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Complex Construction vs. Simple Deconstruction: Alternative Workflows and the Role of 'Ultimate Truth' Models

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Complex models

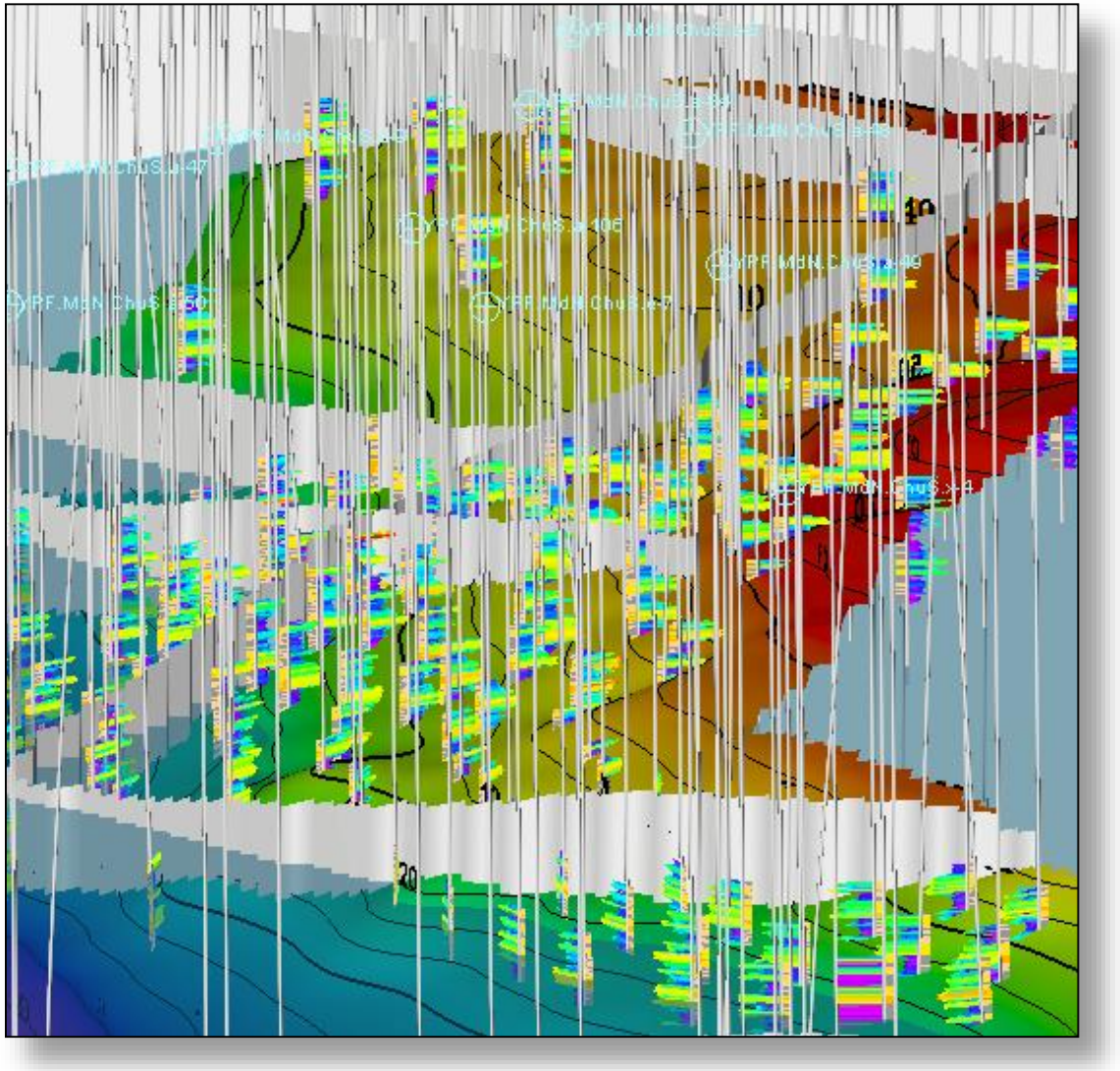
We have a complex problem

We had one thing we didn't understand

so ...

