British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Using Digital Outcrop Data to Improve CO2 Flow Simulation at Reservoir-Caprock Interfaces: An Example from the Sherwood Sandstone of SW England

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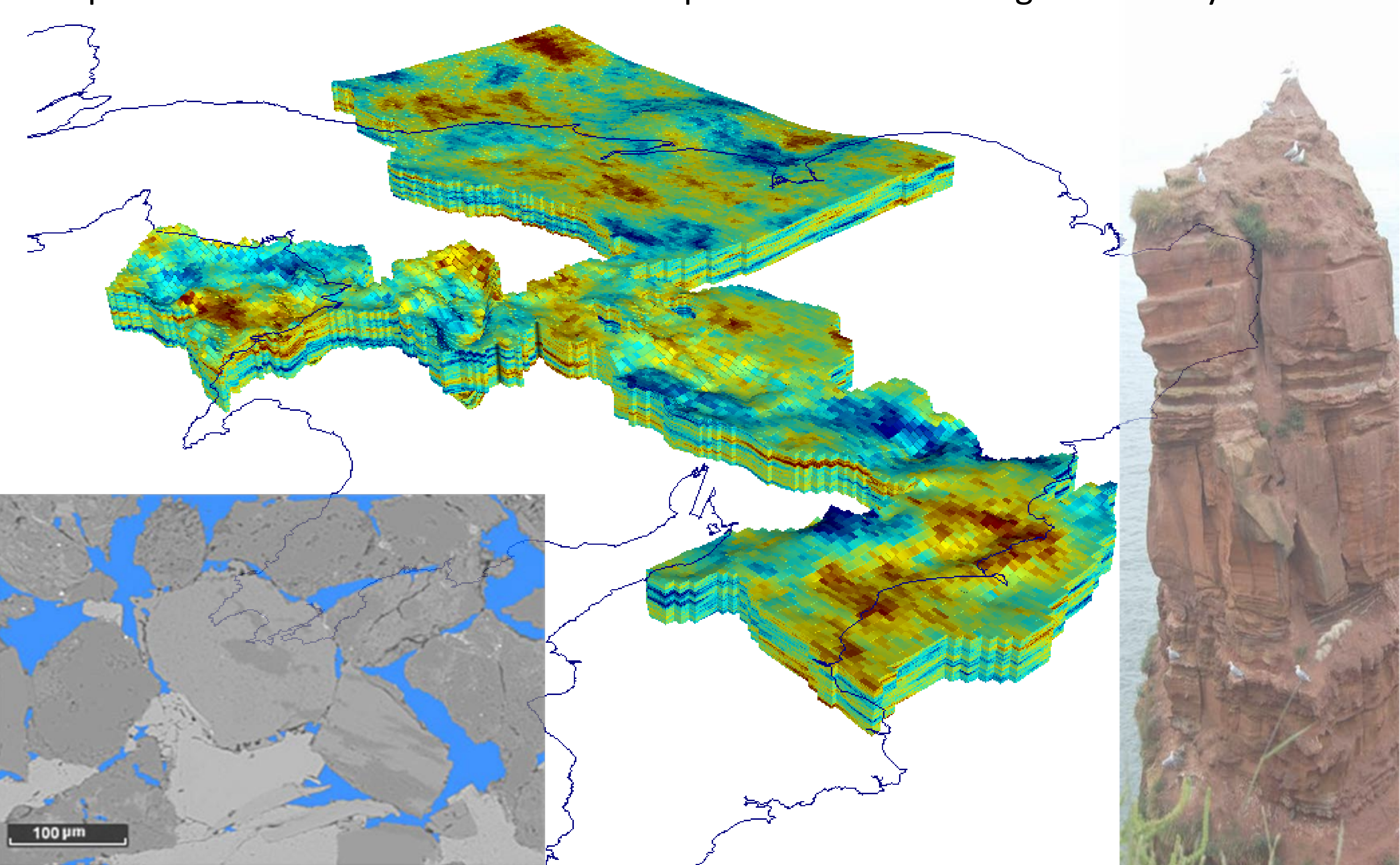
Background:

- Triassic continental clastics of the Sherwood Sandstone are a potential target for carbon capture and storage in the UK
- Requirement to flow model for reservoir performance and long term safety



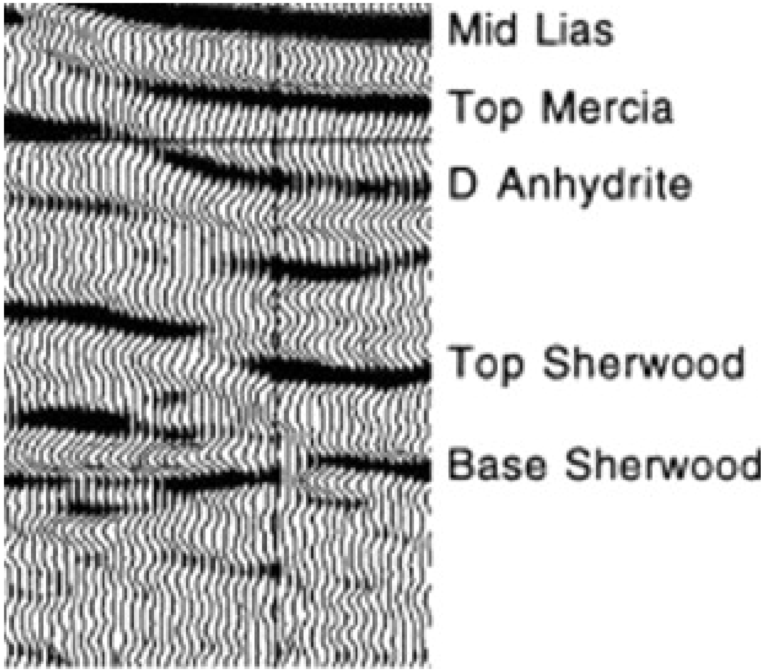
Problem

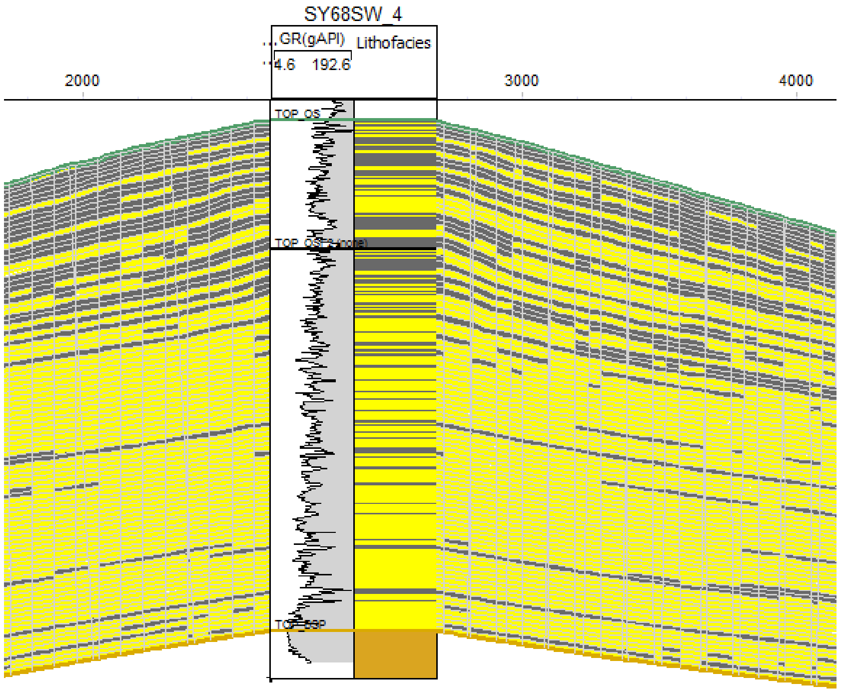
Scale gap in our understanding of the subsurface heterogeneity

Vintage 2D seismic only good at a formation scale (100-1000m)

Core & wireline logs provide: high resolution (mm-cm) vertical control but minimal lateral constraint

Perennial problems e.g. width parameters for shales in stochastic reservoir models ?





Solution

Outcrop can provide information on rock heterogeneity at the 1-10 metre scale

This talk:

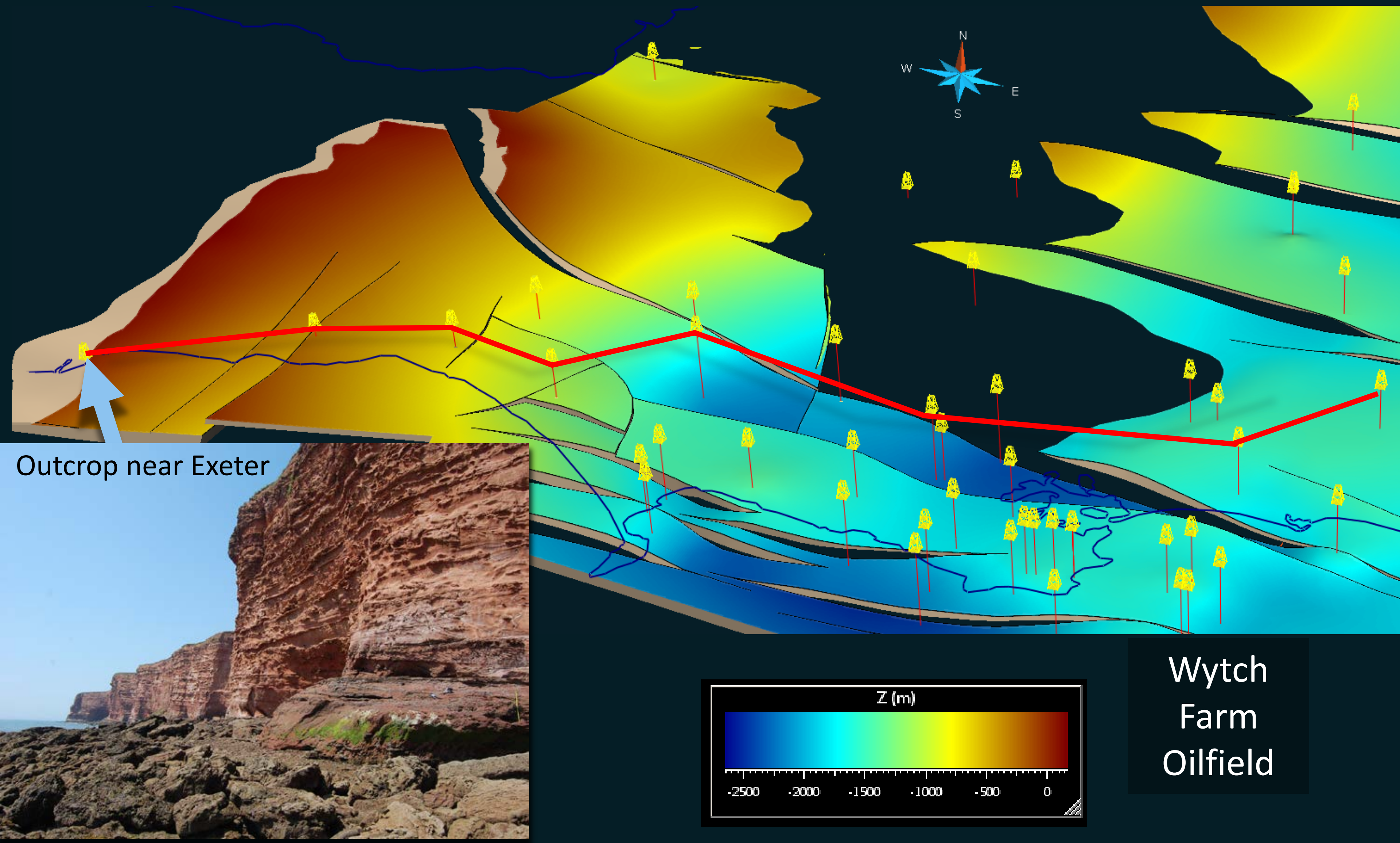
Triassic Sherwood Sandstone (Otter Sandstone Fm)

