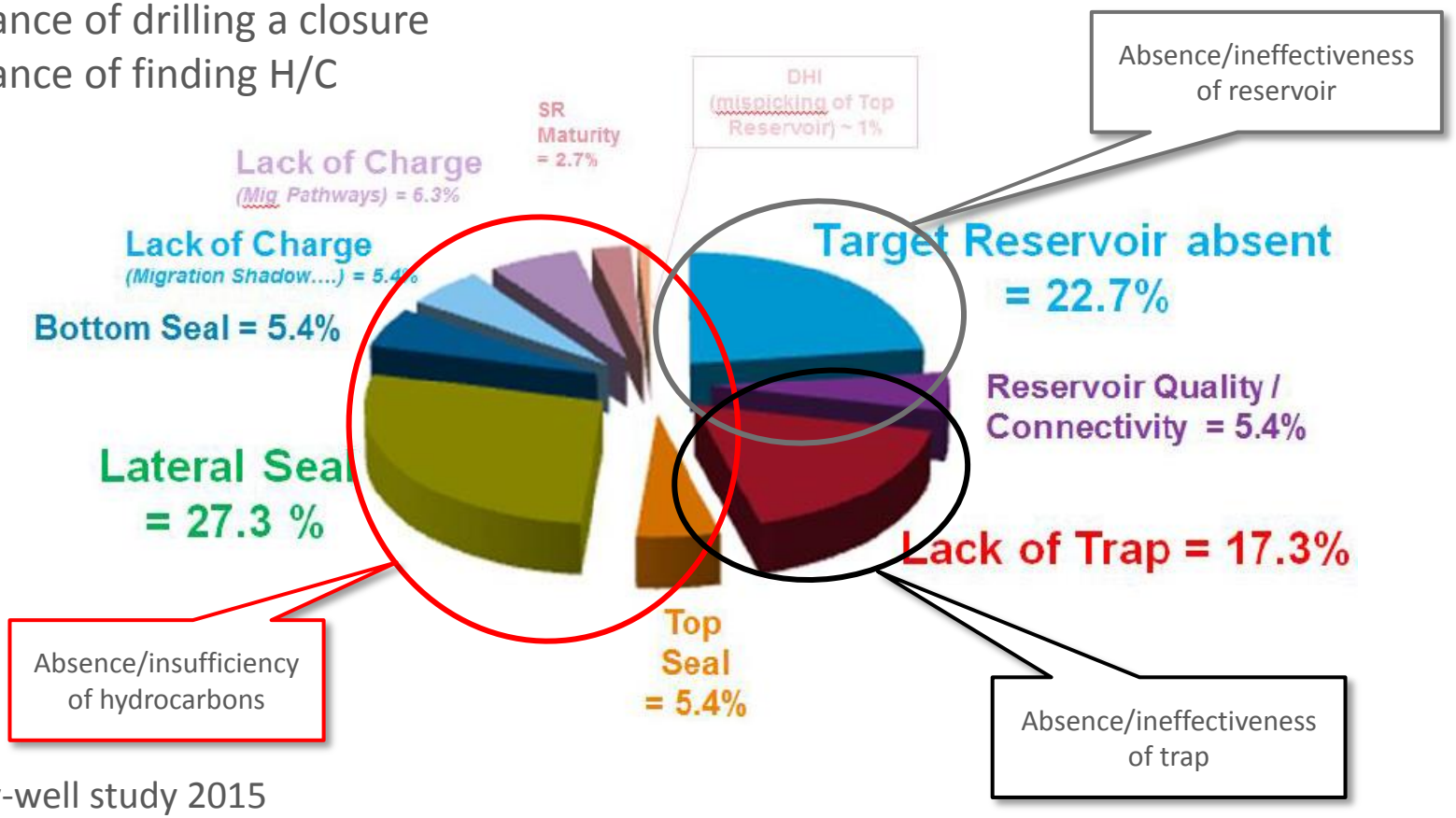
Exploration Well Failure, CNS & OMF

>75% chance of finding reservoir
>80% chance of drilling a closure
<30% chance of finding H/C



OGA Dry-well study 2015
Comprises 98 wells drilled 2003-2013
55% stratigraphic traps

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Pore Fluid Data in an Exploration Context

- Sedimentary rocks are composed of two materials:
    - Mineral solid matrix
    - Interstitial fluid lattice
- Each material responds very differently to stress (the principal of seismic data)
- Geologists tend to focus attention on description of the solid matrix.
- Reservoir engineers tend to focus attention on the fluid properties.

- Fluid pressure data is routinely acquired in a success case .
- Used for well planning and drilling operations.
- Used to determine degree of over-pressure and density of fluids.
- Used to determine OWC and GOC.
- Used to define pressure cells.