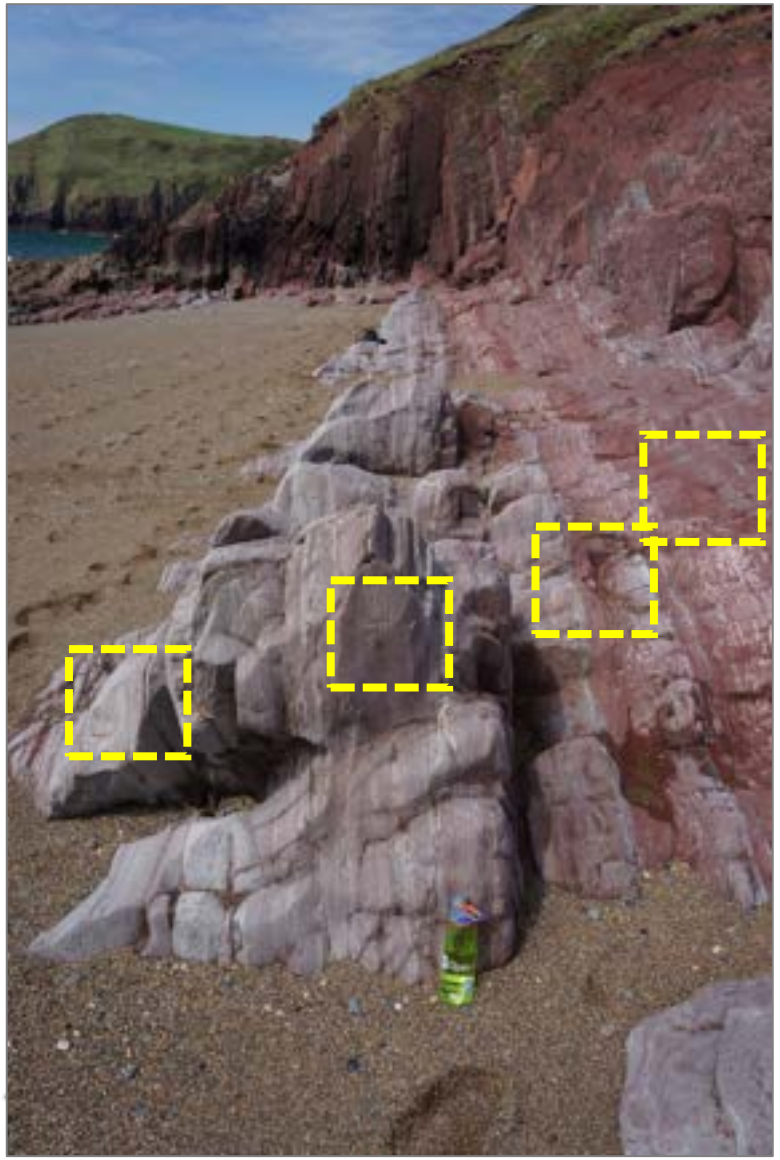
Now we have two

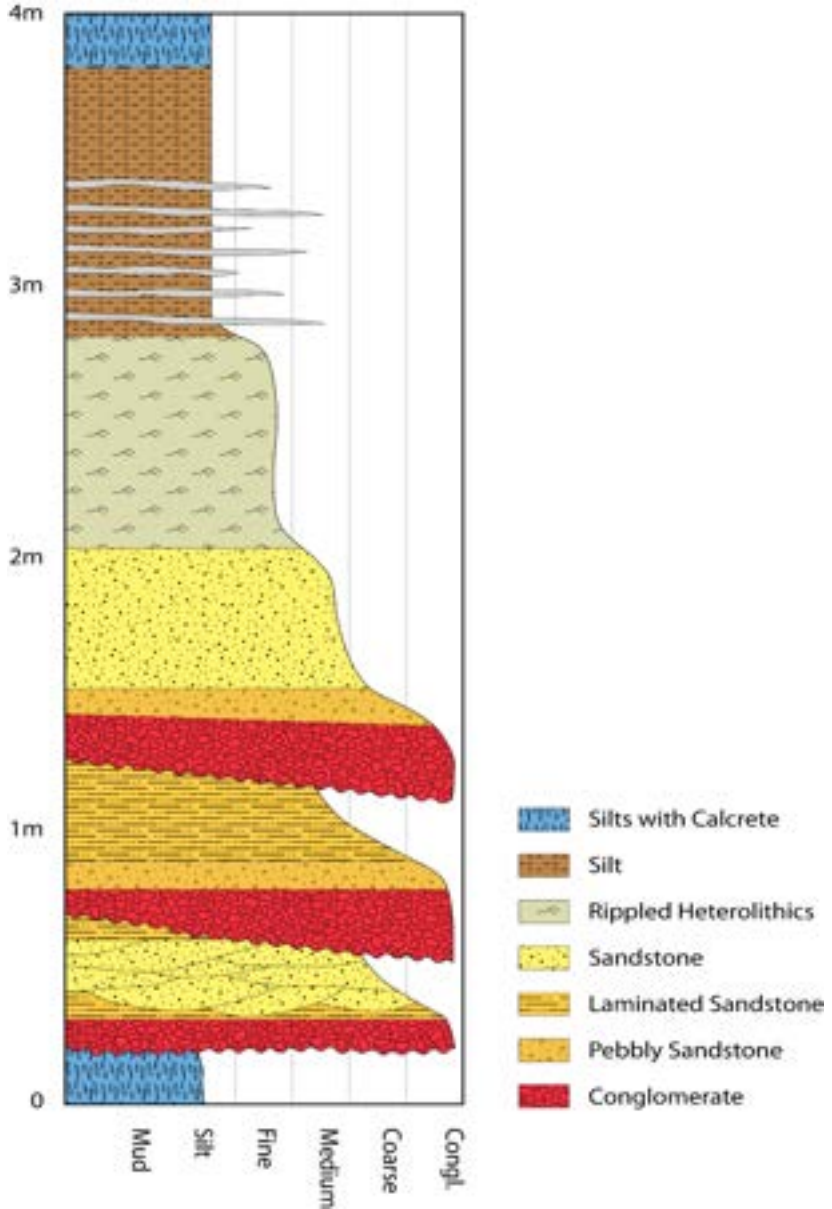
We build a complex model




50m x 50m x 3m
25m x 25m x 1m

Understand one heterogeneous bed



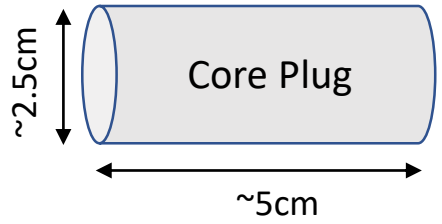


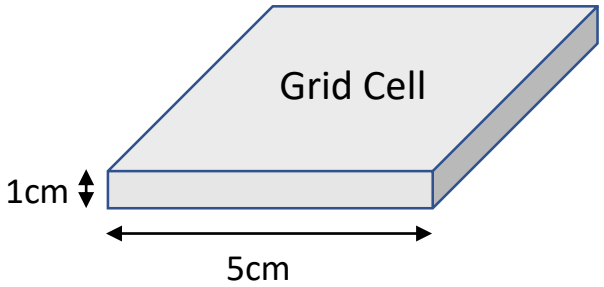
‘Ultimate Truth’ (… almost)

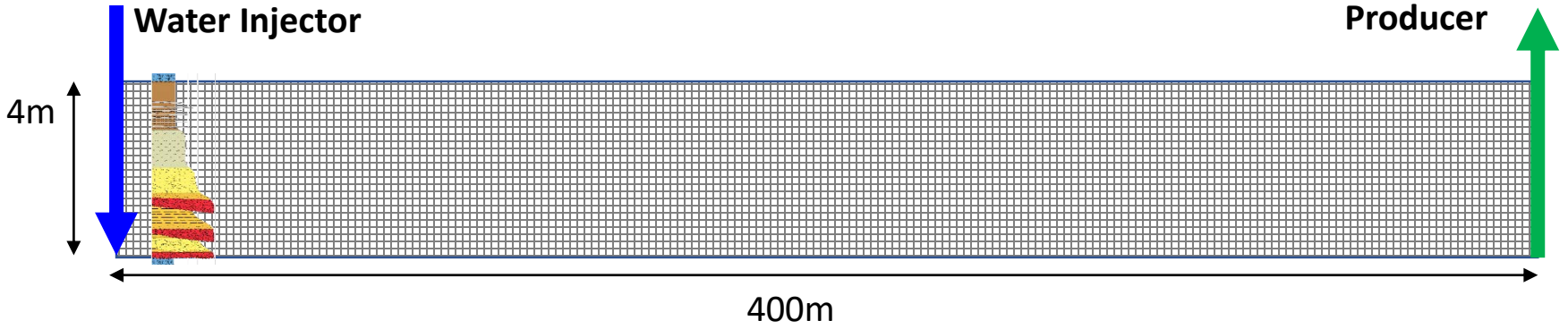
2D cross-sectional model

Typical offshore well spacing

Cell resolution close to the scale of the input data (SCAL)







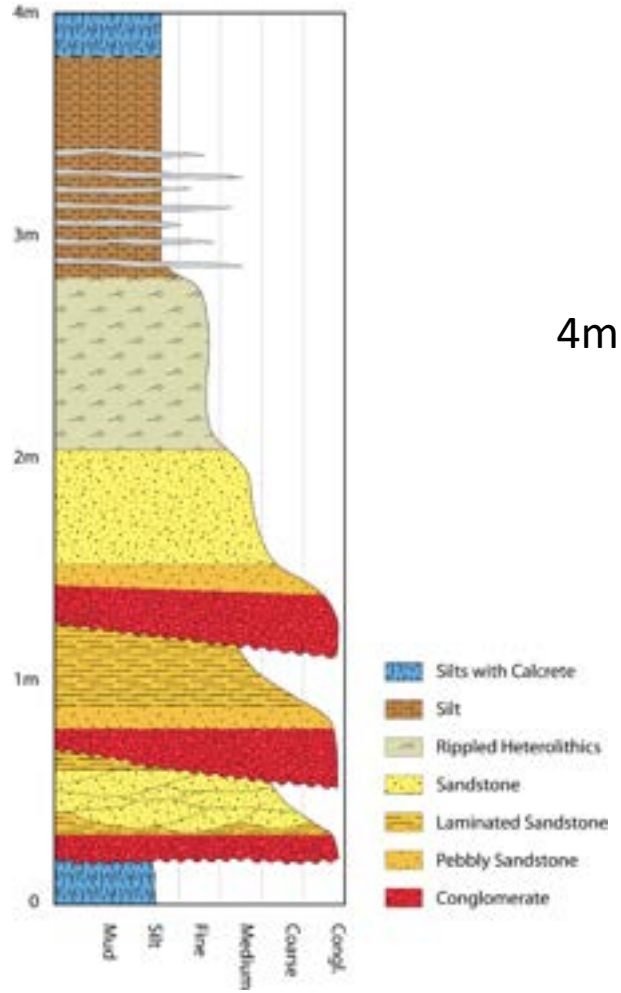
3.2 million static cells

320,000 dynamic cells

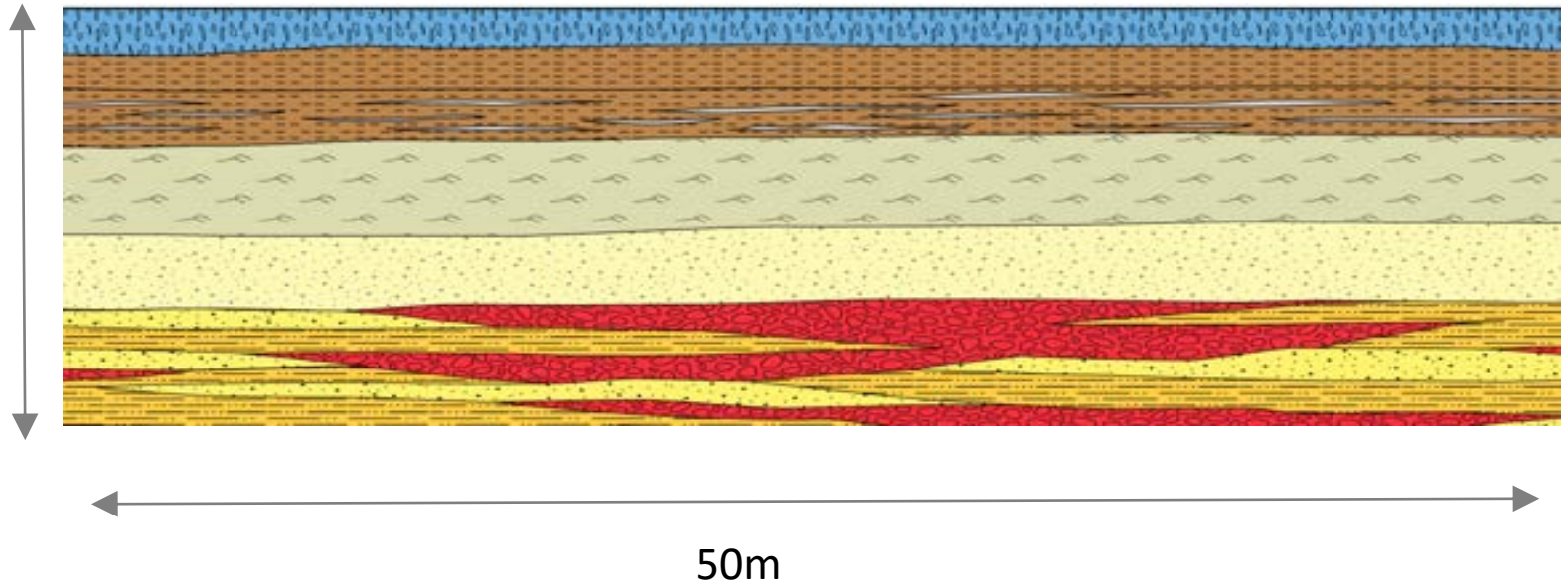
(the full field equivalent would be a trillion cells)