Wessex Basin of SW England

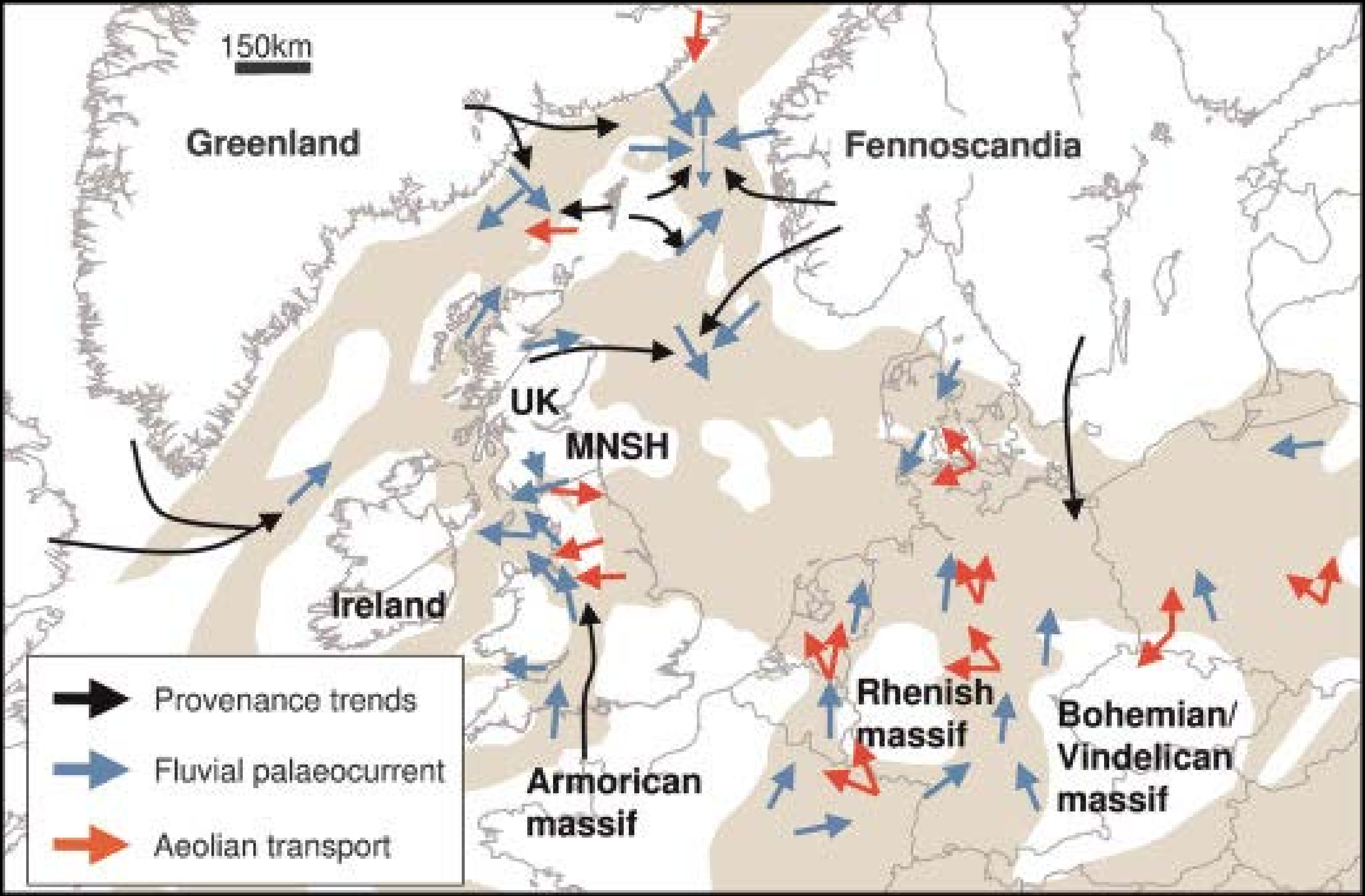
Outcrop near Exeter

'Fluvial redbeds'

Formation can be readily correlated from surface outcrop into the subsurface (Wessex Basin)



Conventional, generalised palaeogeographic models show northward flowing Triassic rivers



Triassic palaeogeography and fluvial dispersal across the northwest European Basins

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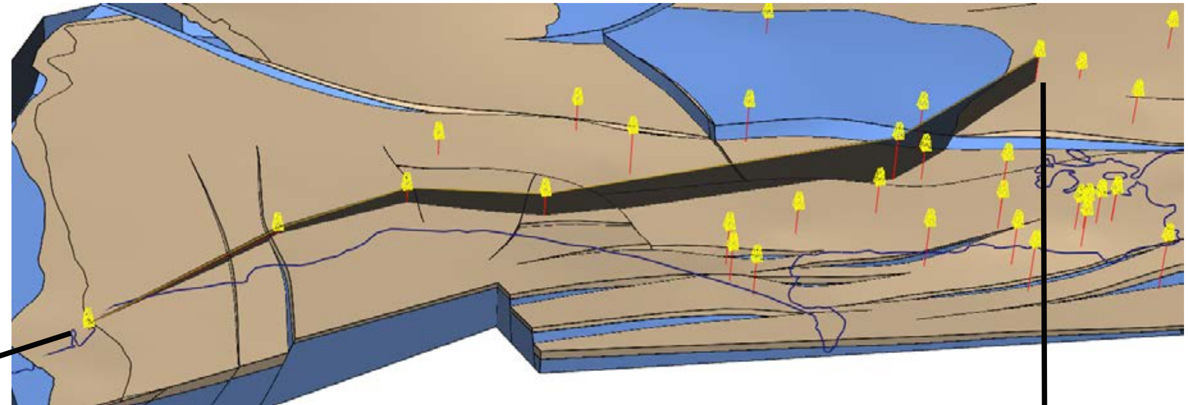
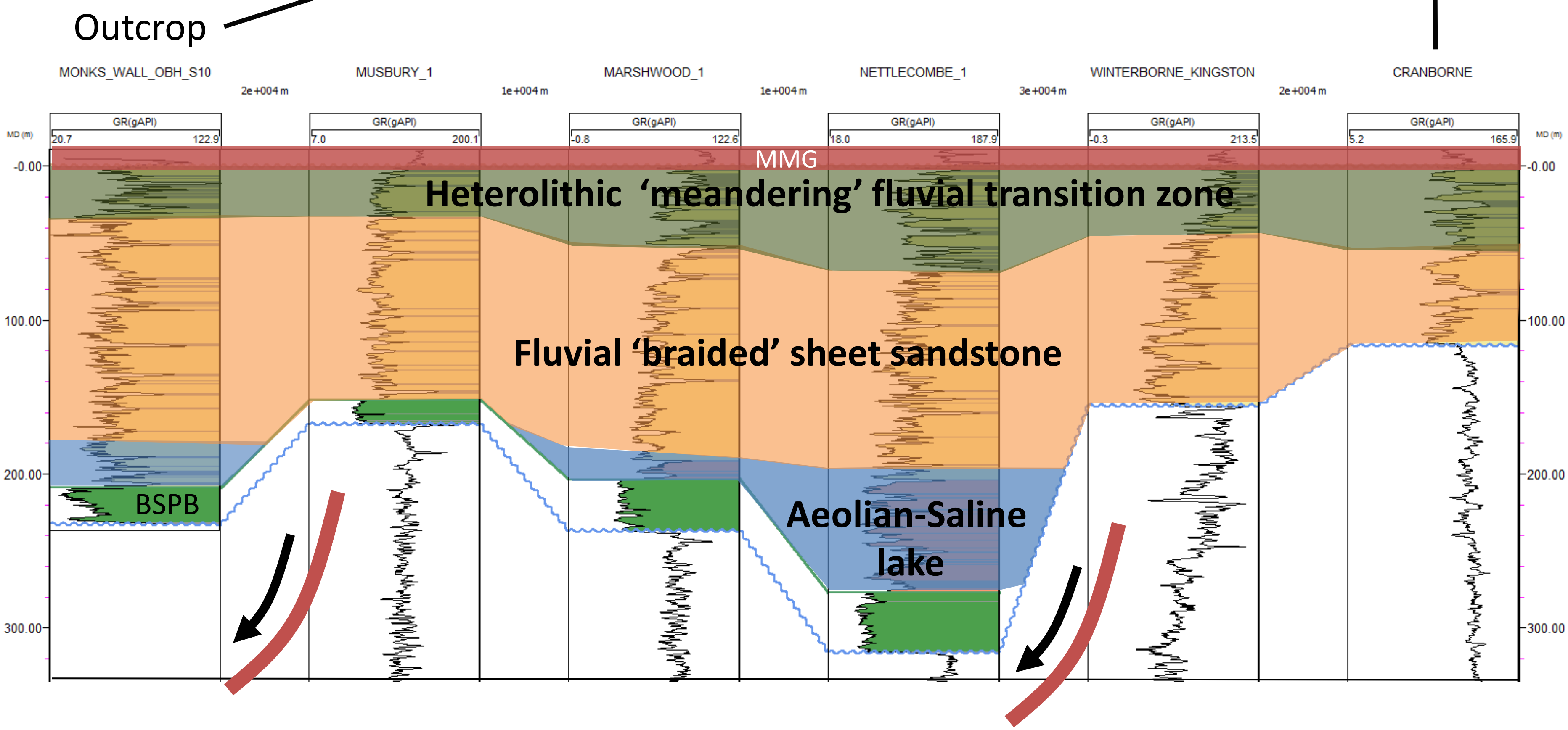
Log correlation and structural modelling indicates it is more complex