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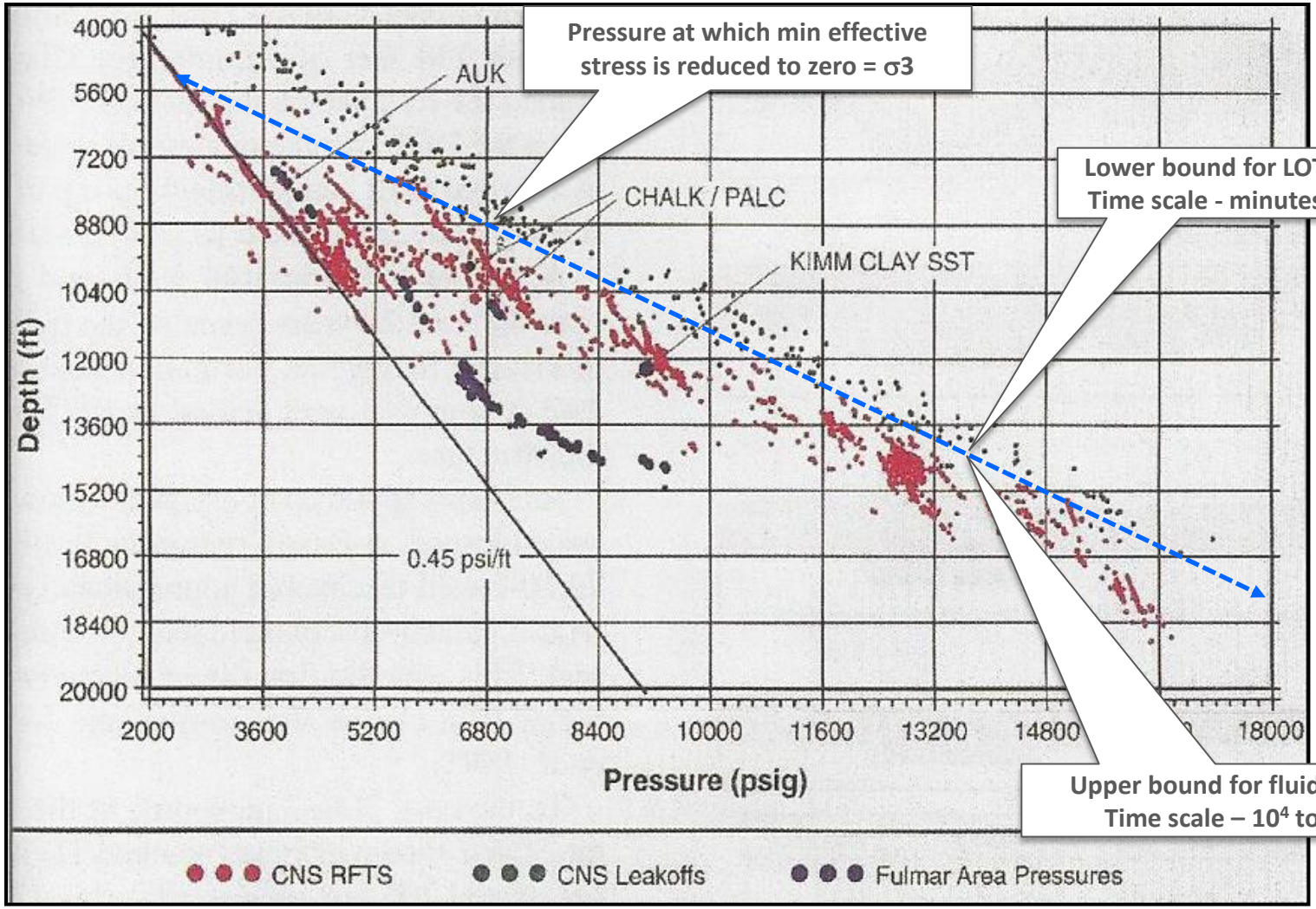
CNS Pore Fluid Pressure Data



After Erratt *et al* 2005

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What does the Pore Pressure and LOT Distribution tell us?

- The lower bound of LOTs reveal the fluid pressure necessary to fracture the rock
- The upper bound of aquifer pressure gradients represents a shared bound with LOTs (Ep)
- Ep is equivalent to the min compressive stress or effective $\sigma 3 =$ zero
- Each aquifer gradient represents a pressure cell and each cell terminates at Ep
- Which implies the pressure in each cell is determined by Ep
- WHICH MEANS SEAL CAPACITY IS PRINCIPALLY CONTROLLED BY TOTAL BURIAL DEPTH

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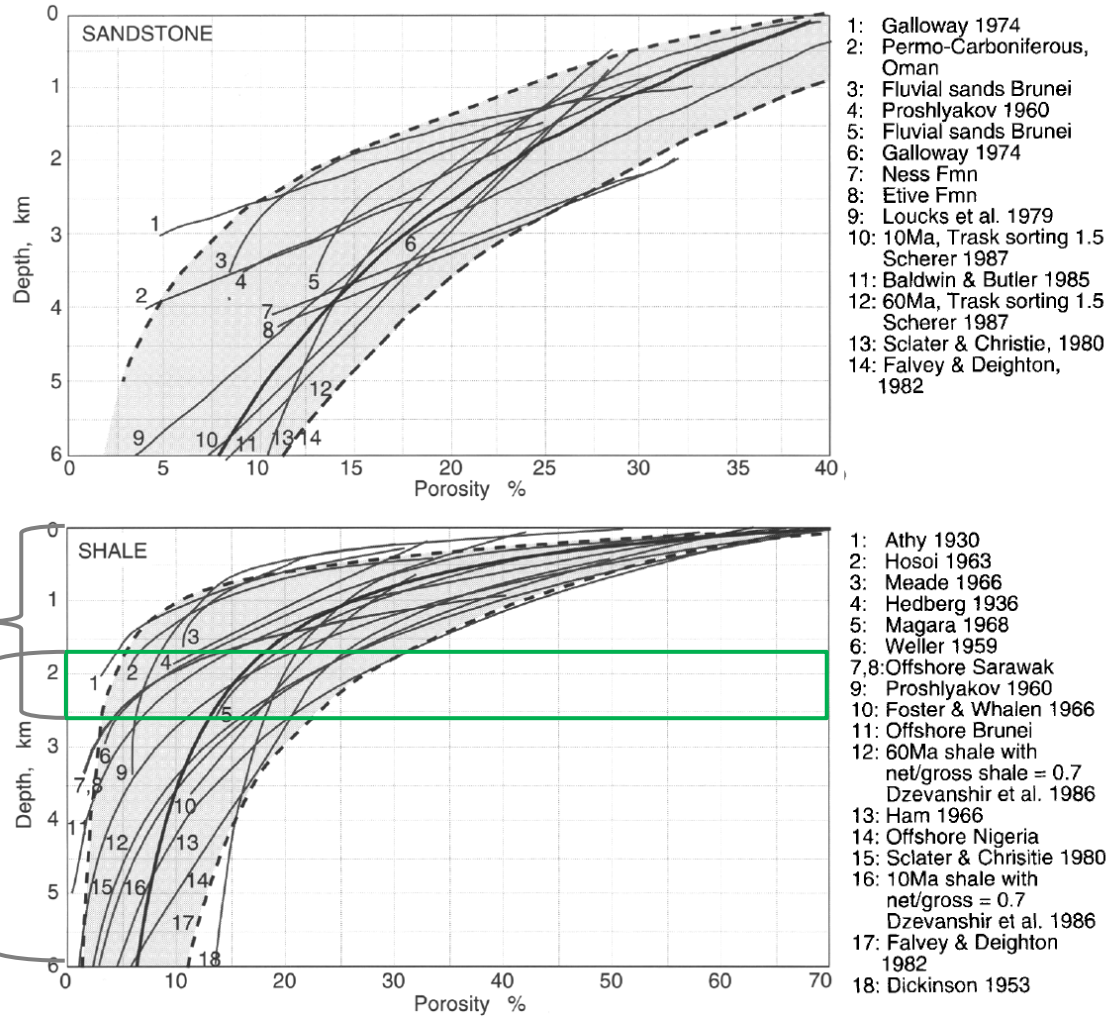
Porosity Loss in Sands & Shales

