AAPG ICE, London, 2017

Microbial Carbonate Reservoirs of the Argyll & Auk Fields Reinterpreted in a Sequence Stratigraphic Context

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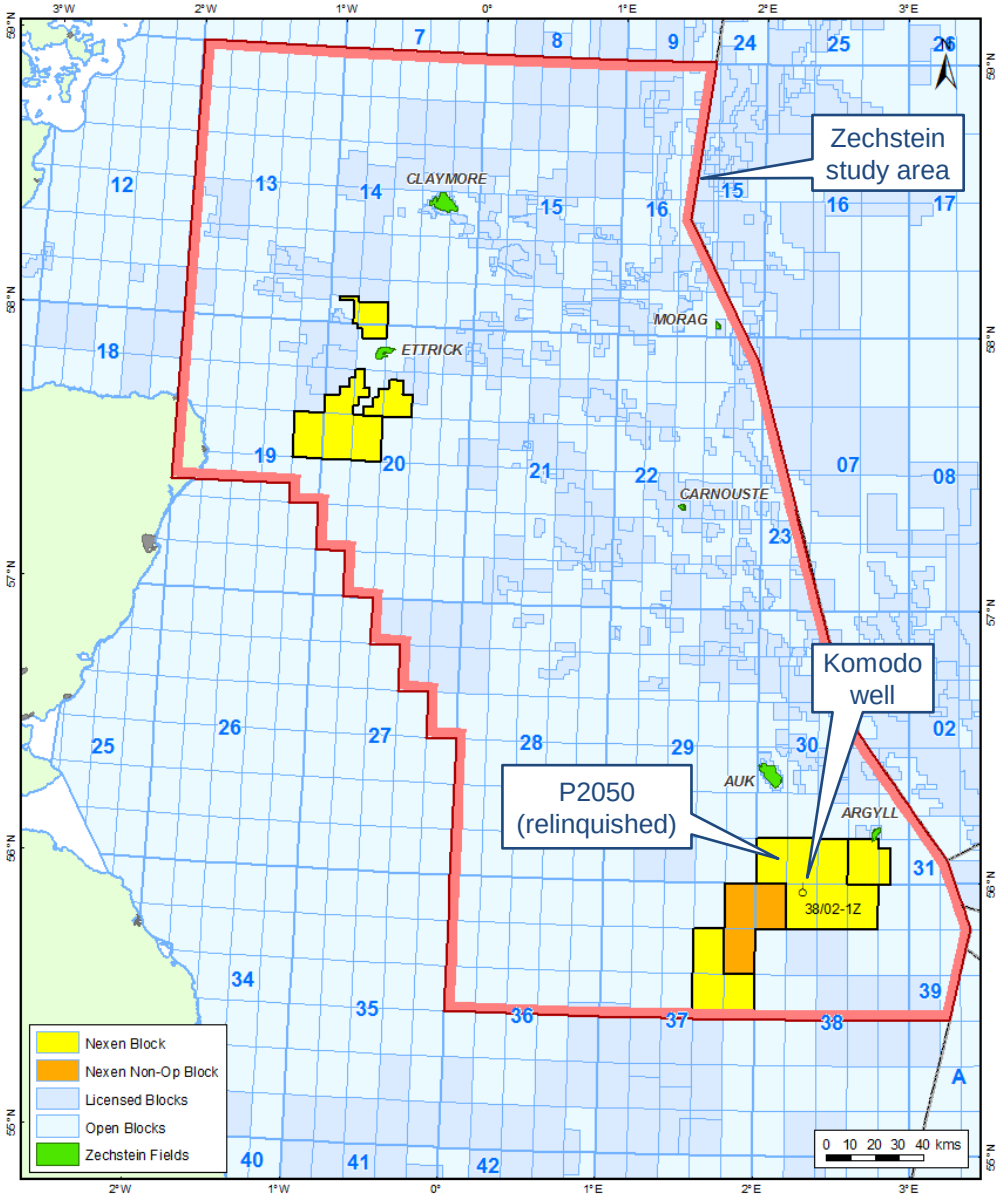
A New Energy