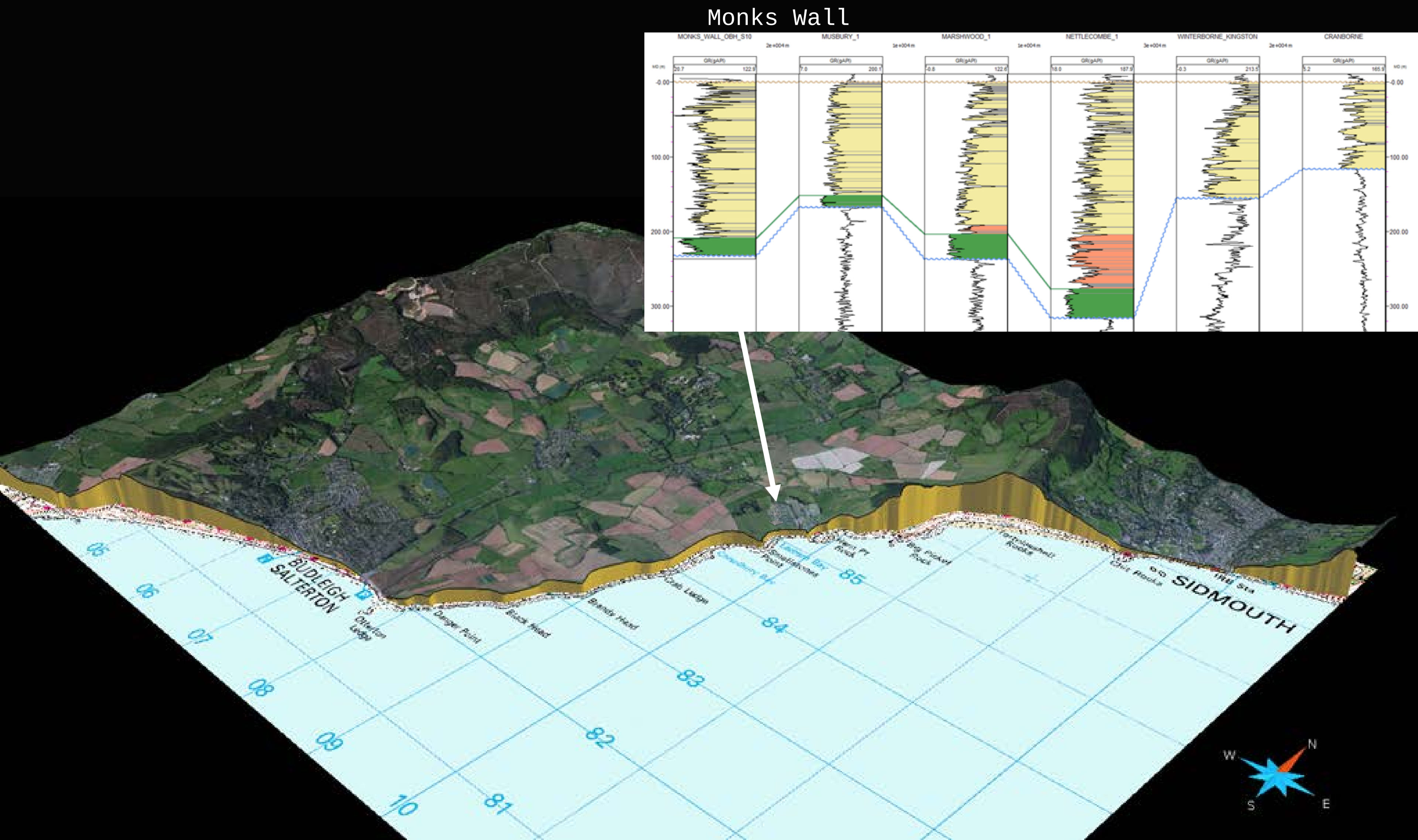
Evolving ‘fill and spill’ rift basin stratigraphy





• Outcrop studies are vital to refine subsurface stratigraphy and sedimentary architecture

• Enabled because wells immediately behind the SSG outcrop provide a direct correlation from outcrop into the subsurface Wessex Basin