Mudstones compact

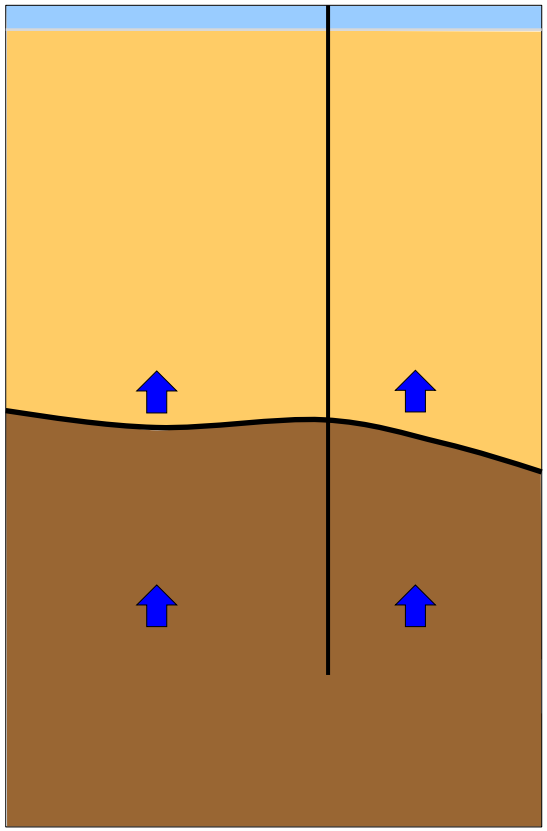
Porosity is lost

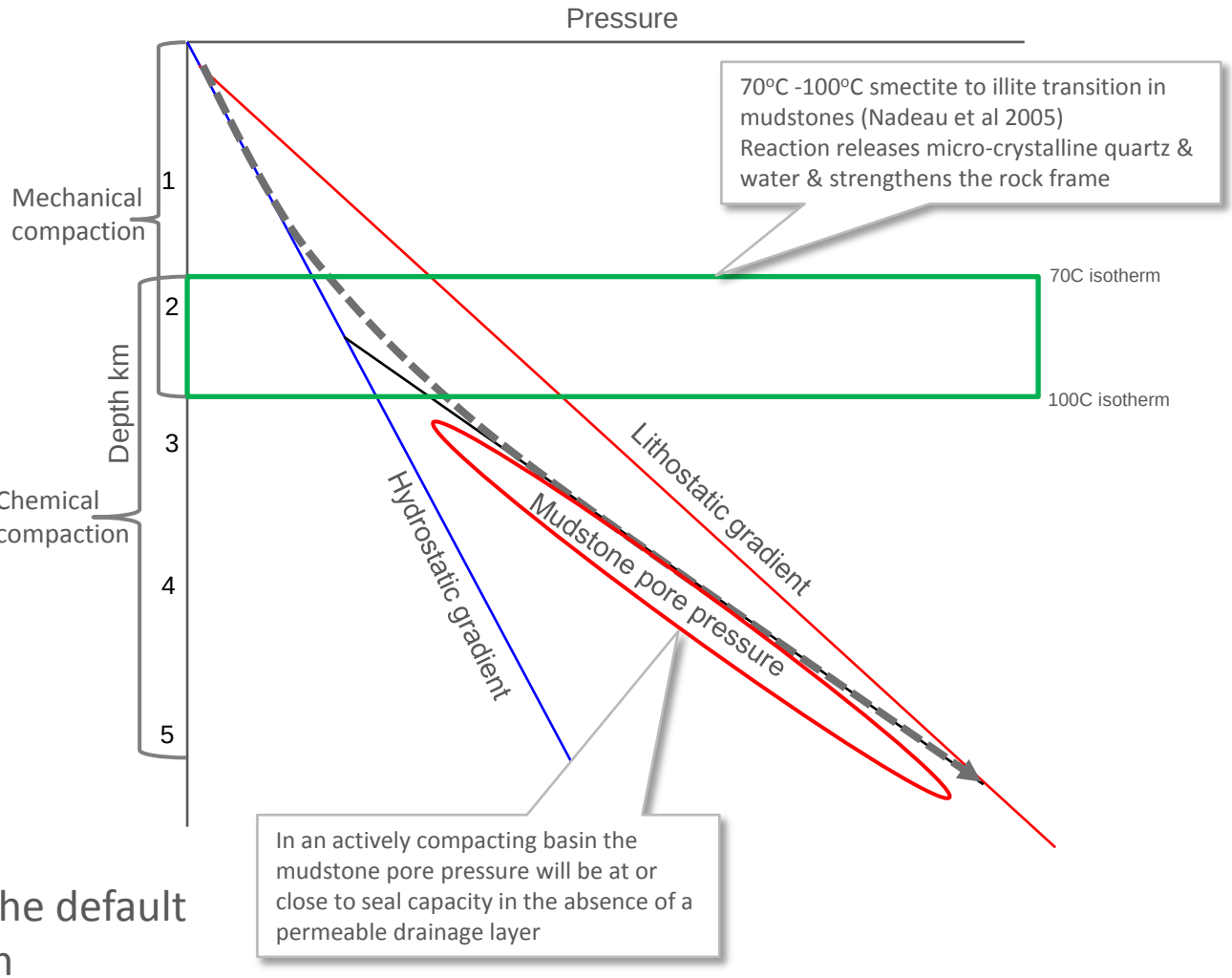
Where does the water go?