Static build – concept-driven

Sedimentary log

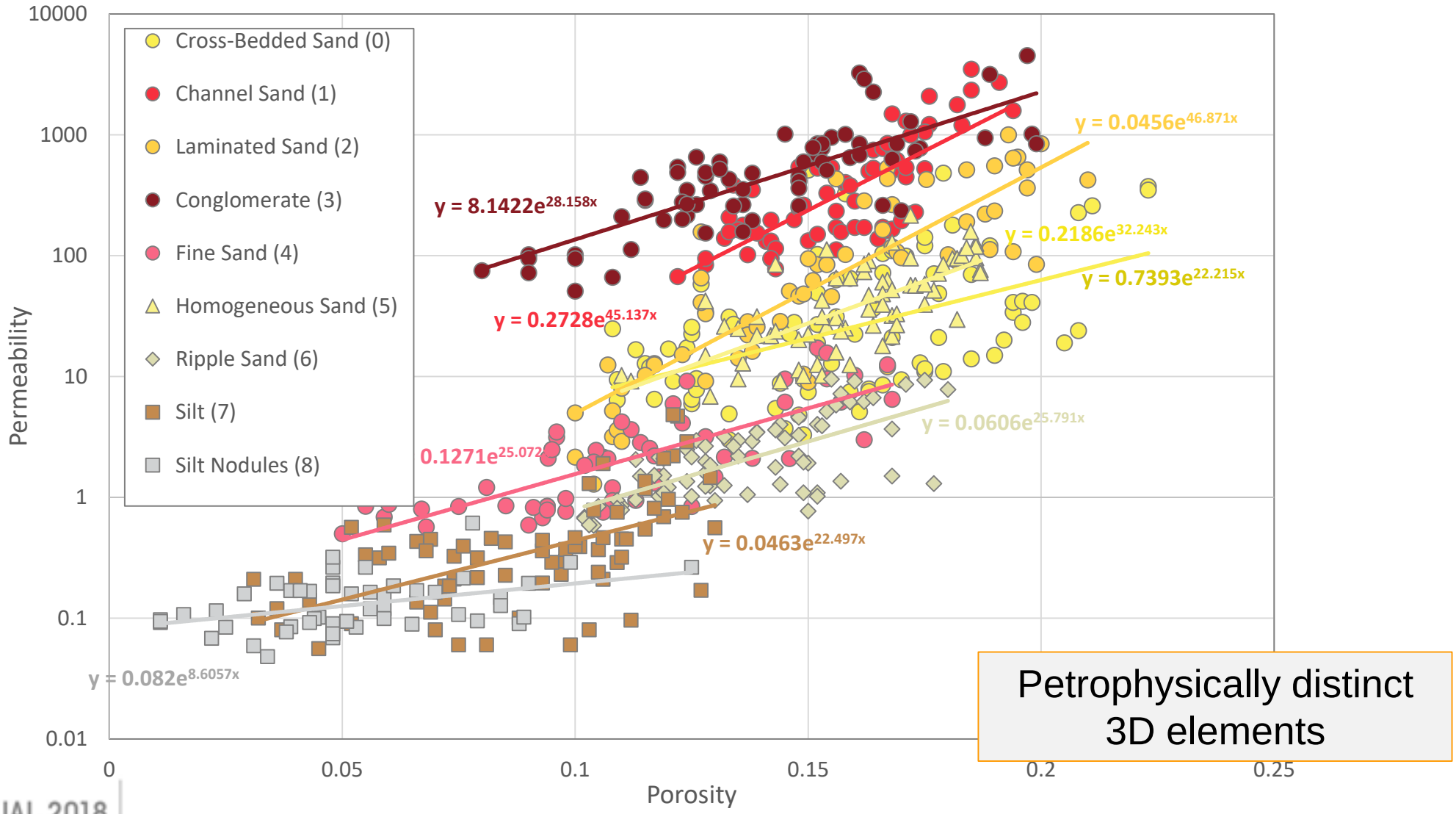


Conceptual sketch



If you can sketch it, you can model it ….

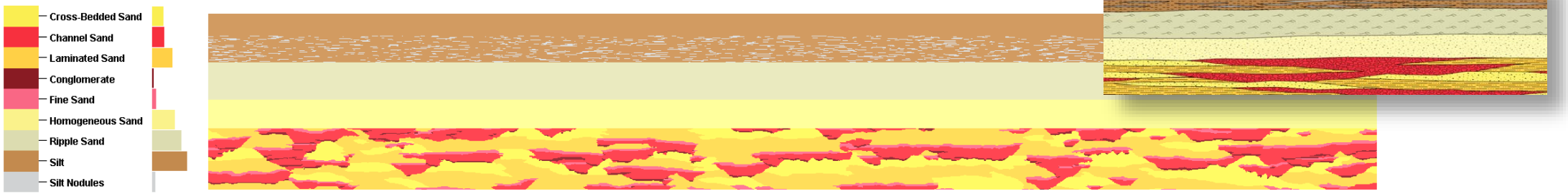
Model elements



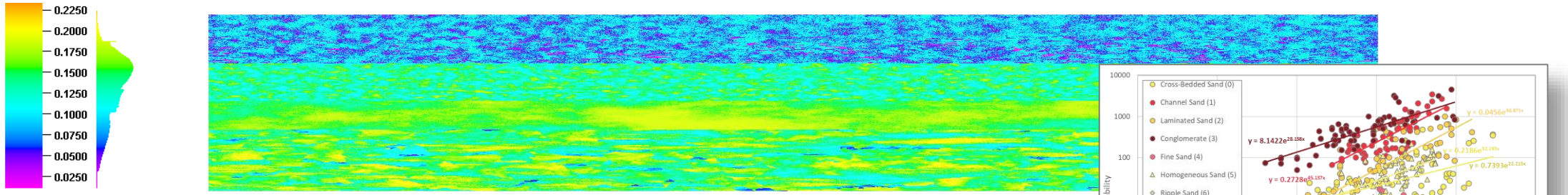
Petrophysically distinct 3D elements

Static model

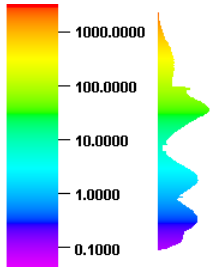
Model elements from multi-point statistics (MPS)



Porosity (frac)



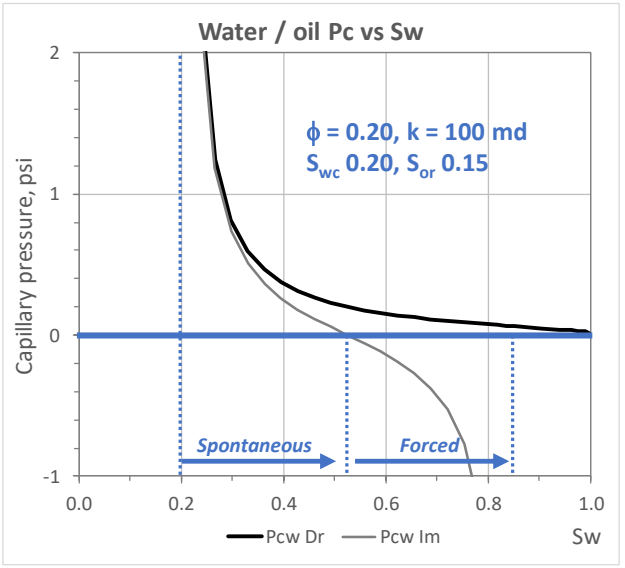
Permeability (mD)

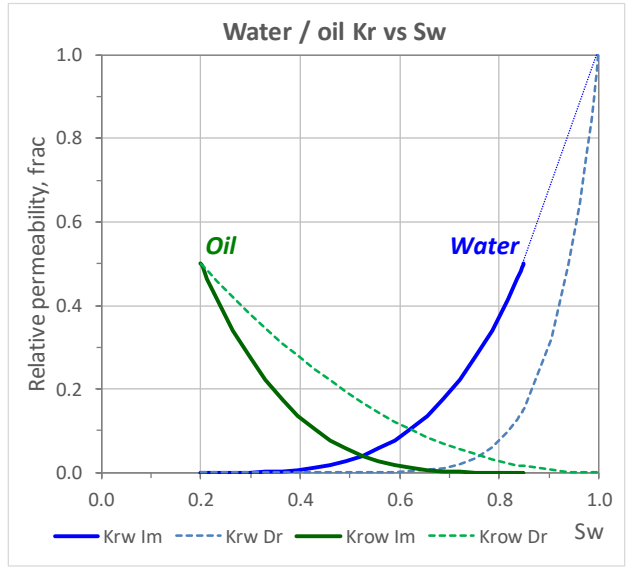


Dynamic model build

FLUID
Light oil (35 API), undersaturated

SATURATION
Mixed wet (I_w 0.5)



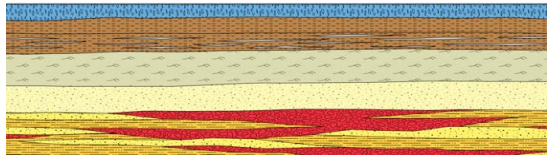


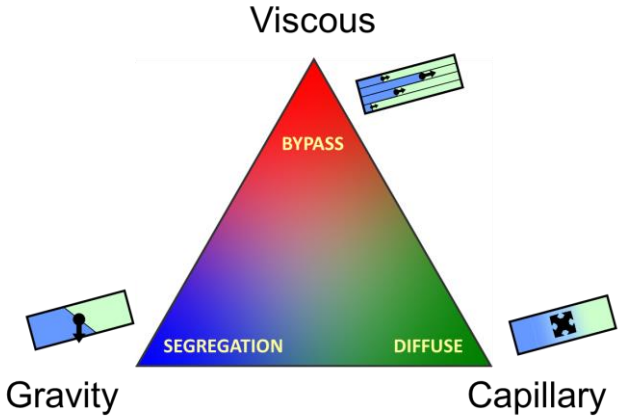
Model performance – how wrong can we be?