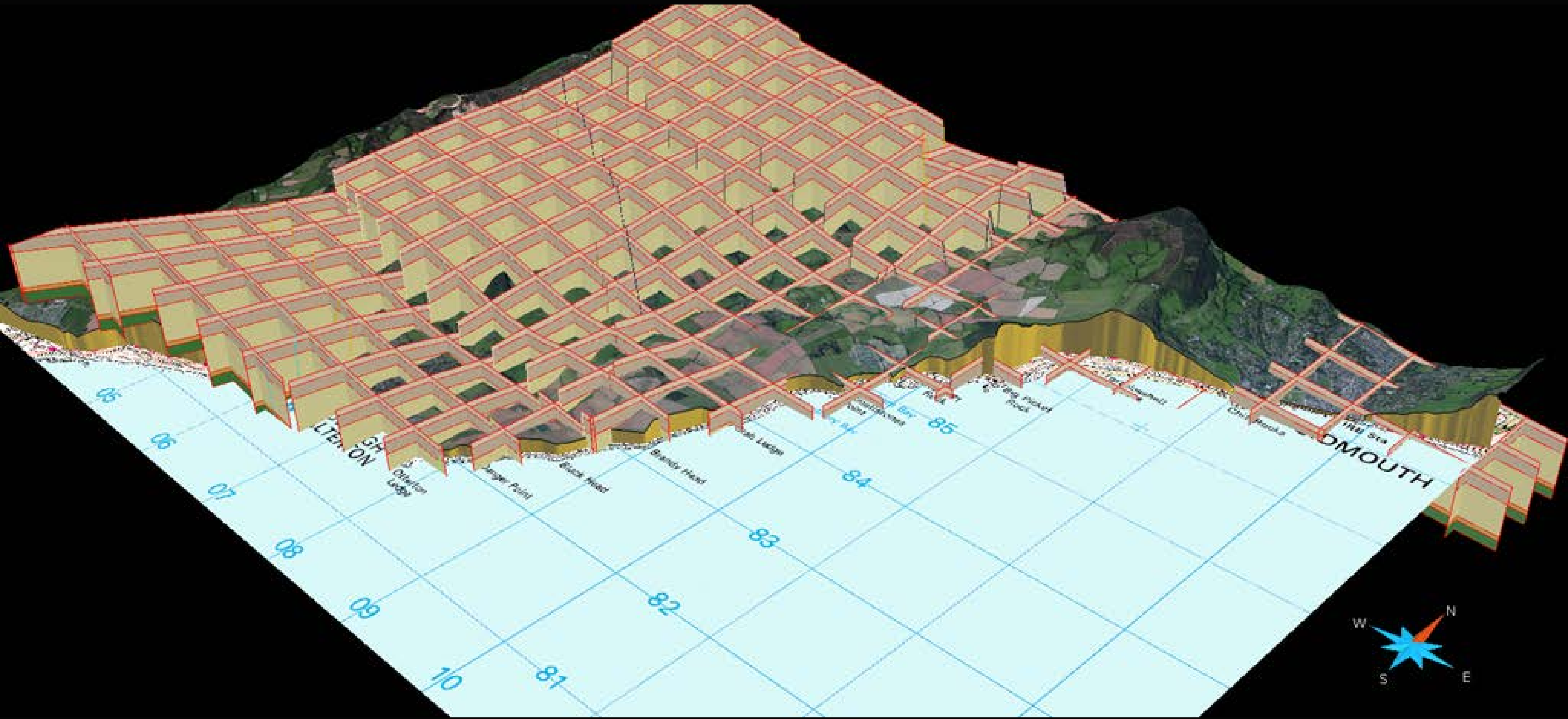


Problem

Stratigraphic correlation at outcrop is hampered by extensive faulting

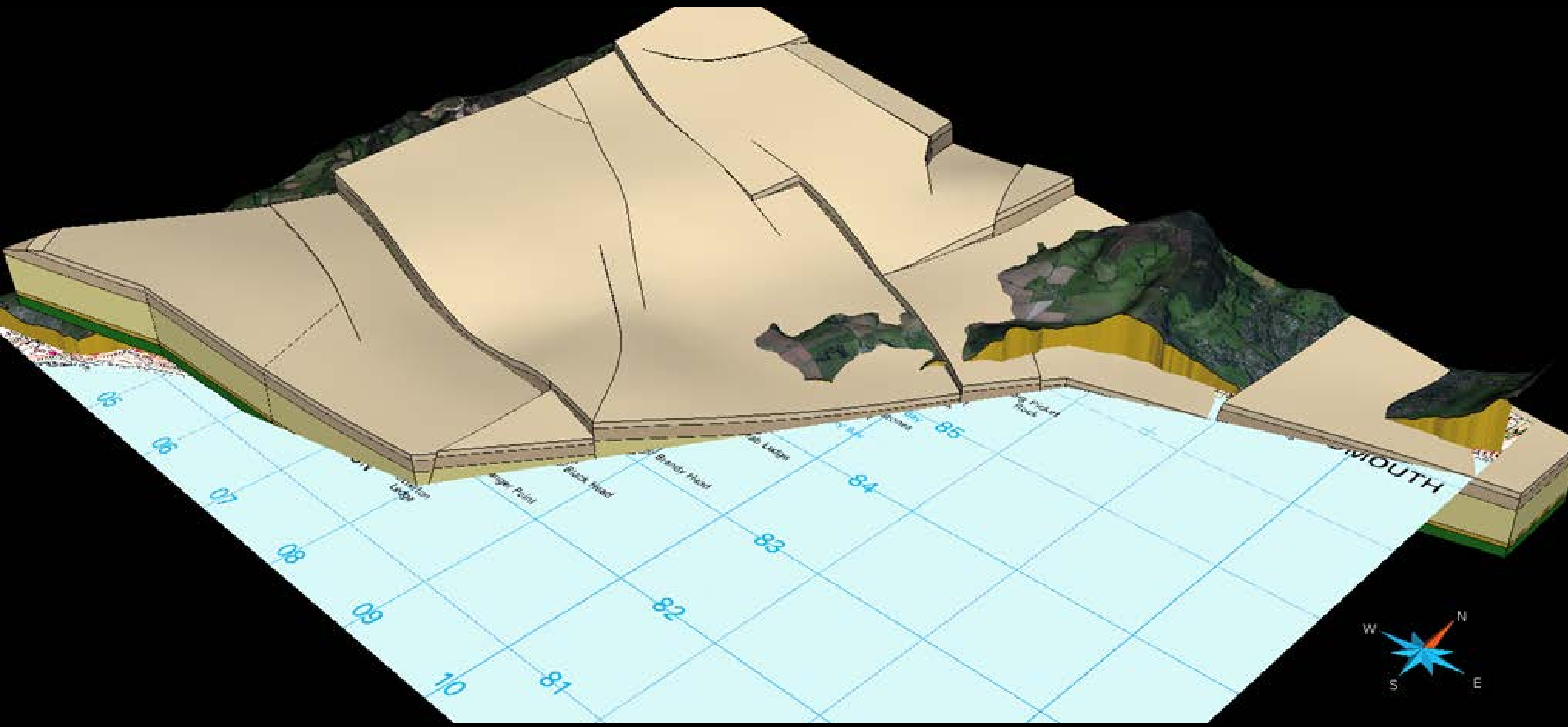
Solution

All outcrop work was carried out within the framework of an evolving 3D model



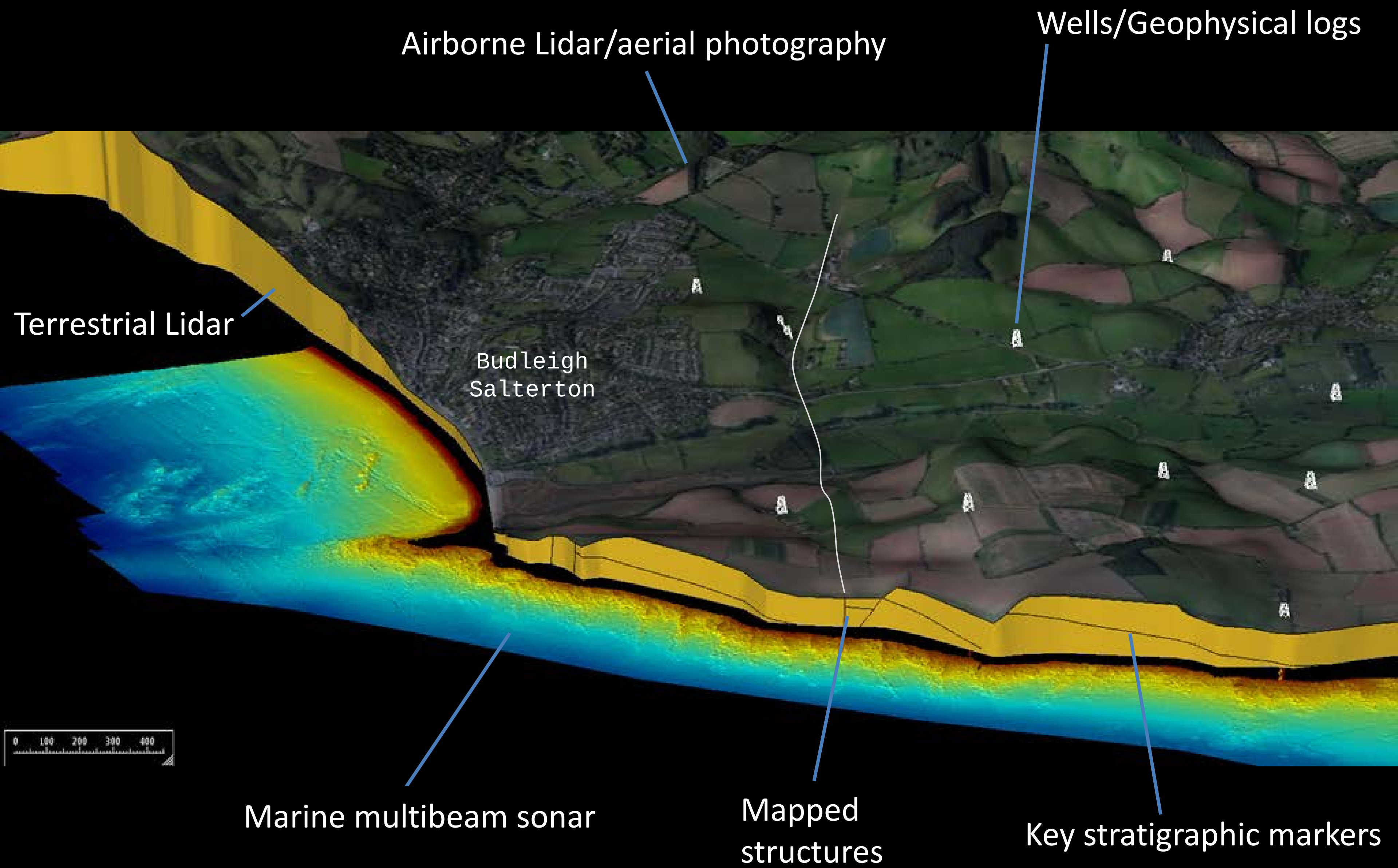
Solution

All outcrop work was carried out within the framework of an evolving 3D model

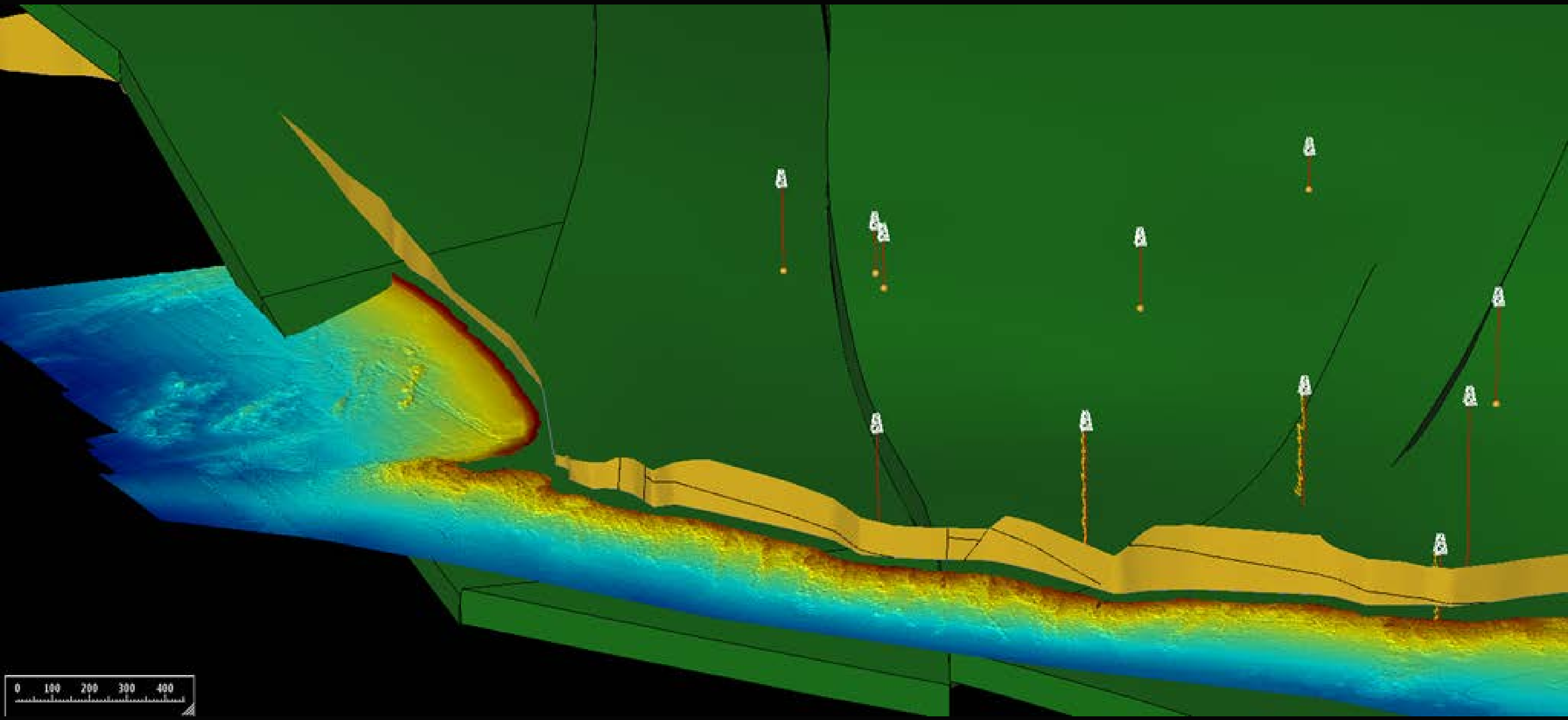


Paradigm SKUA®

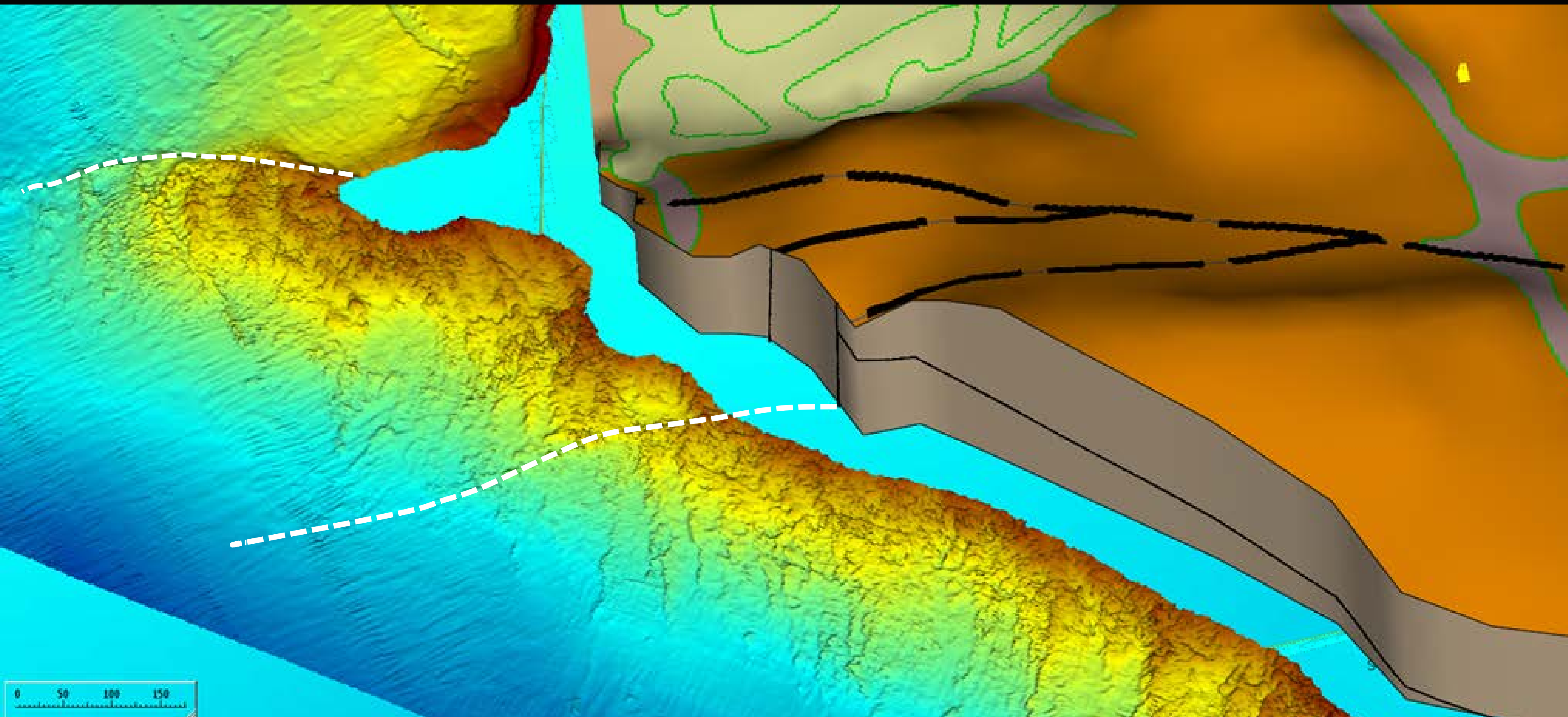
Model input data



Wells confirm onshore trajectory and displacement of faults