Giles et al, 1998

Model for Mudstones in an Actively Compacting Basin





Over-pressured mudstone: the default setting in a compacting basin

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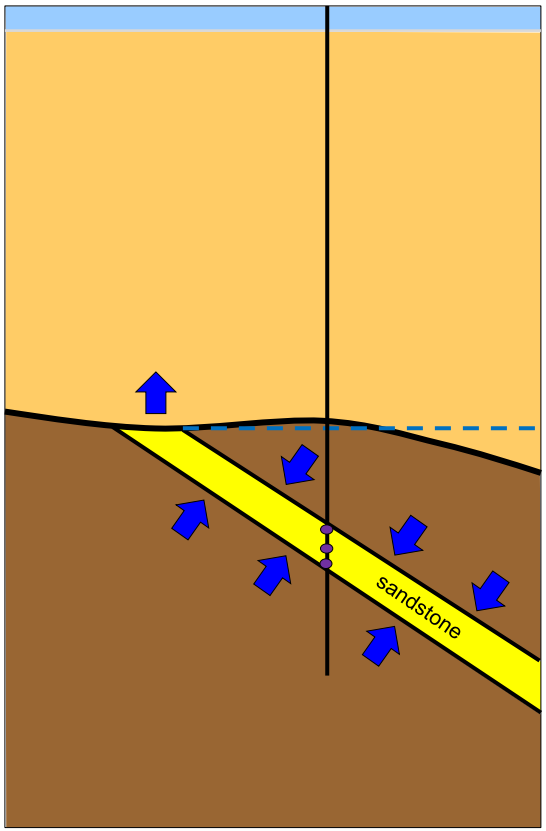
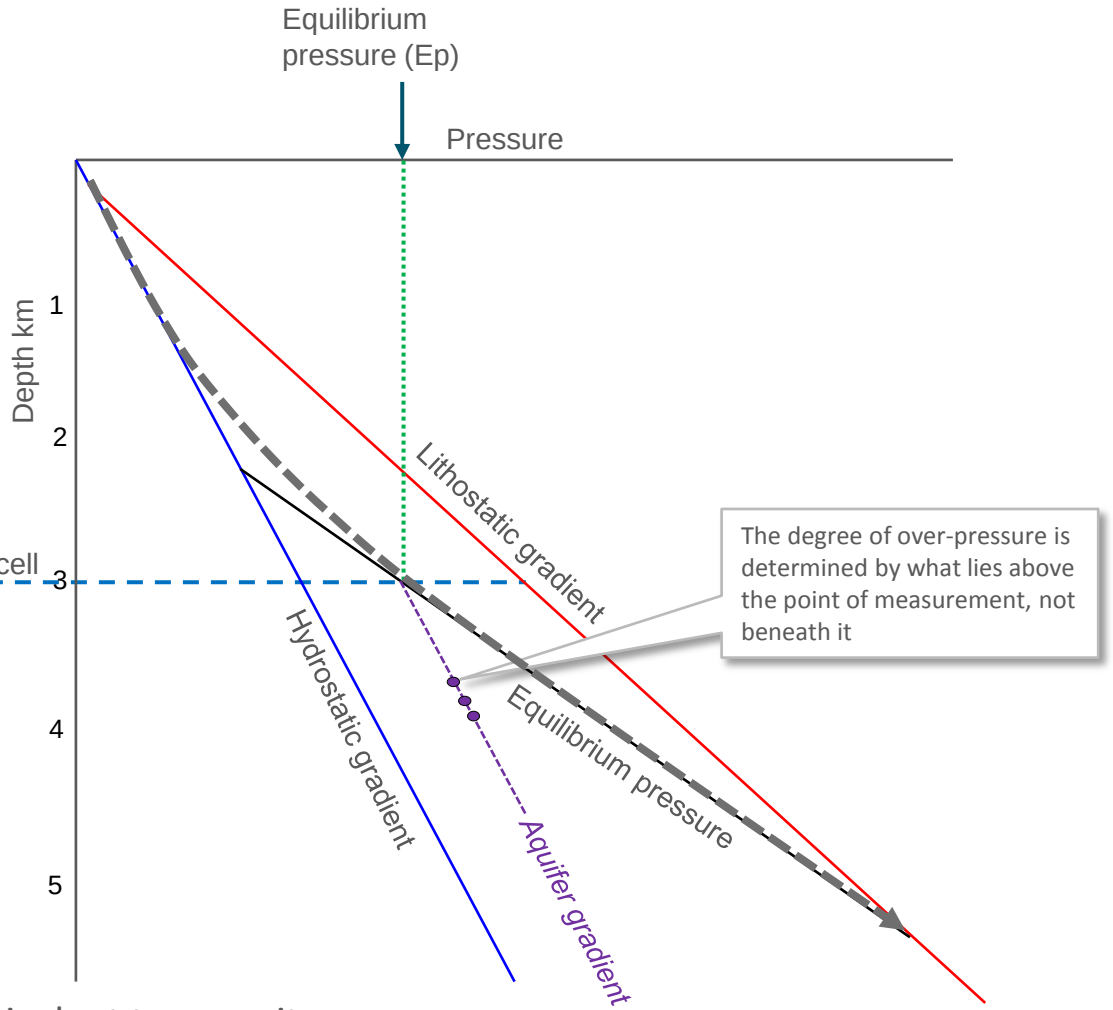
Equilibrium Pressure (Ep) Model



Depth of pressure cell breach



Equilibrium pressure = pore pressure equivalent to capacity of a mudstone to seal at a given depth = min compressive stress