Location Map



Key Points

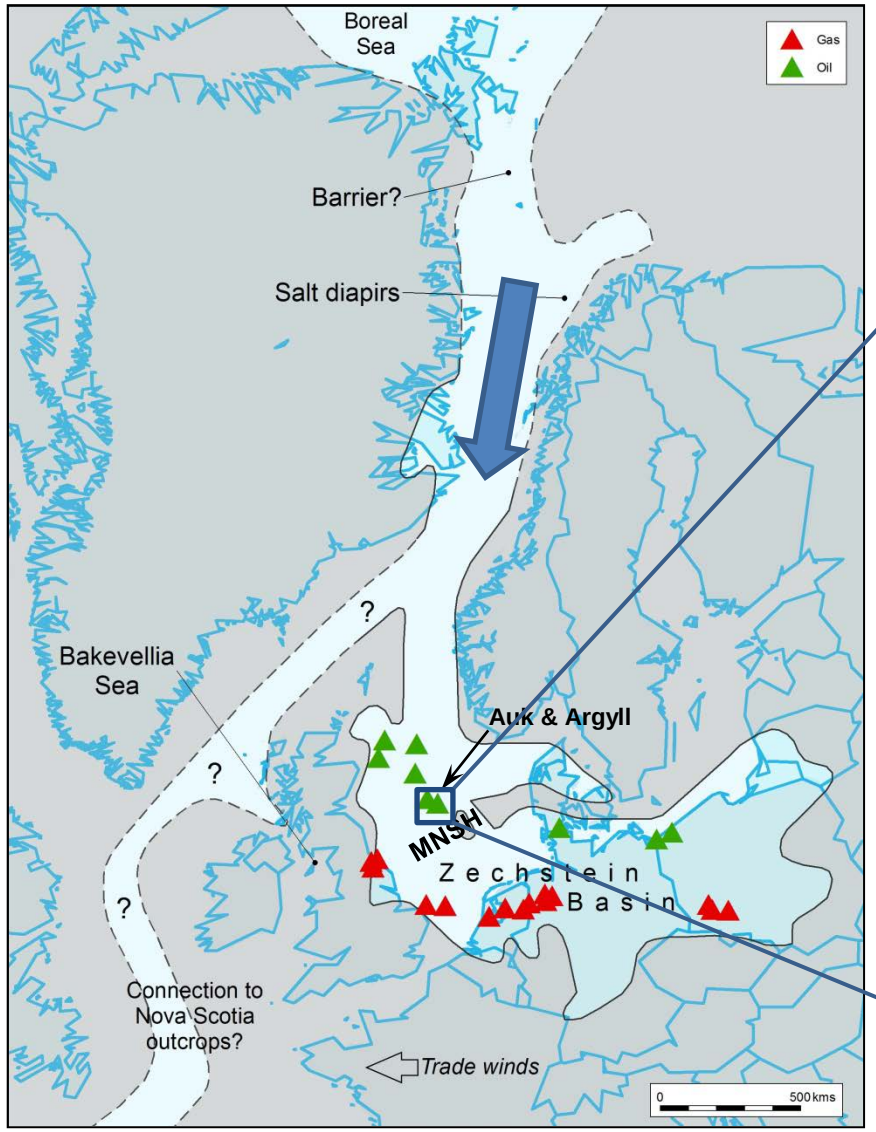
Zechstein specific:

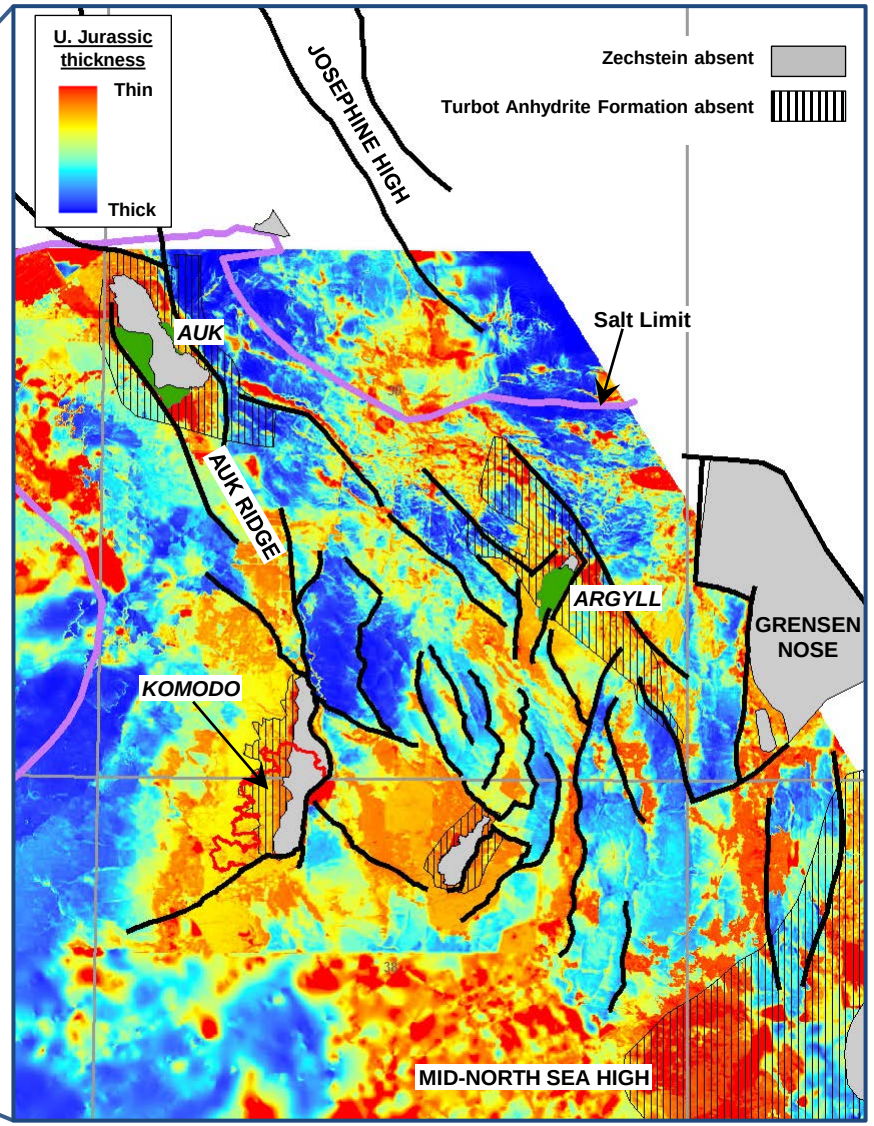
The Zechstein of the Auk and Argyll fields includes a previously unrecognised Z1 lowstand systems tract that can be widely recognised in the Northern Permian Basin

General:

Given the same data set, it is possible to produce very different depositional models, with potentially major implications for hydrocarbon exploration and development