Marine multibeam sonar confirms the offshore trajectory of faults and can be used to map bedding relationships



Channel Coastal Observatory

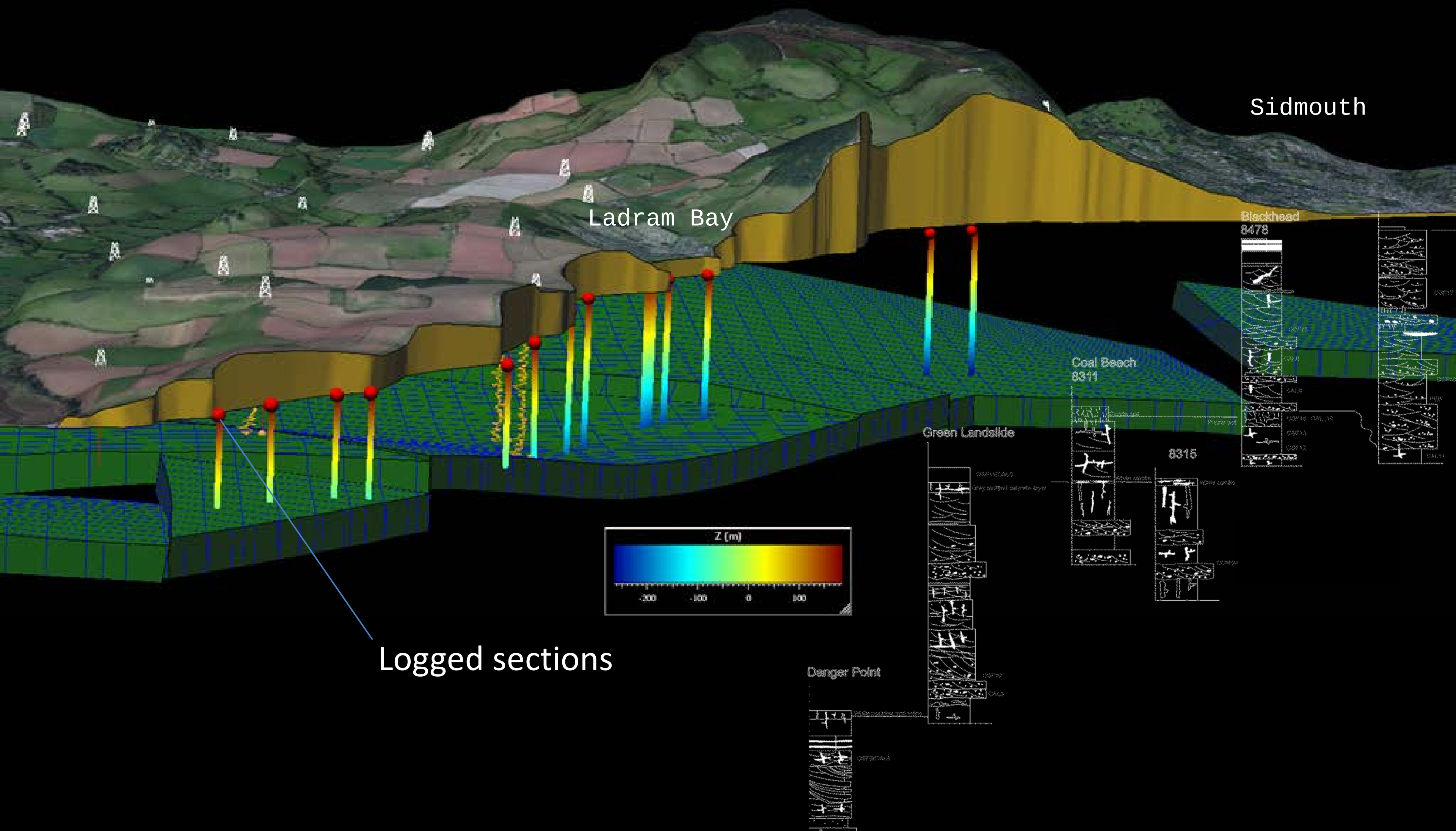
Realtime Data

Map Viewer & Data Catalogue

Applications of 3D model

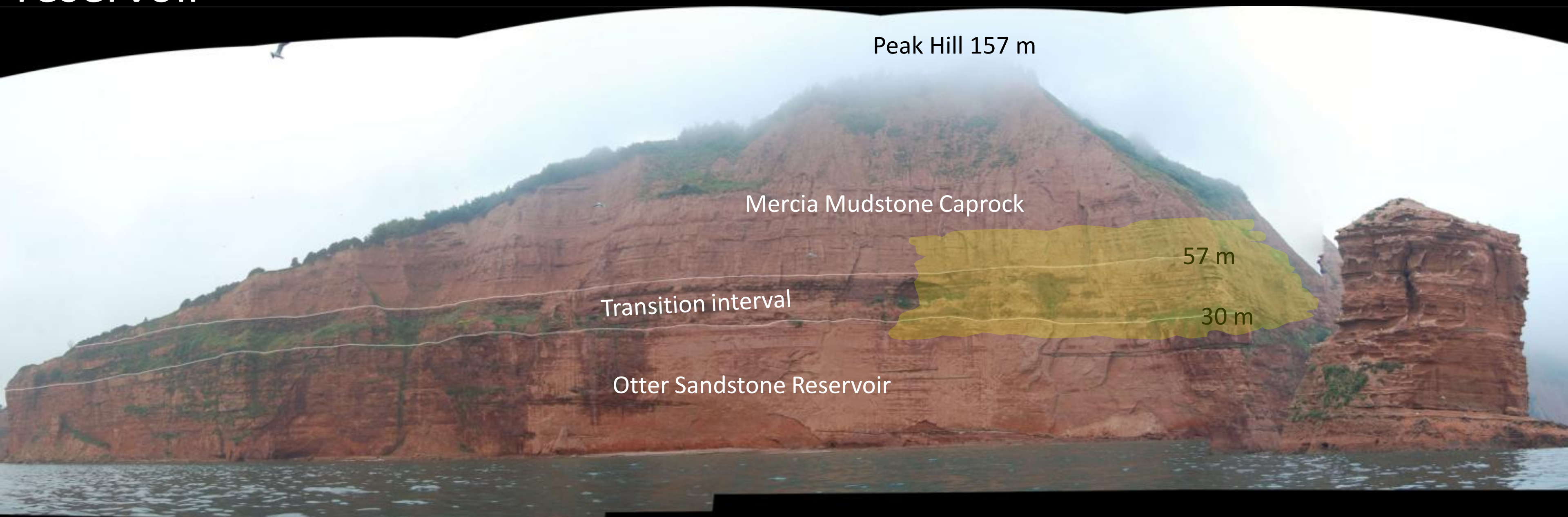
Validate correlation and stratigraphic position of composite logged sections

Link outcrop to geophysics



Particular interest in the heterolithic transition interval between the main Otter Sandstone fluvial sheet sandstone and the MMG caprock