Impact of heterogeneity

Impact of viscosity

Need for ‘full physics’





UNDERSTANDING THE PRODUCING SYSTEM

effective net

effects of imbibition

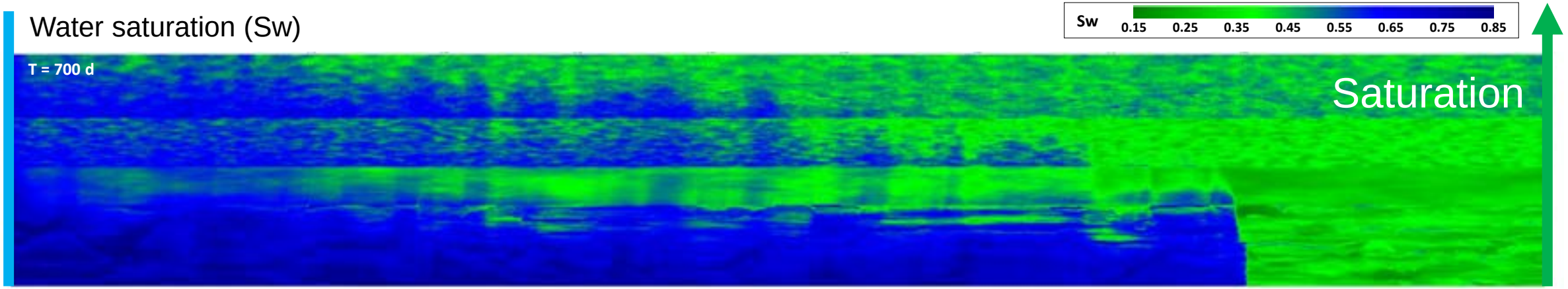
wettability

locating remaining oil

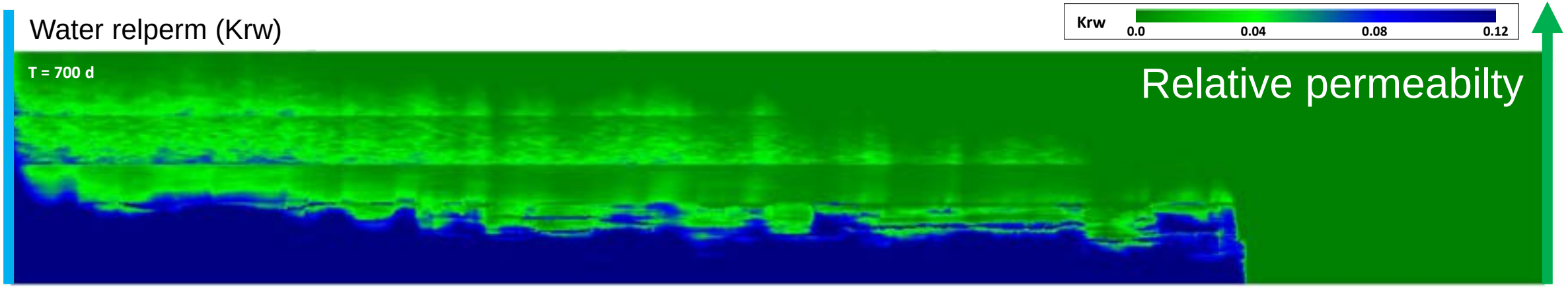
… and what happens when we scale back up …

Viewing the floodfront

Water saturation (Sw)



Water relperm (Krw)



Heterogeneity and sweep

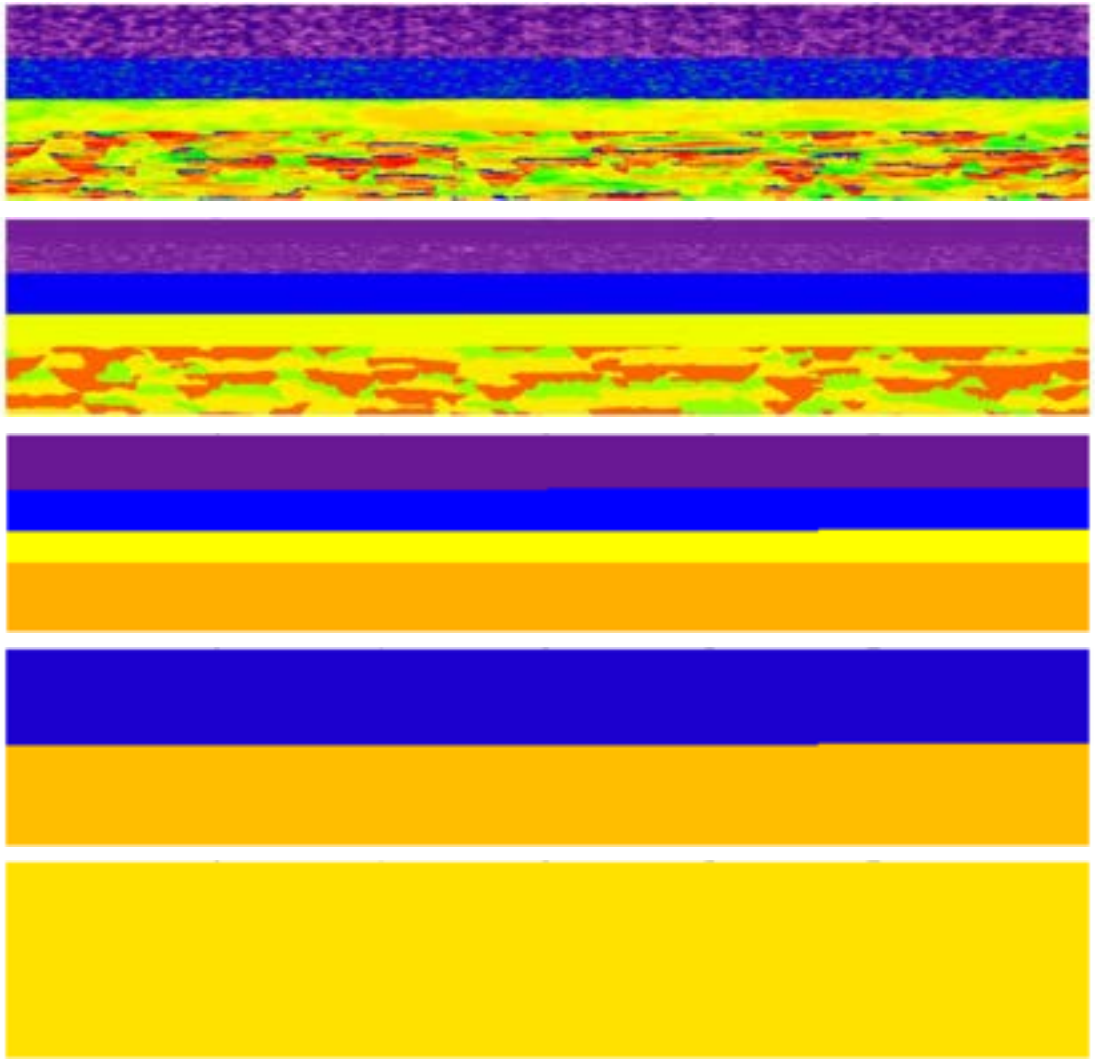
‘Truth’