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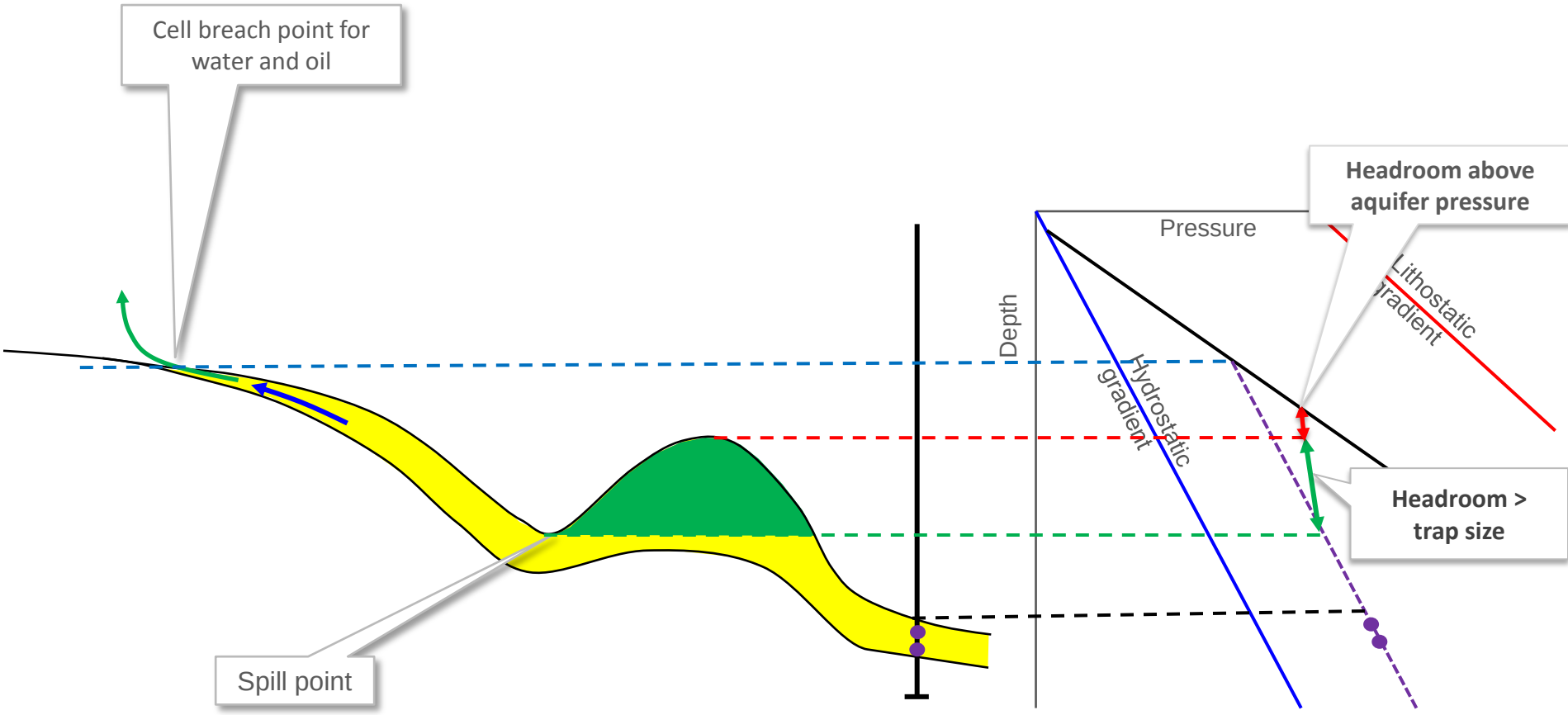
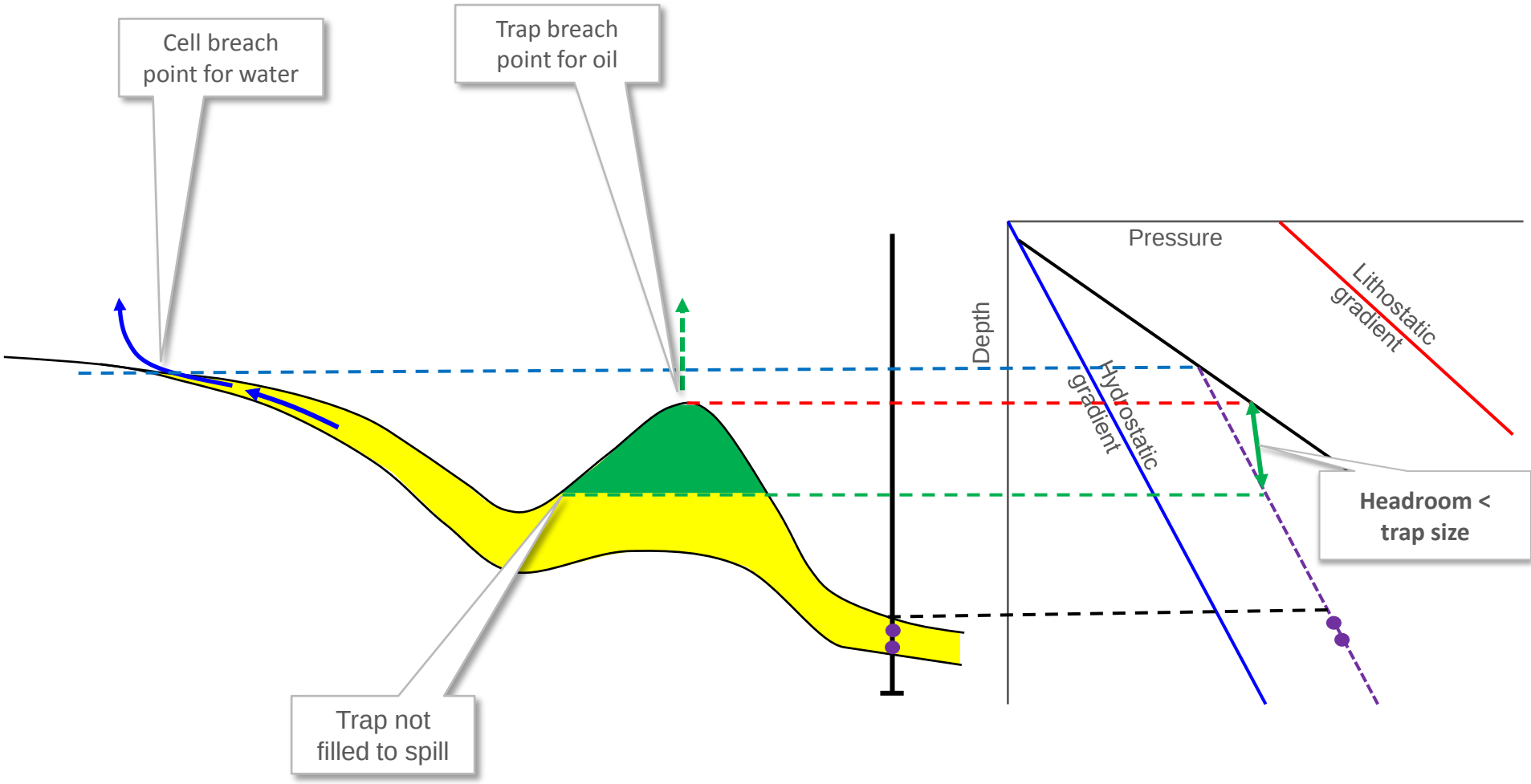
Basin De-watering and Fluid Pressure Control