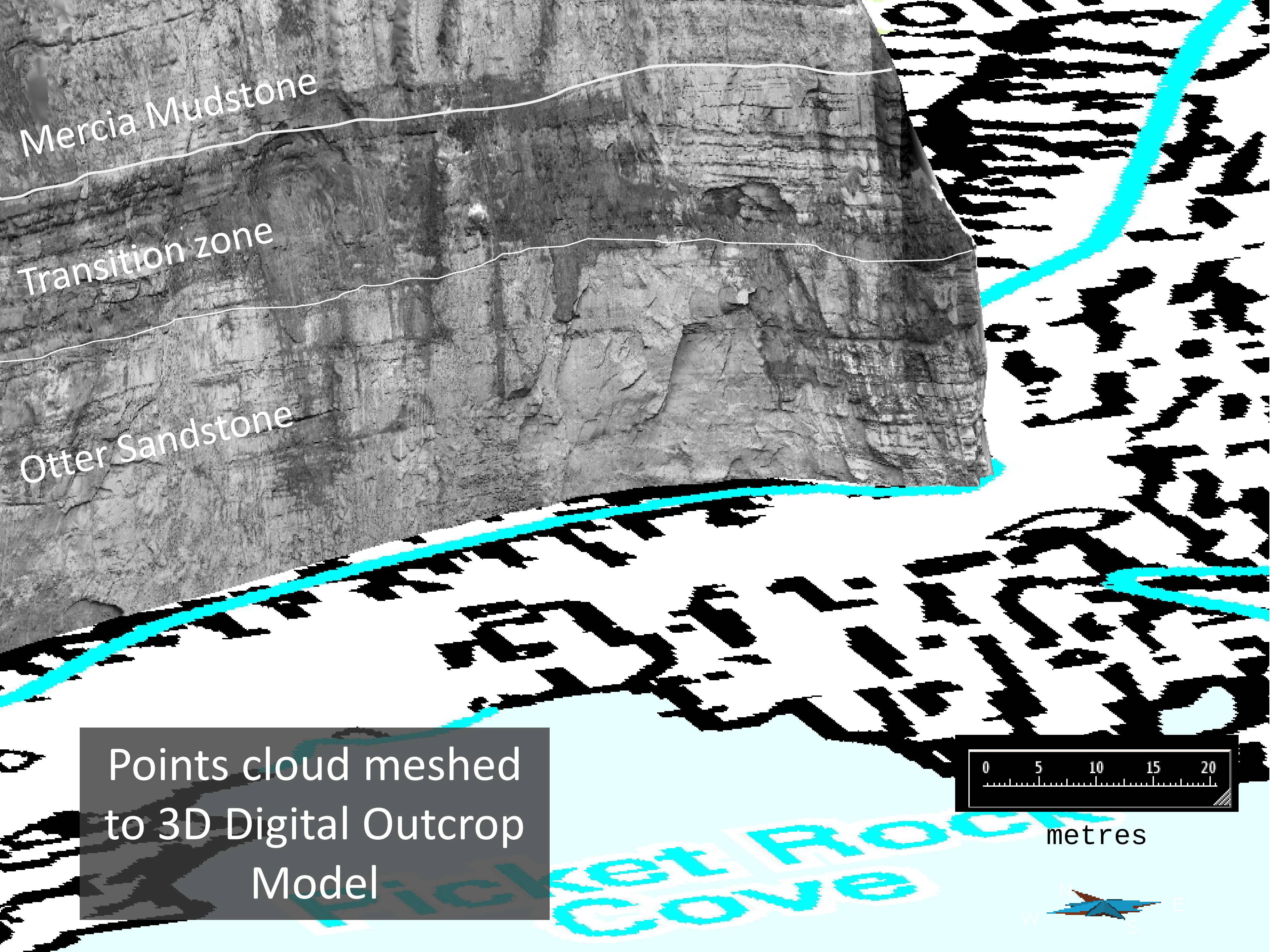
‘Where it matters’ in terms of injecting buoyant CO_2 into a saline reservoir



Fieldwork has identified some interesting sedimentary structure high on Peak Hill on a useful right angle outcrop giving sections parallel and perpendicular to palaeoflow

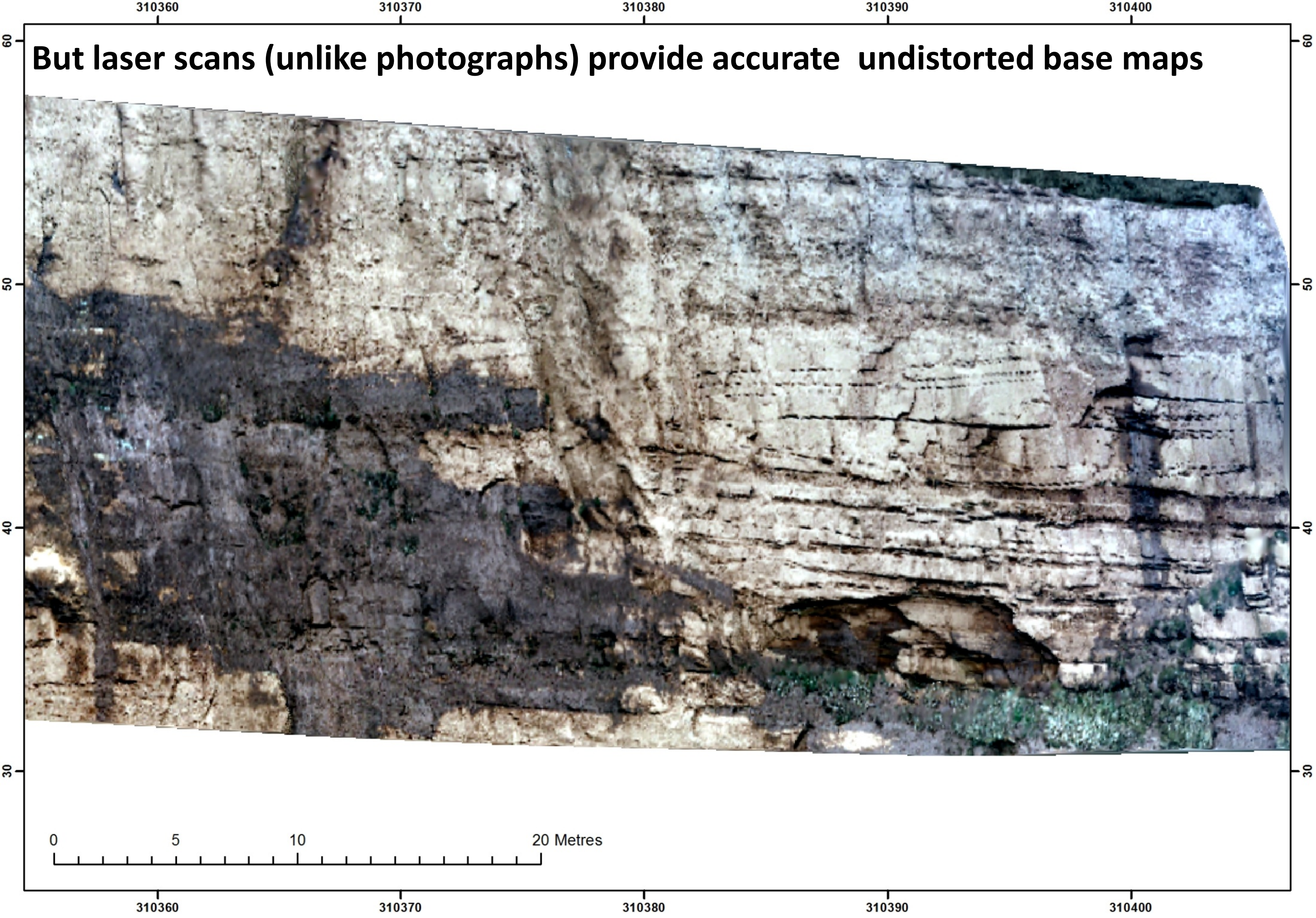
Inaccessible so time for some laser scanning


DGPS
Laser scanner
DSLR
British
Geological Survey
BGS
1835
RIEGL
ERROR
POWER ON

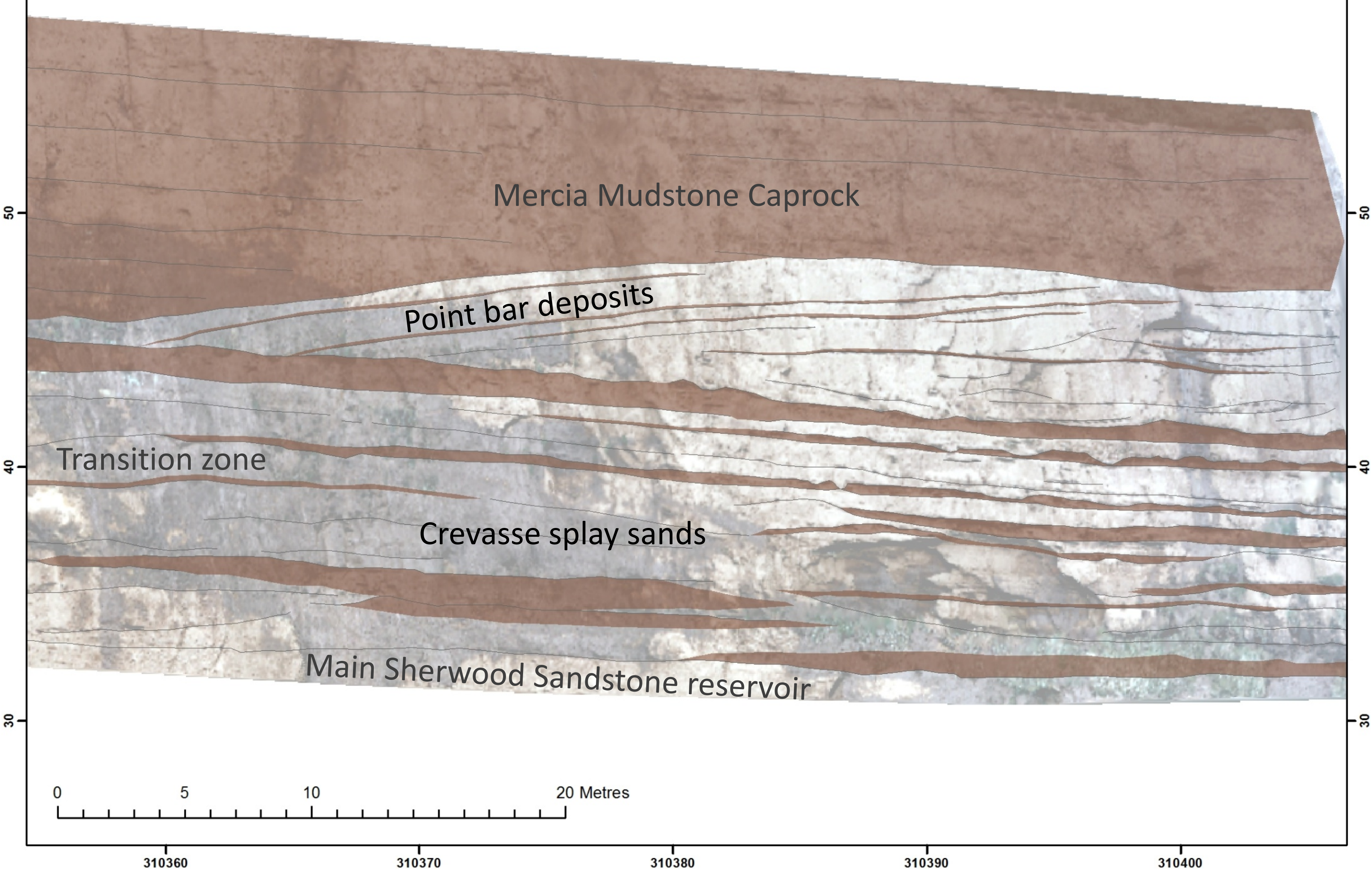

Mercia Mudstone
Transition zone
Otter Sandstone
Points cloud meshed to 3D Digital Outcrop Model
0 5 10 15 20
metres
Picket Rock Cove