Zechstein Basin Palaeogeography

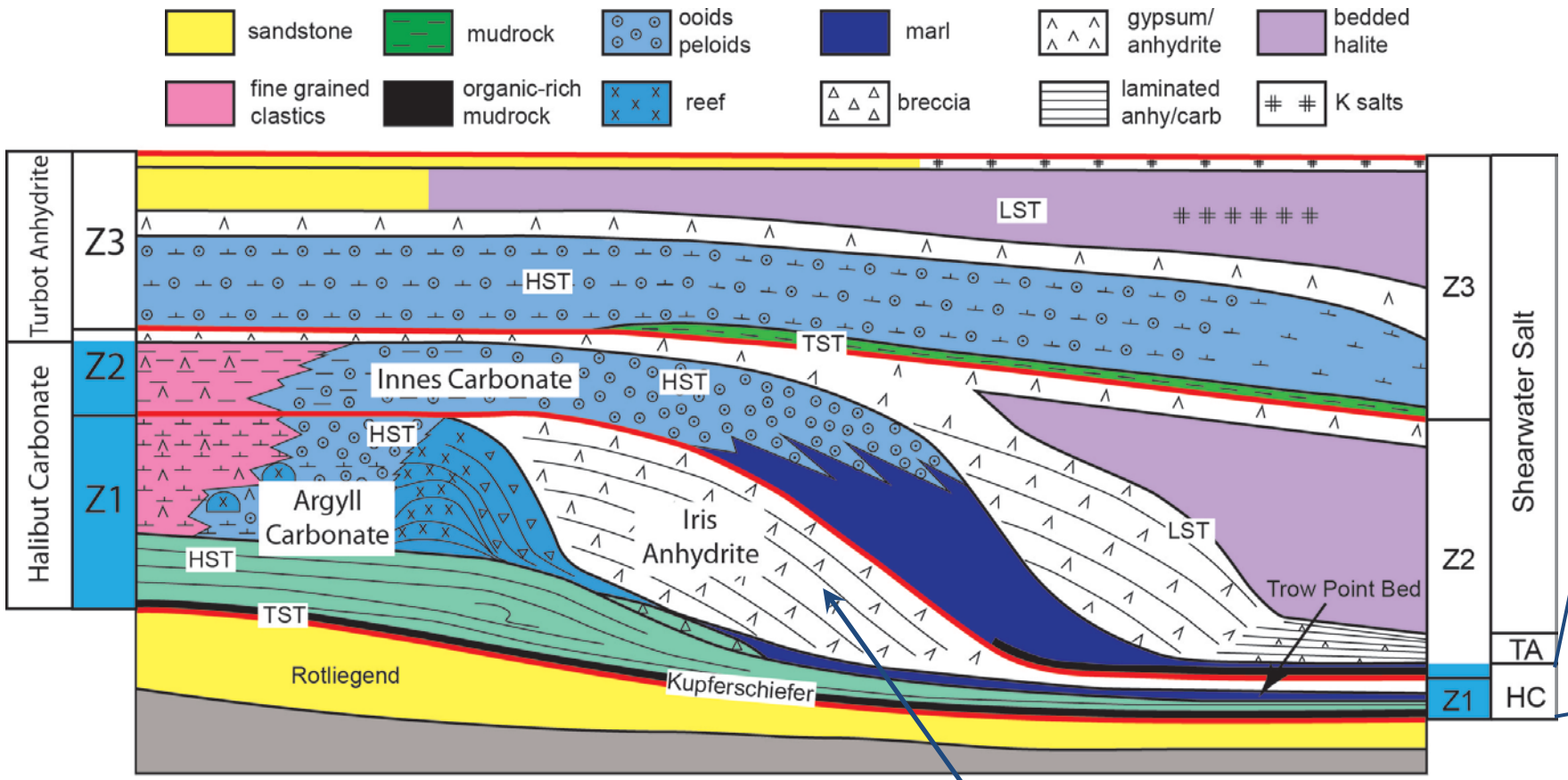




based on Taylor (1986)