- Compacting basins **must** de-water.
- Sandstones facilitate but mudstones regulate de-watering thereby controlling overpressure.
- There is a robust relationship between total burial depth and capacity to contain pore pressure.
- Pressure cells are most likely to breach at the shallowest point of burial (Equilibrium pressure point).
- At burial depths of 2km or greater in the CNS hydraulic fracturing is the dominant failure mode while the fluid pressure differential is the dominant sealing mode.
- In an actively compacting basin like the CNS sealing is determined by the pressure gradient across the reservoir/seal interface, and the sealing capacity of this interface is predictable.
- In inverted basins (unloaded) sediments are not actively compacting and the above does not apply.

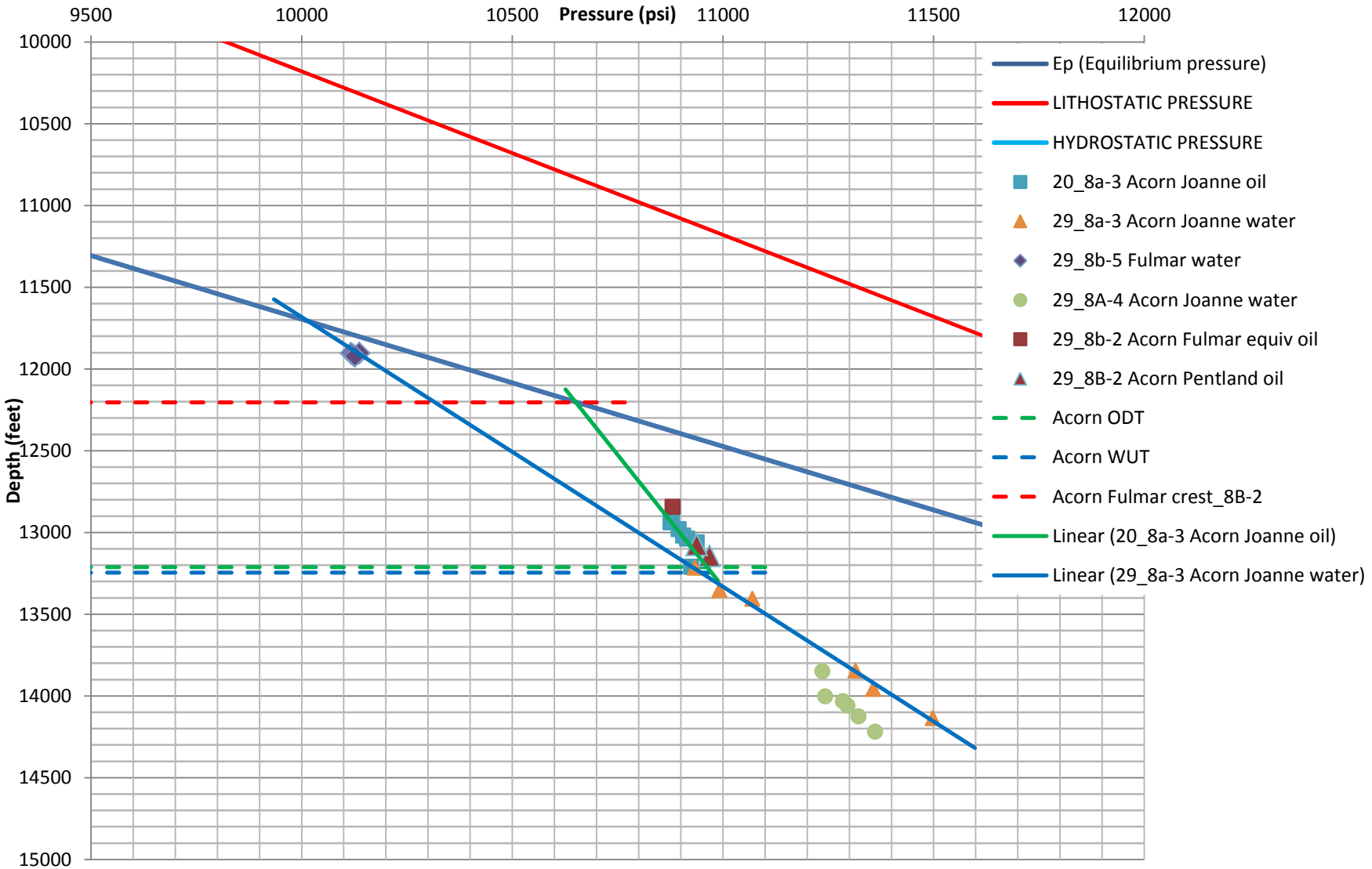
Trap Filled-to-spill in an Over-pressured Setting