Laser scanning: the harsh realities
• Slow (but getting faster)
• Heavy (but getting smaller)
• Failed to get 2 rock faces

But laser scans (unlike photographs) provide accurate undistorted base maps



Map the complex sand-shale architecture of the reservoir-caprock interface

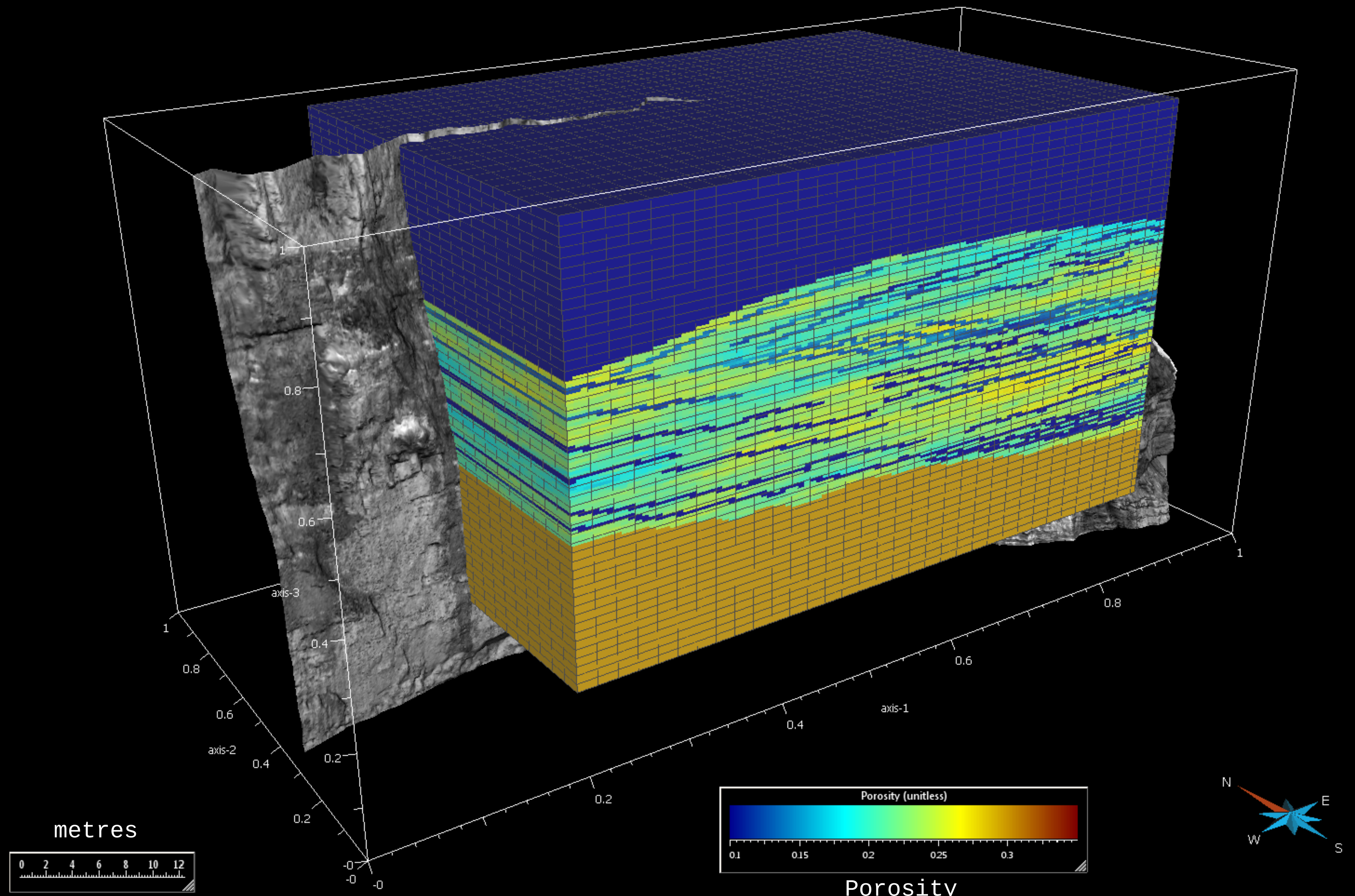


Augment remote scans with more accessible outcrops

- Determine representative permeabilities using portable air minipermeameter

- Examine how features like sand injection structures and burrows link sandbodies in heterolithic fluvial deposits

Convert outcrop maps and poroperm measurements into lithofacies/reservoir grids



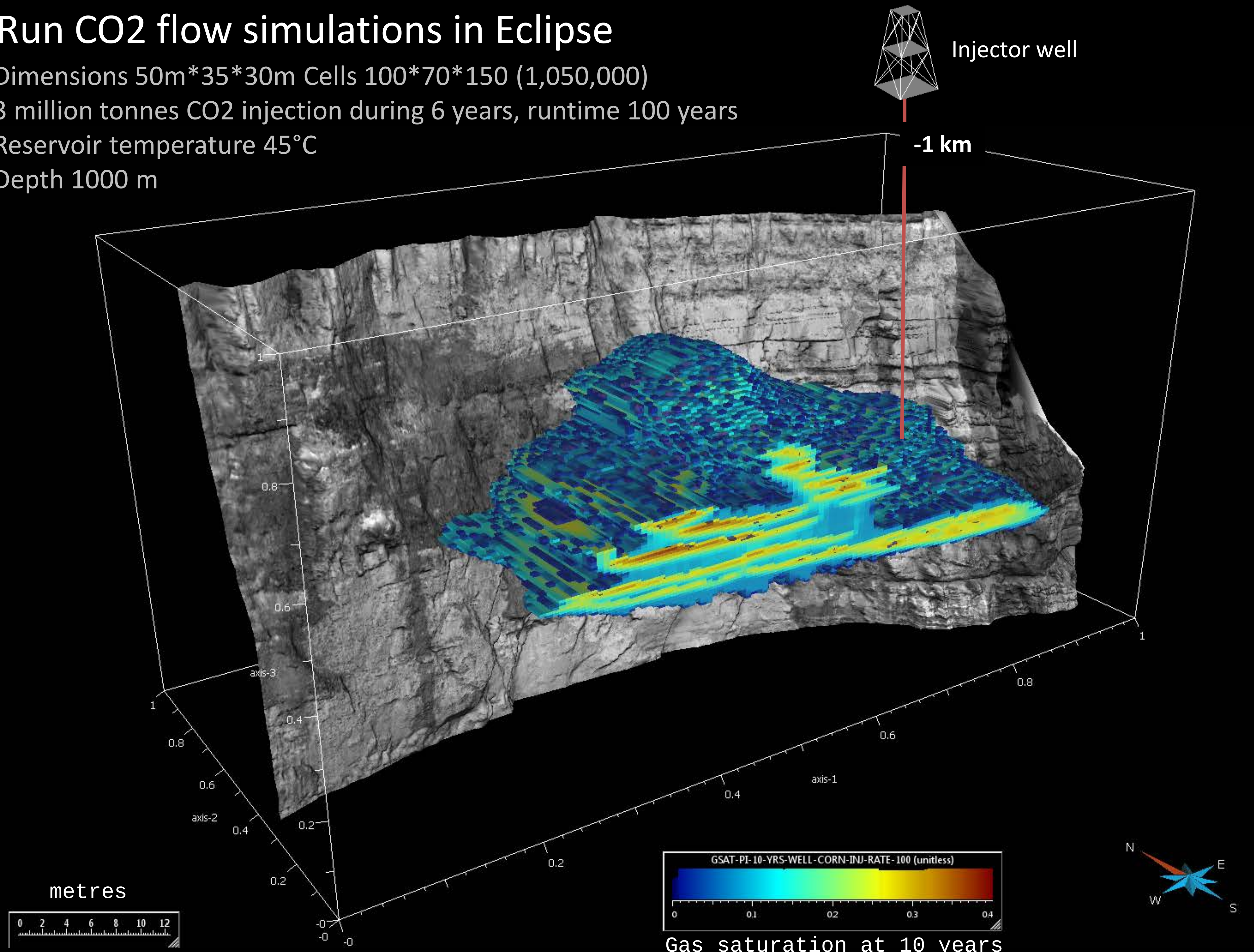
Run CO2 flow simulations in Eclipse

Dimensions 50m*35*30m Cells 100*70*150 (1,050,000)