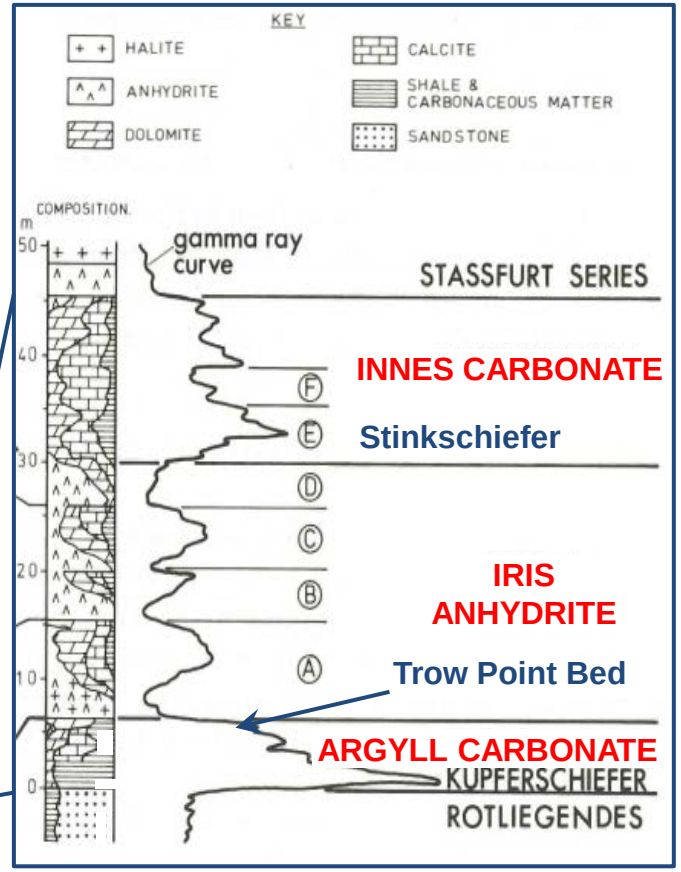
Southern Permian Basin Analogue

Lower Zechstein architecture in Southern Permian Basin



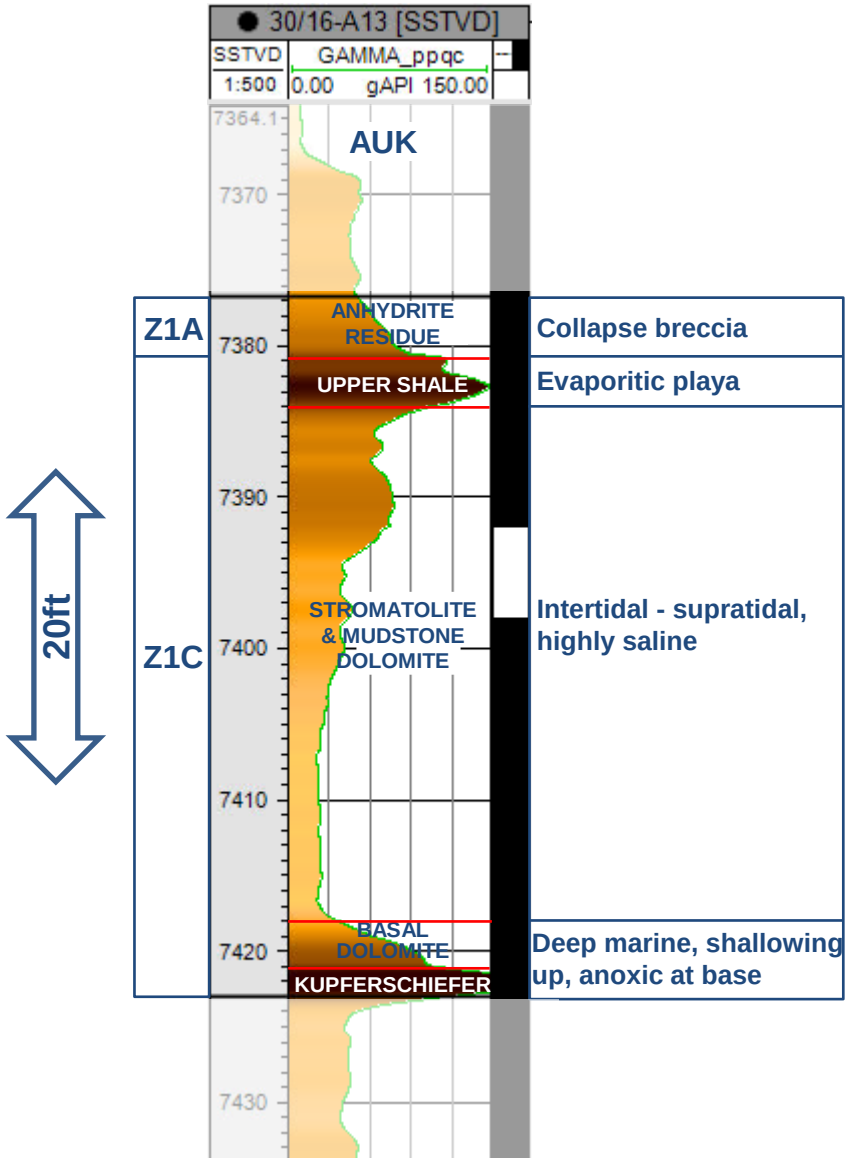
after Tucker, 1991

Z1 anhydrite rim >150 m thick and 40km wide, tapering over 10km to ≤20m in Southern Permian Basin