Partially Filled Trap in an Over-pressured Setting



Case History 1 - Acorn Field



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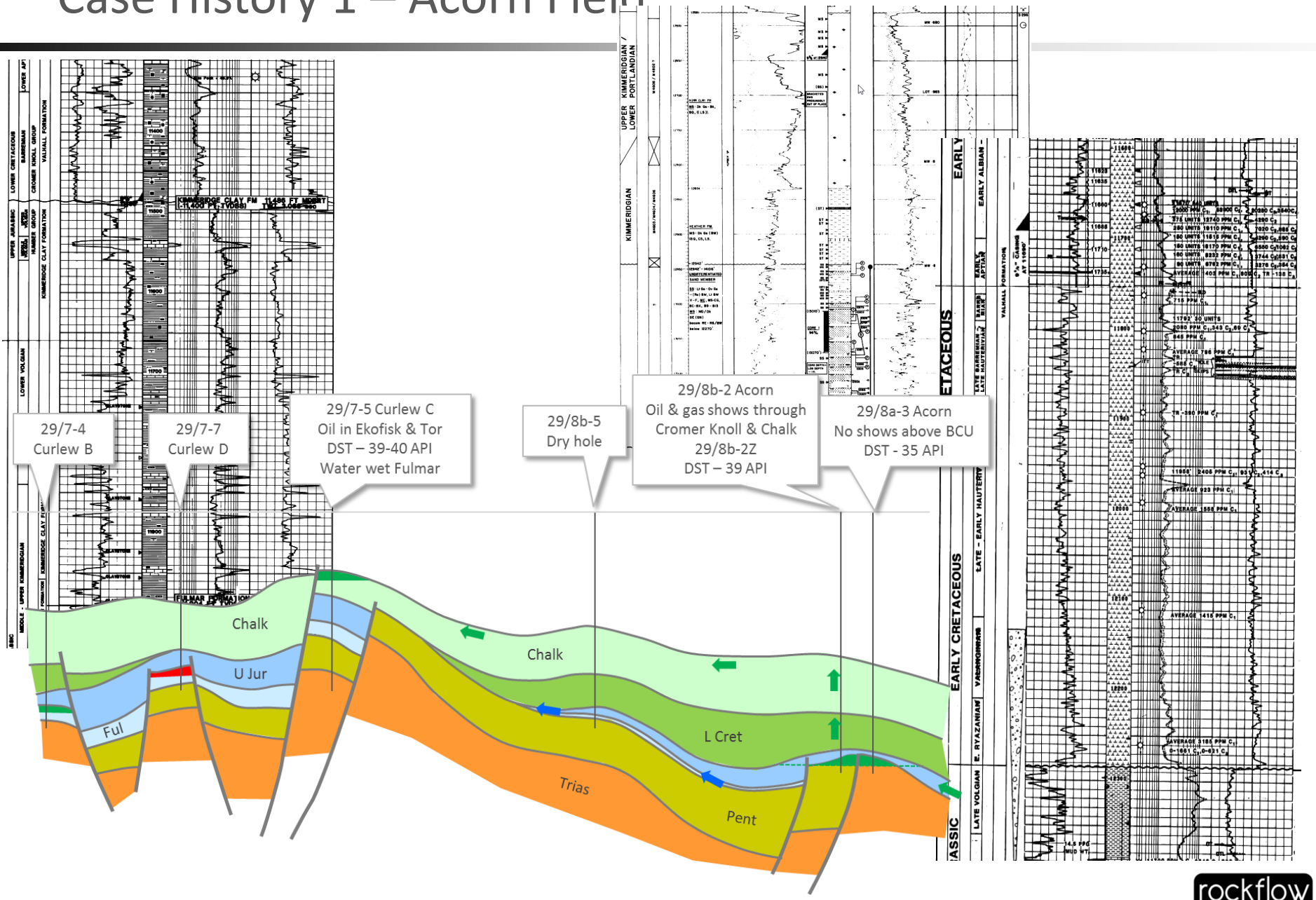
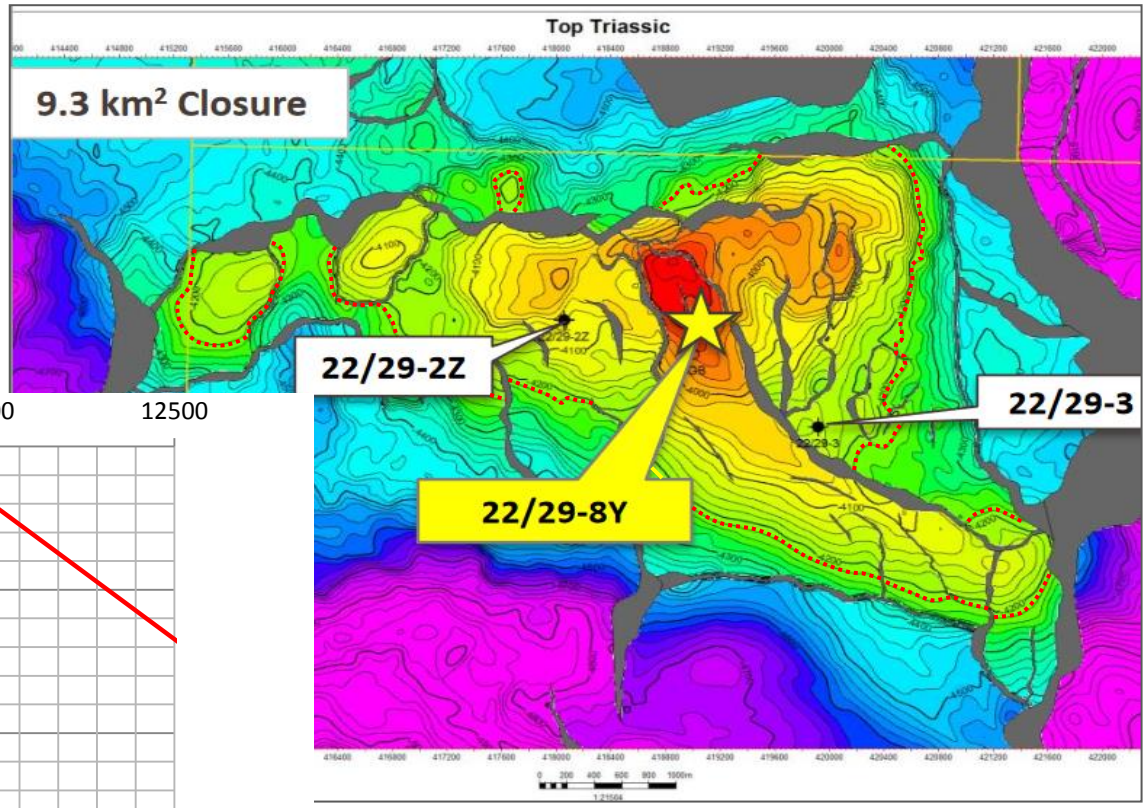
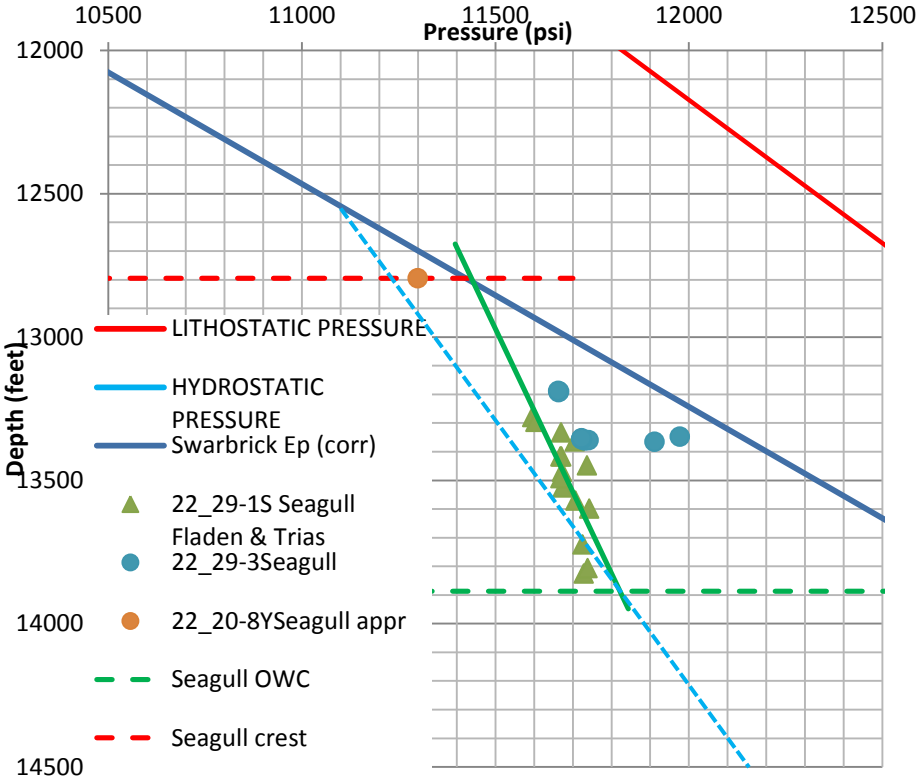
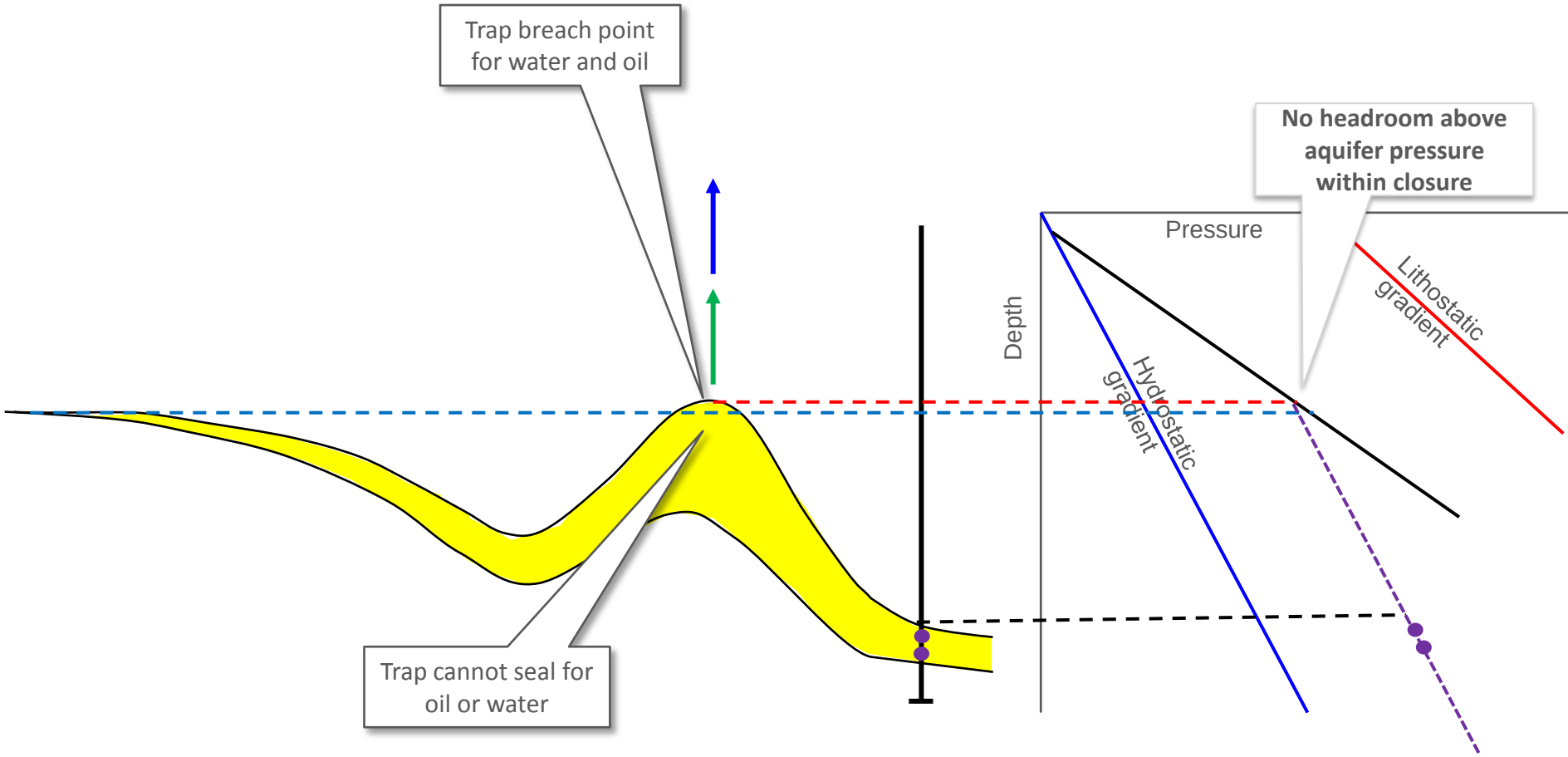


Case History 2 – Seagull Discovery





Ineffective Trap in Over-pressured Setting



The Exploration Method – CNS (compacting basin)

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Risk categories

Charge
Reservoir
Trap
Pressure headroom

Investment decision

Field economics

Chance of Commercial Success (CCoS)

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