Homogeneous bodies

4 layers

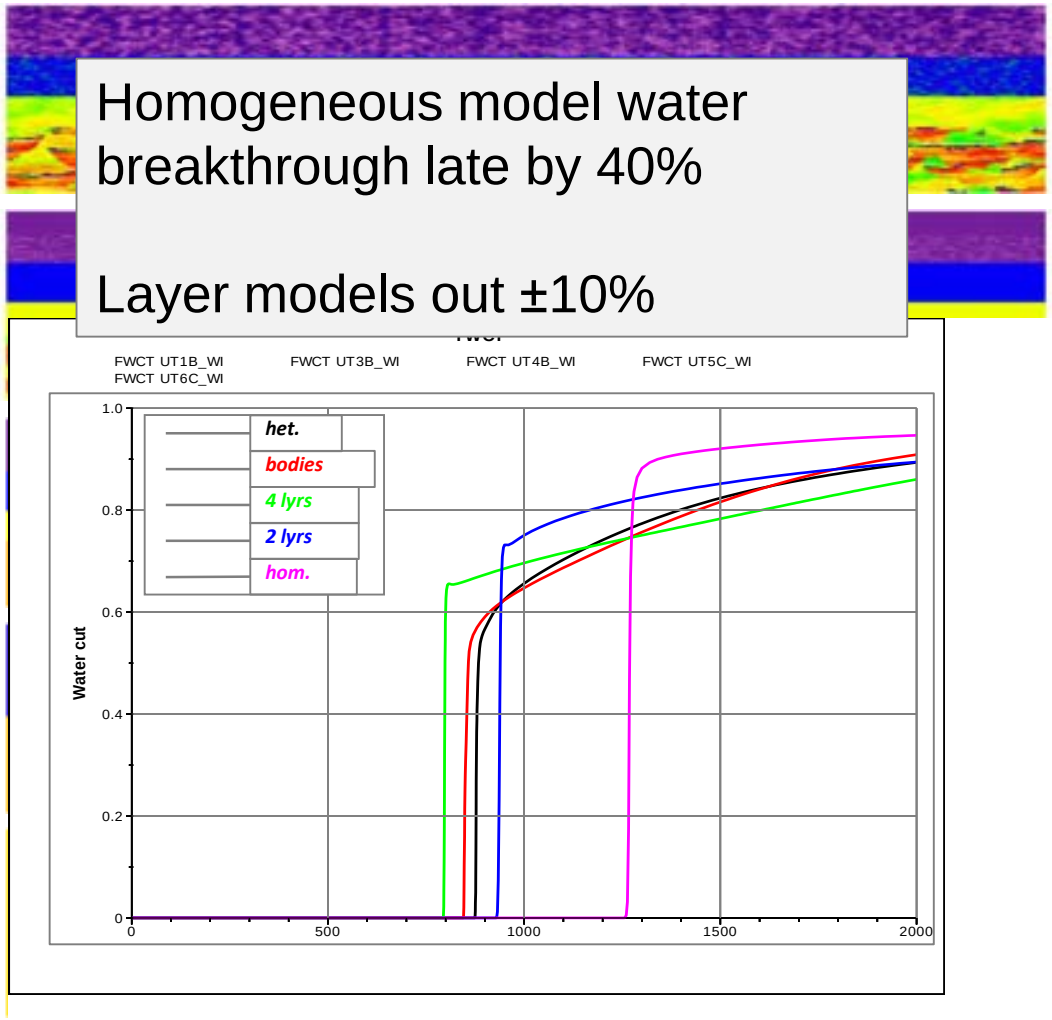
2 layers

1 layer

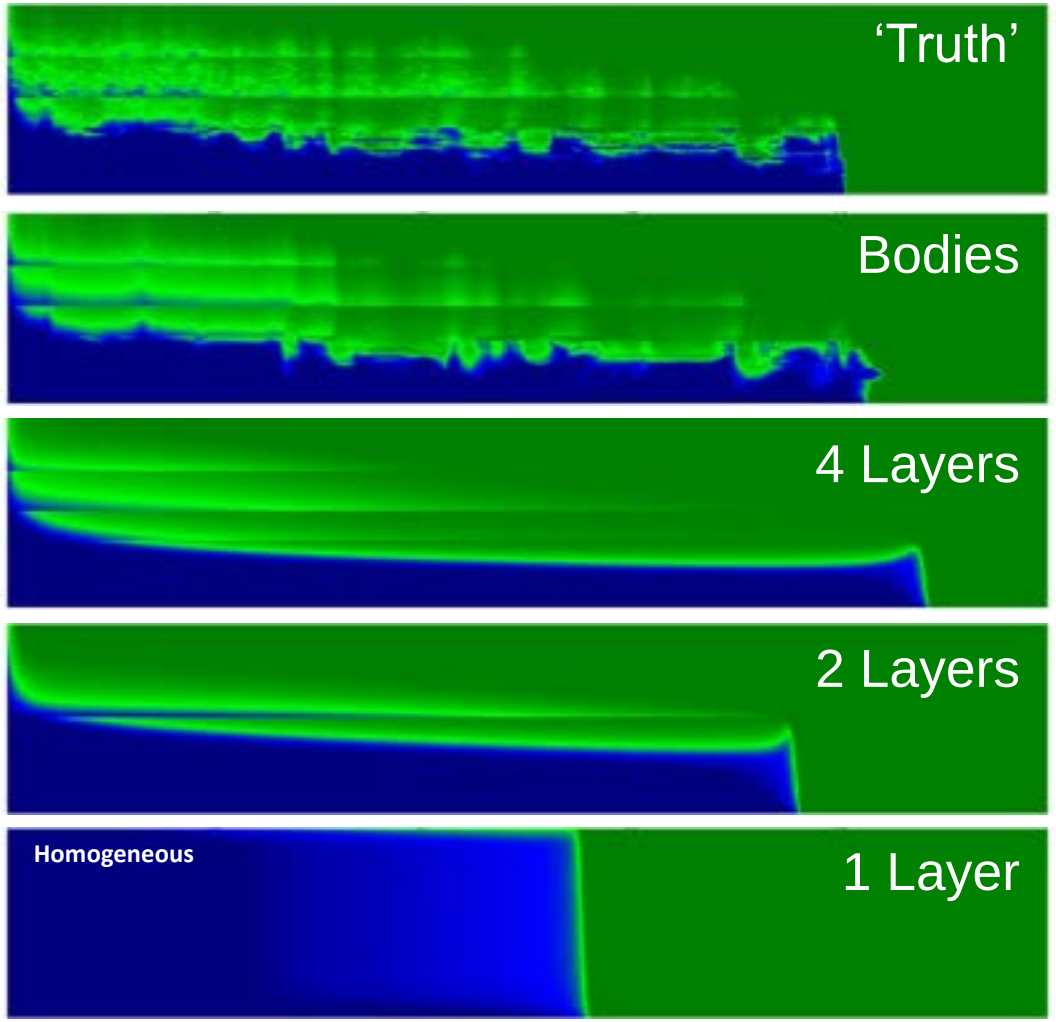


Heterogeneity and sweep

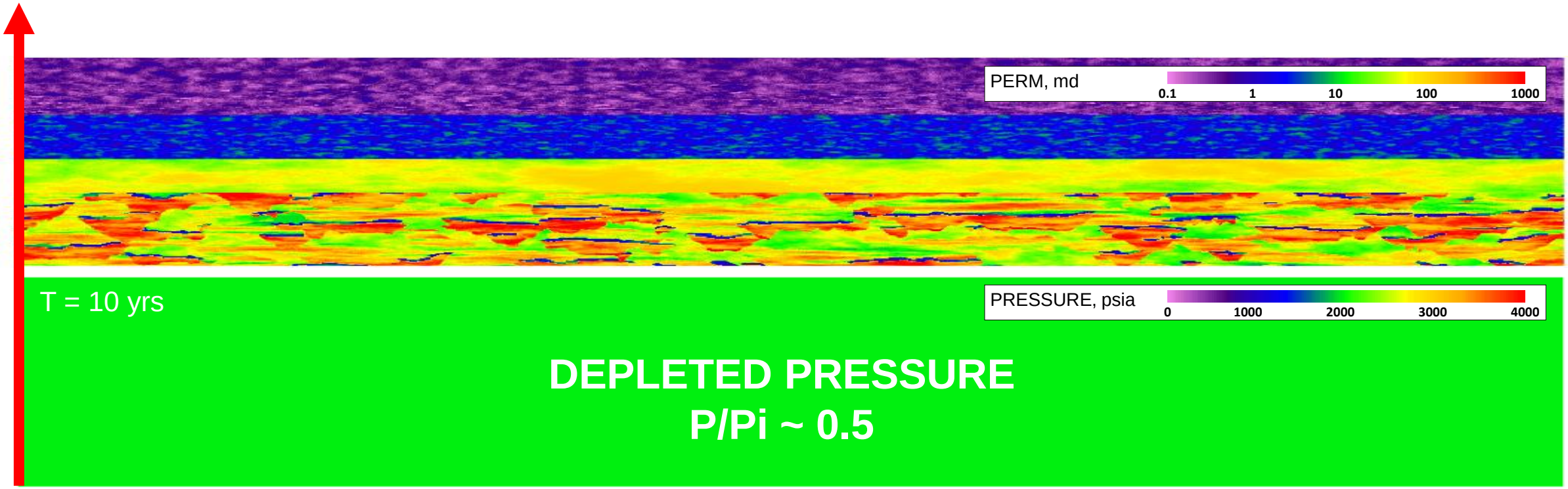
Permeability



Krw @ 700d



Impact of viscosity 1: gas

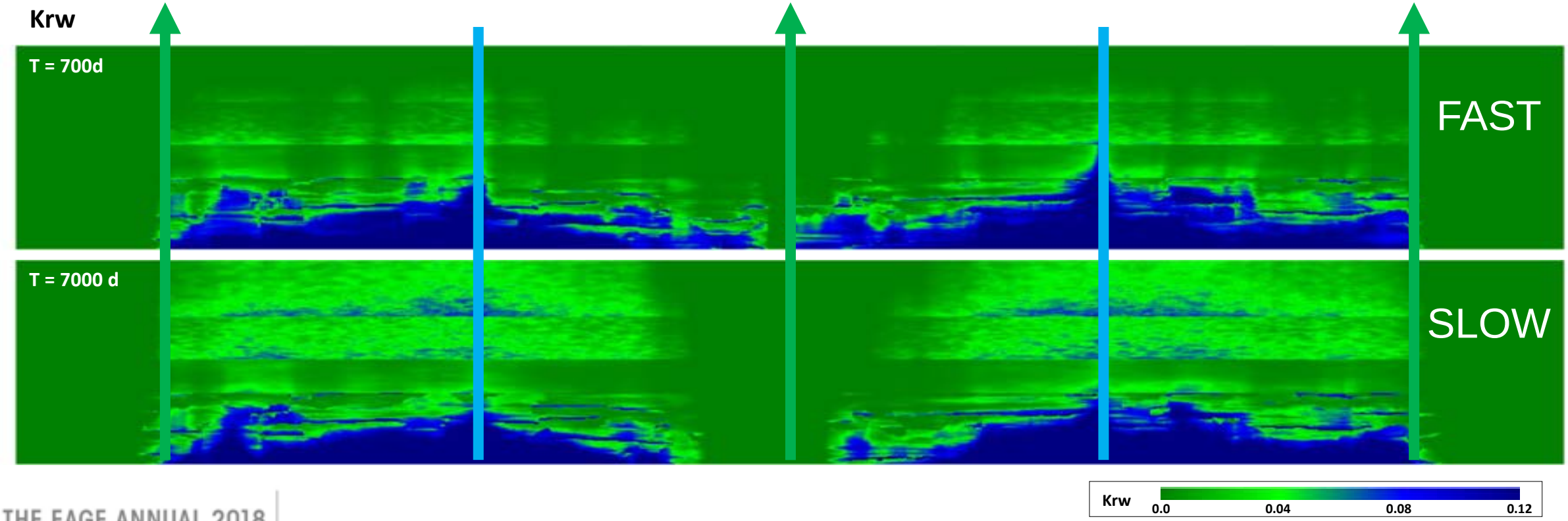


Gas doesn't 'see' the heterogeneity

Impact of viscosity 2: viscous oil

Viscous oil, 5 cp, unfavourable mobility ratio

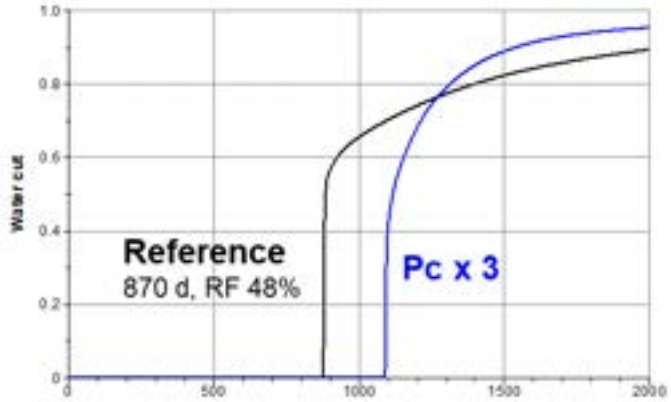
Contrasting fast *vs.* slow injection (15% *vs.* 1.5% PV/yr)