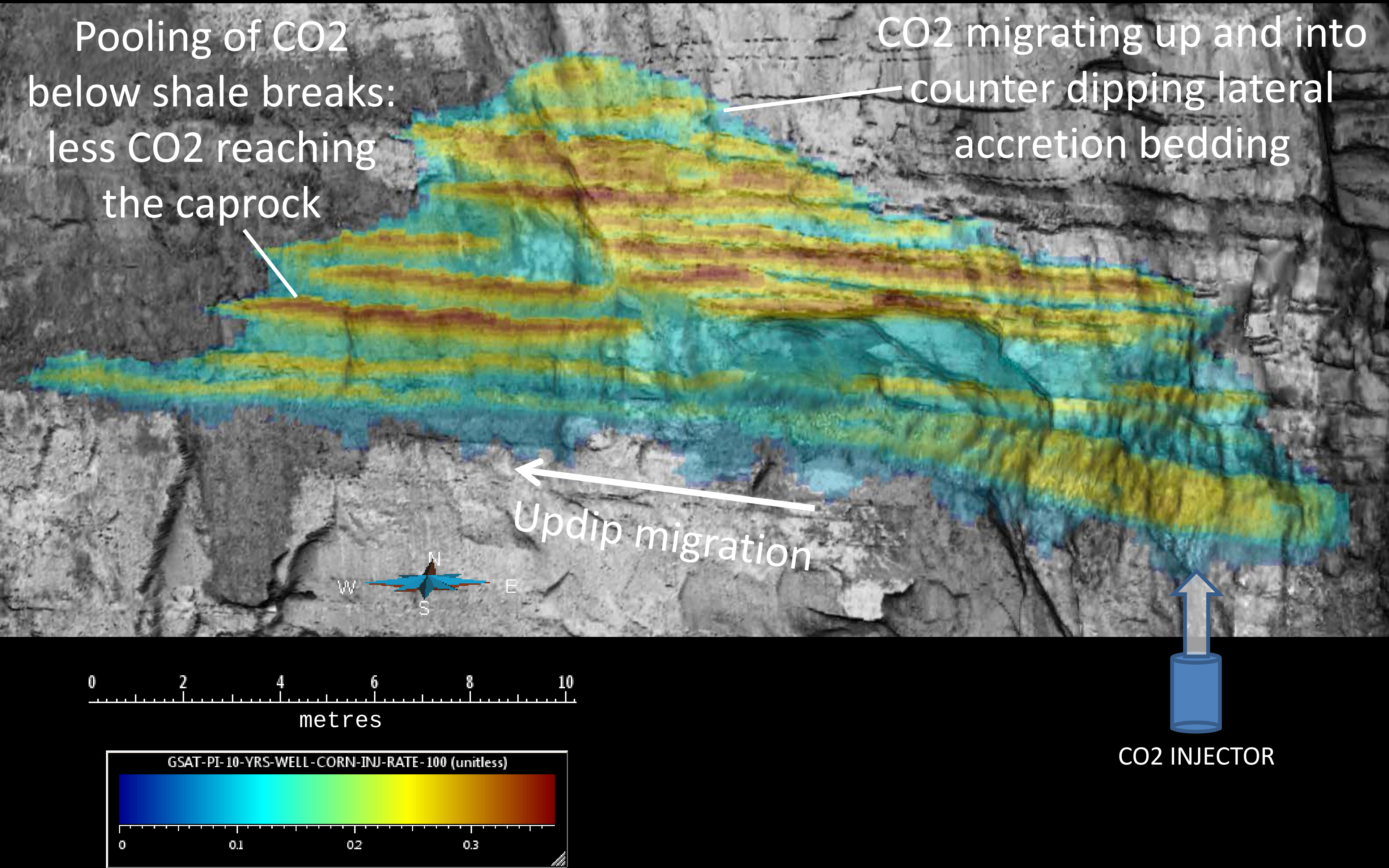
3 million tonnes CO_2 injection during 6 years, runtime 100 years

Reservoir temperature 45°C

Depth 1000 m

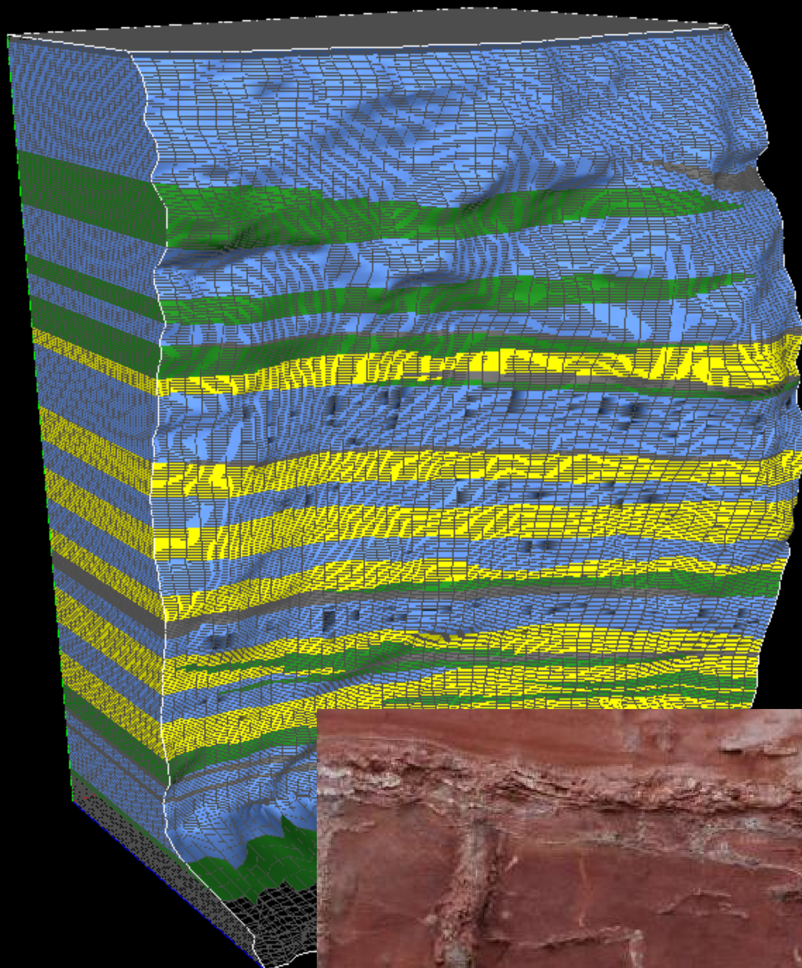


Transfer flow simulation results back onto the rock face

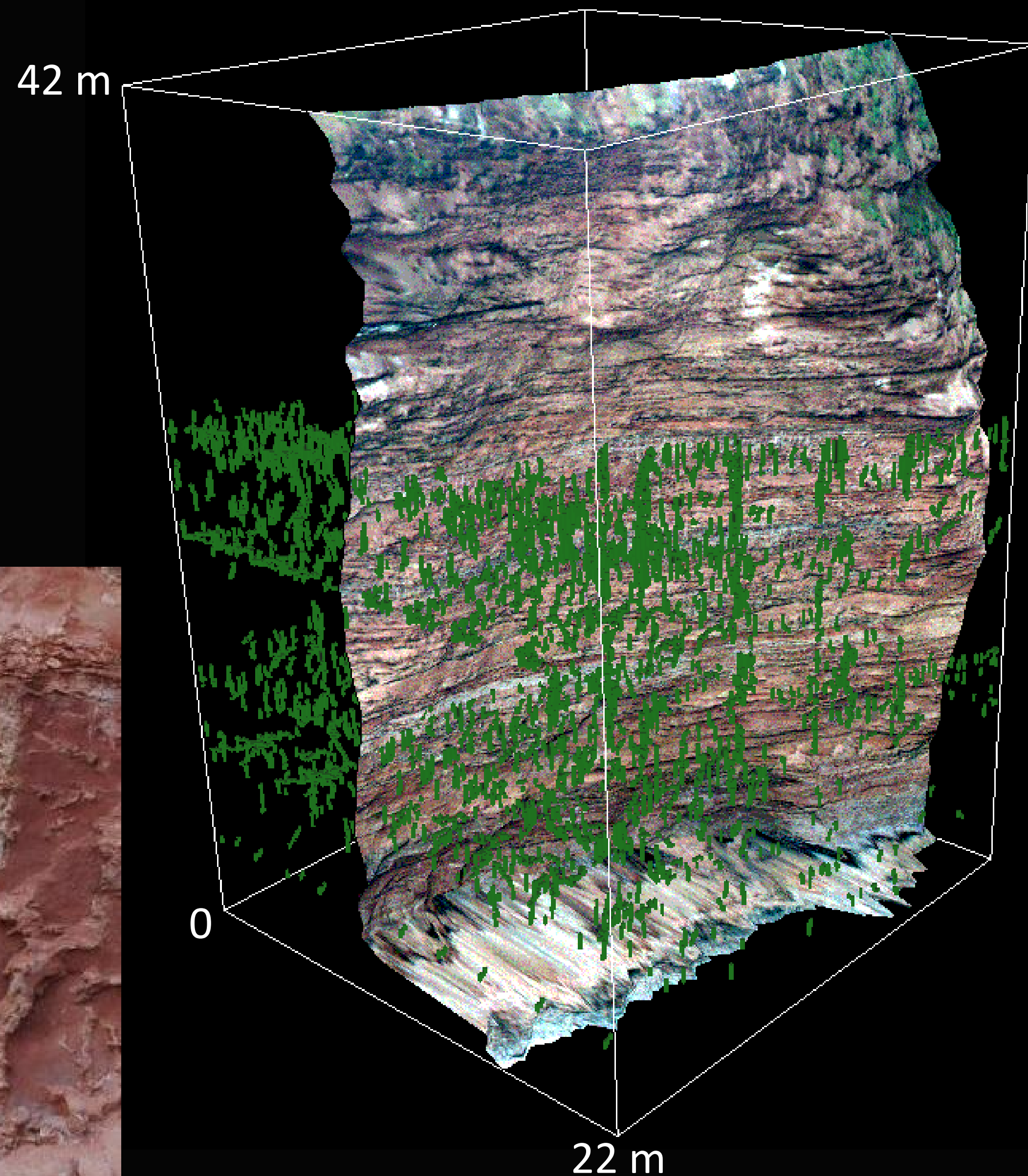


Gas saturation after 10 yrs of injection

Many other aspects of the Otter Sandstone to test



Impact of calcretes and rhizocretions



To conclude

Modern field methods and software (3D visualisation, laser scanning, lightweight minipermeameters etc) make it easier than ever to incorporate outcrop data into reservoir studies

Small scale outcrop-based flow models provide a very tangible link between what is happening inside flow simulators and real rocks

Creating reservoir grids around outcrops provides a sense of scale and is a valuable learning experience for geologists and reservoir engineers

Inform decisions on how we upscale rocks to coarse reservoir grids (e.g. Kv/Kh)