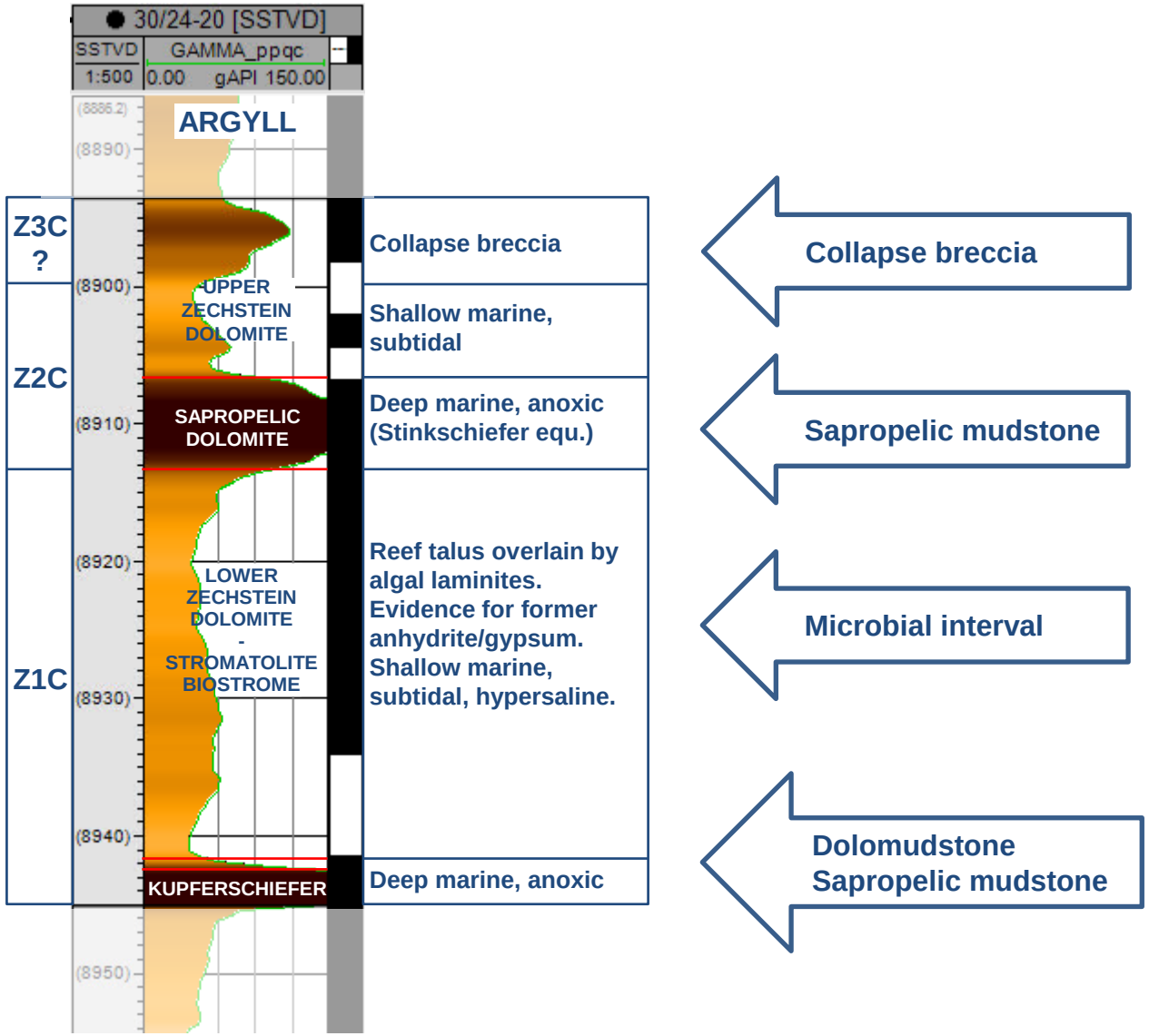


Z1/Z2 basinal log signature in Southern Permian Basin (Taylor, 1980)