Understanding 1 - the impact of capillary forces

Increased Pc shows significant recovery from upper units

Delays WBT by ~ 25%, increased RF ~ 5%



Krw @ 700d

Reference case Htr ~ 10 ft @ 100 md

‘Truth’ reference case

Pc x 3 case, Htr ~ 30 ft @ 100 md

‘Truth’ with stronger Pc

Krw 0.0 0.04 0.08 0.12

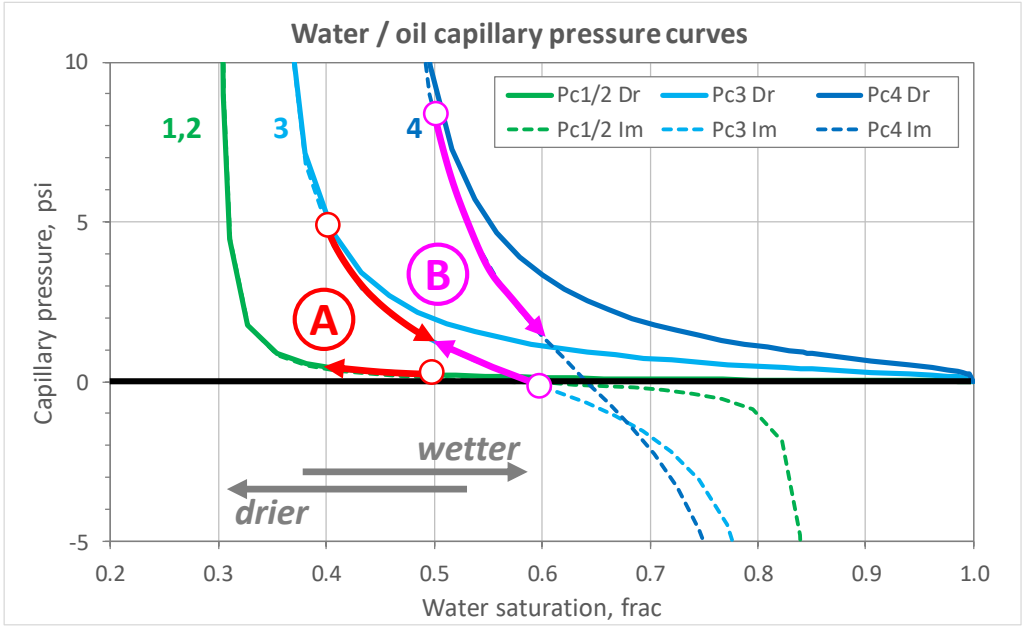
Understanding 1 – capillary imbibition ‘dry towel’ effects

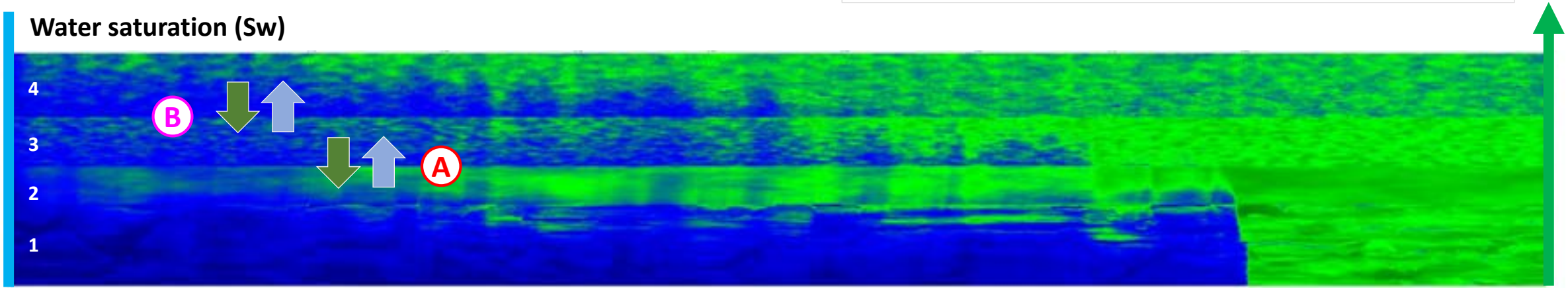
Ⓐ Potential gain ~ 3 psi from Sw exchange by ca. 0.1 from unit 2 to unit 3

Ⓑ Potential gain ~ 6 psi from Sw exchange by ca. 0.1 from unit 3 to unit 4

Water drawn up displaces oil down

Additional recovery from nominally ‘non-net’ material

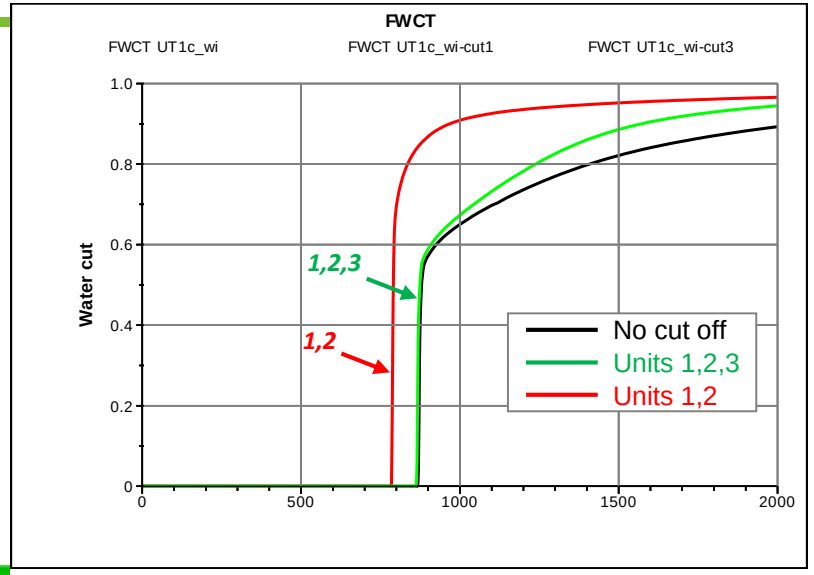


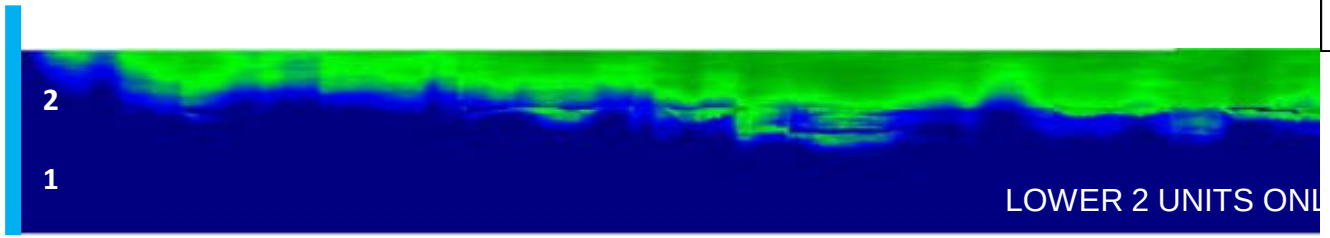


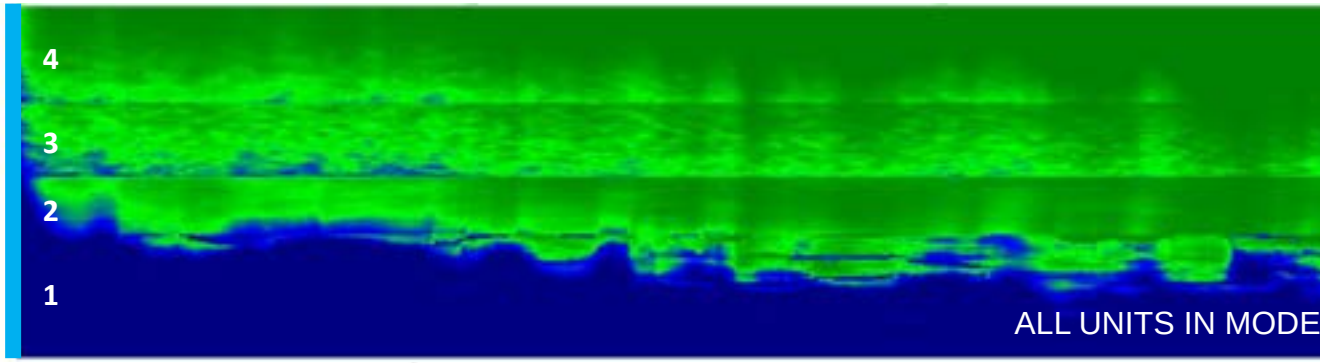
Sw 0.15 0.25 0.35 0.45 0.55 0.65 0.75 0.85

Understanding 2 – flow-based determination of net

Water breakthrough time in Units 1 & 2 is 10% early if poorer units cut-off



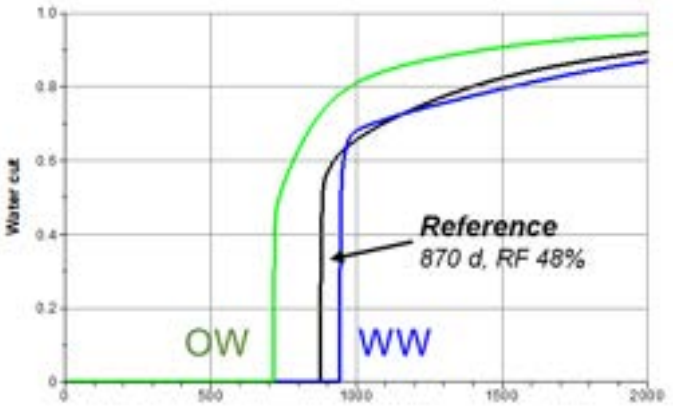




Understanding 3: the impact of wettability

WW: WBT later by ~ 10%,
RF higher by ~ 3%
Stronger spontaneous imbibition into upper units

OW: WBT earlier by ~ 20%,
RF lower by ~ 10%
Bypass of lower perm material within lower unit



Krw @ 700d

Water wetting (Iw 0.8)

Water Wet

Oil wetting (Iw 0.2)

Oil Wet

Krw 0.0 0.04 0.08 0.12

Understanding 4 - Locating Remaining Oil

Saturation behind the flood front

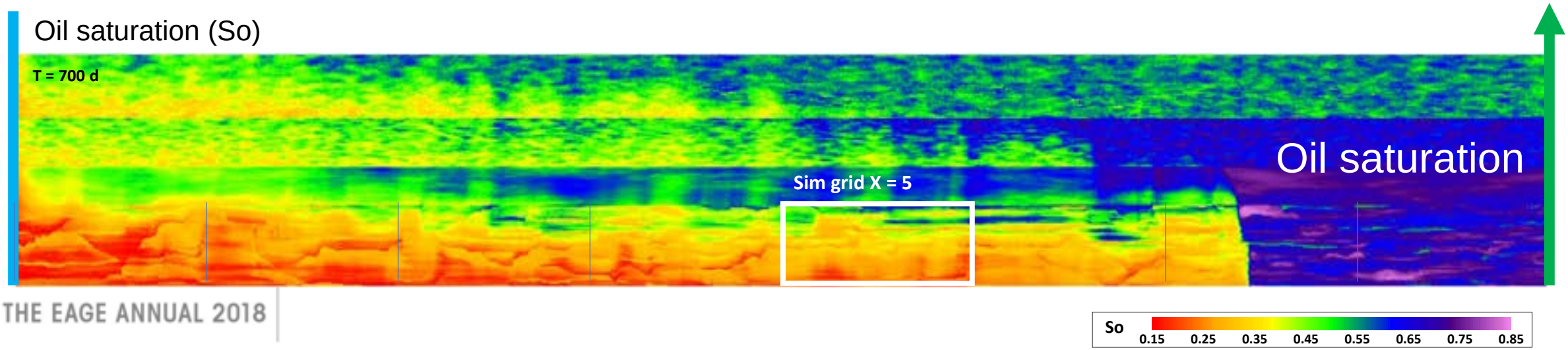
Explore sim grid cell X=5 flowing ~90% water-cut

Residual oil saturation

Same result in fine and sim grid models

…but fine model illustrates where the higher Sor is located

Model	Swi	W/cut	Krw	Kro	Soil
Ultra fine grid	30.7%	87%	**0.1305**	**0.0188**	**34%**
Sim grid X=5	30.6%	93%	**0.0992**	**0.0076**	**34%**