Auk and Argyll Zechstein Published Interpretations

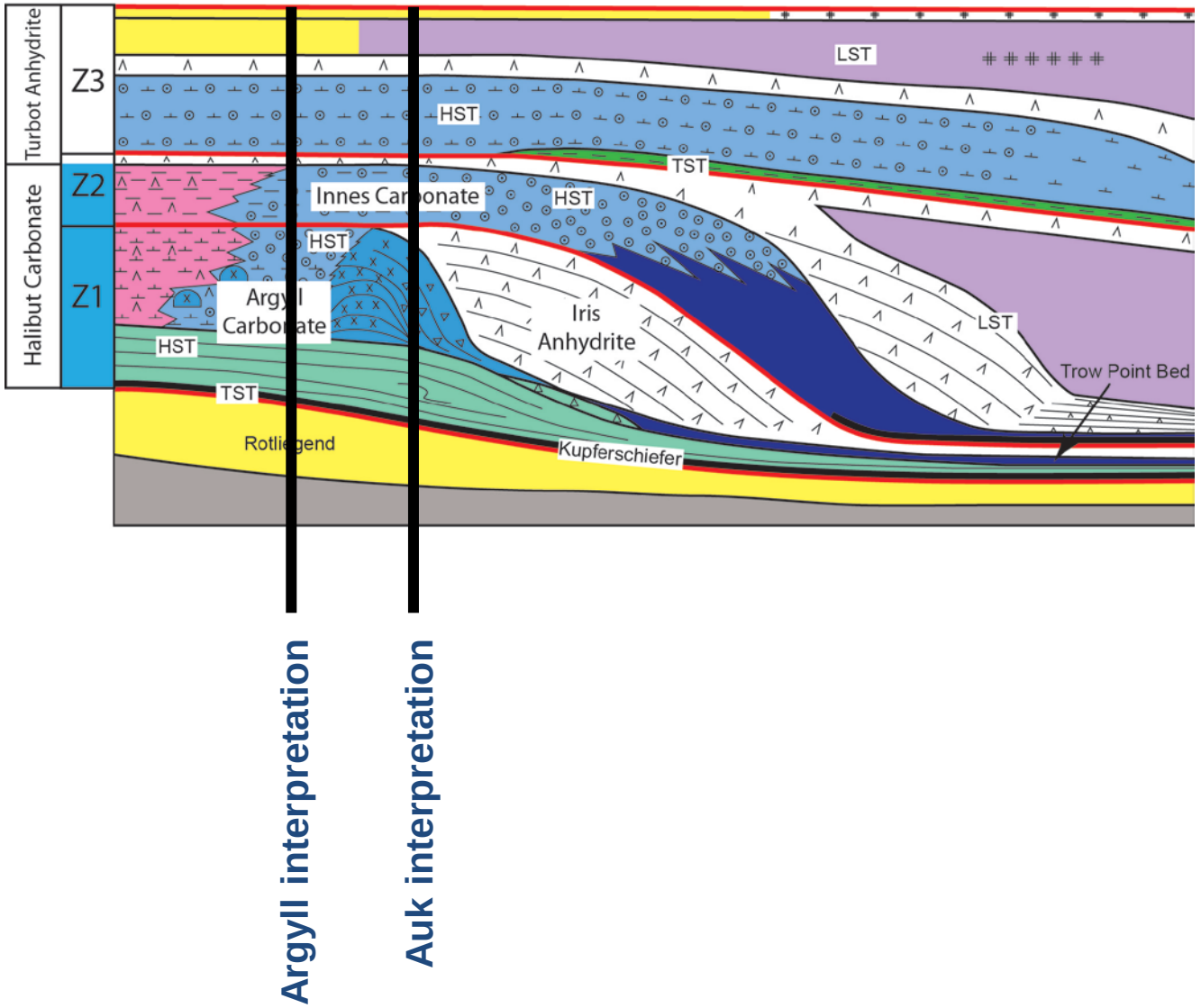