Upscaling to normal life

Ultra Fine 0.25 x 0.02 m
320,000 cells

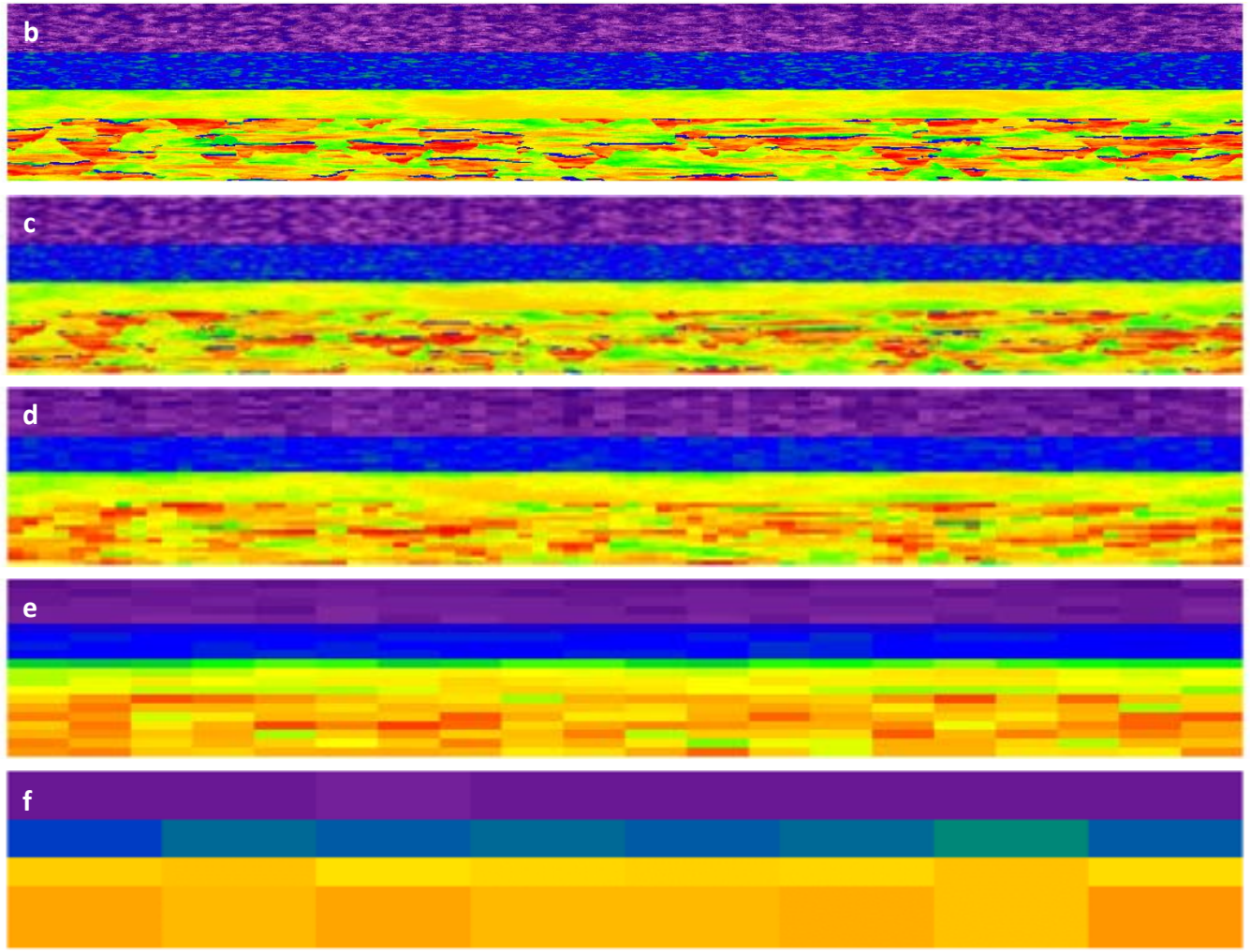
Fine 1 x 0.04 m
40,000 cells

‘Logging scale’ 5 x 0.1 m
3,200 cells

‘High res’ simulation 20 x 0.2 m
400 cells

‘Normal simulation’ 50 x 1 m
32 cells

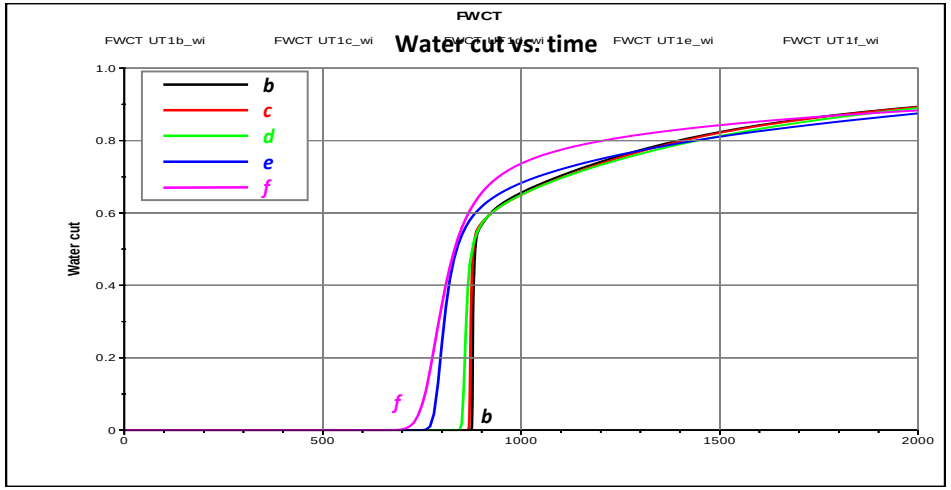
Permeability

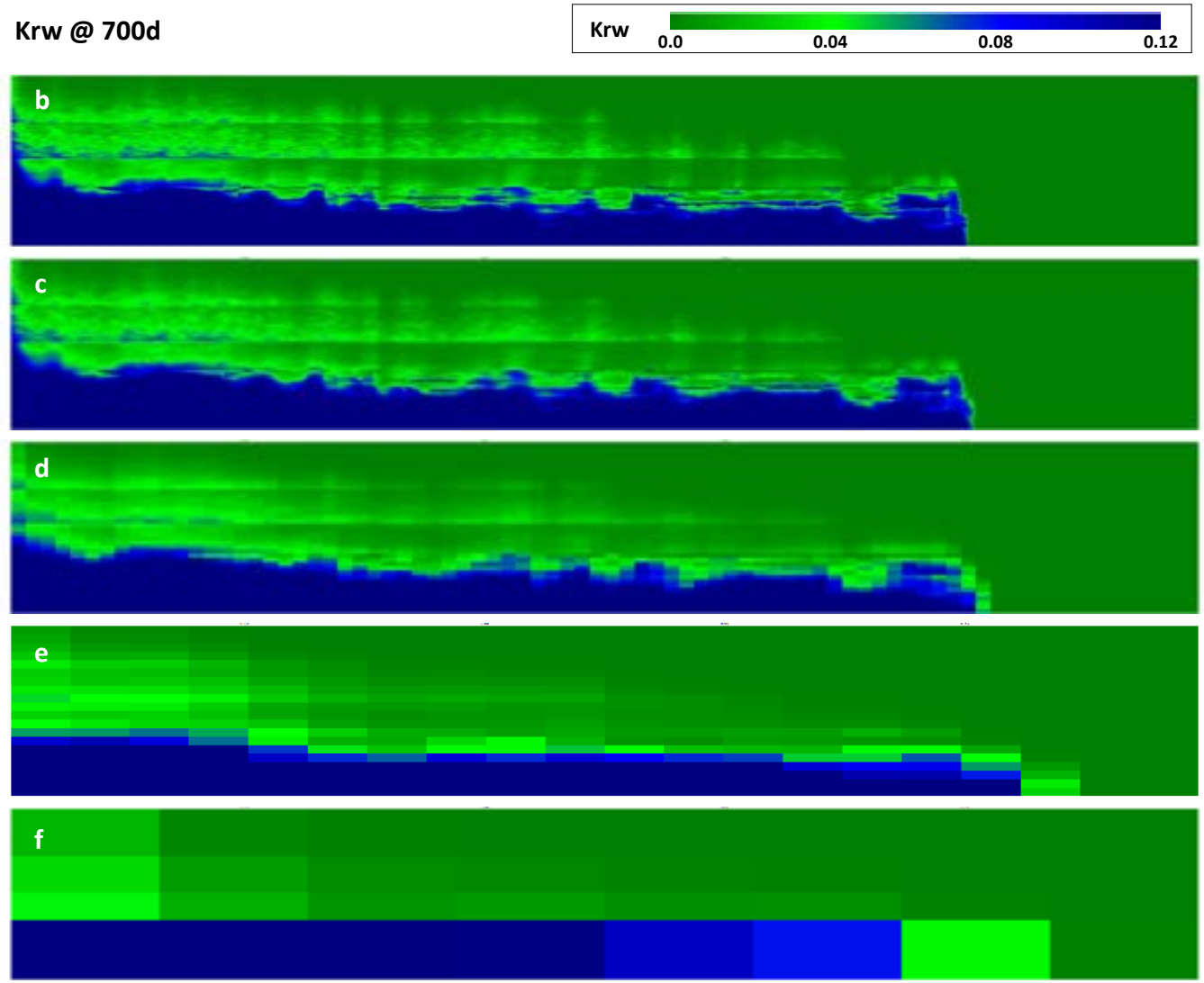


Upscaling to normal life

Ultimate recovery similar (within 3%)

But breakthrough times progressively error-prone (up to 20%)

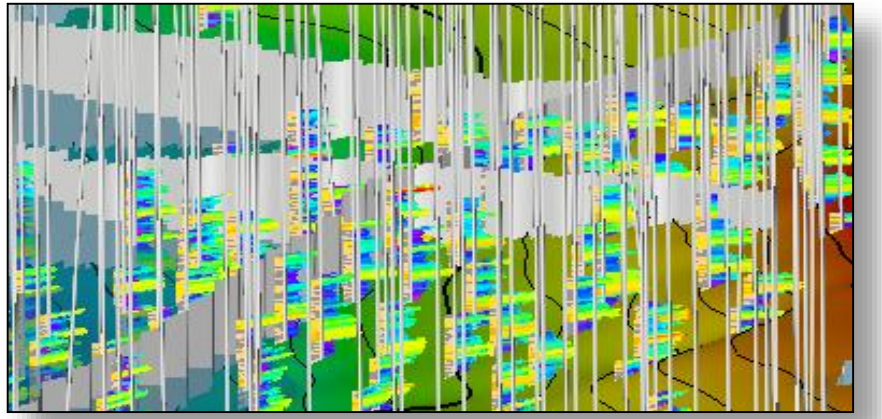


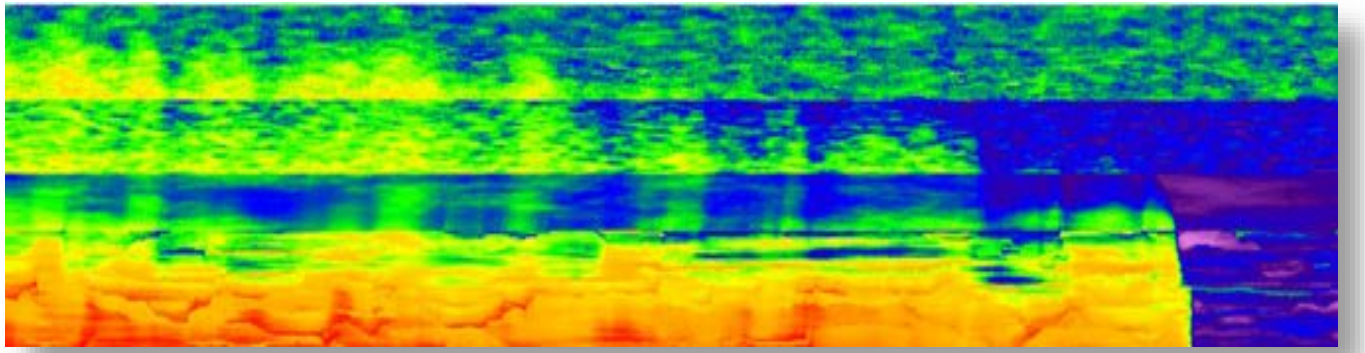


The role of ‘Ultimate Truth’ models

Truth models repeatedly show that removing detail is a *systematic* bias

Big, ‘complex’ full-field models tend to over-optimism





We understand more through deconstruction

… and can then make appropriate workflow adjustments at larger scales

Sometimes, small really is beautiful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