Based on Vahenkamp (1995)

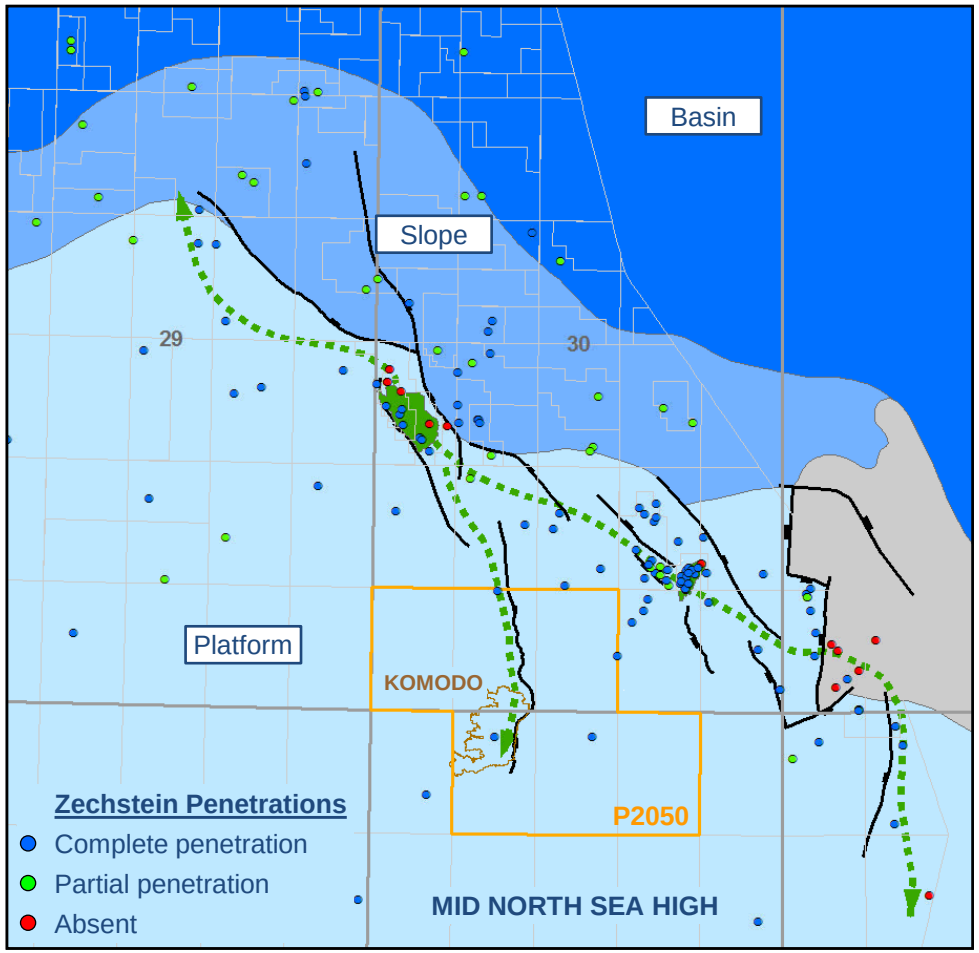


Based on Bifani & Smith (1985)

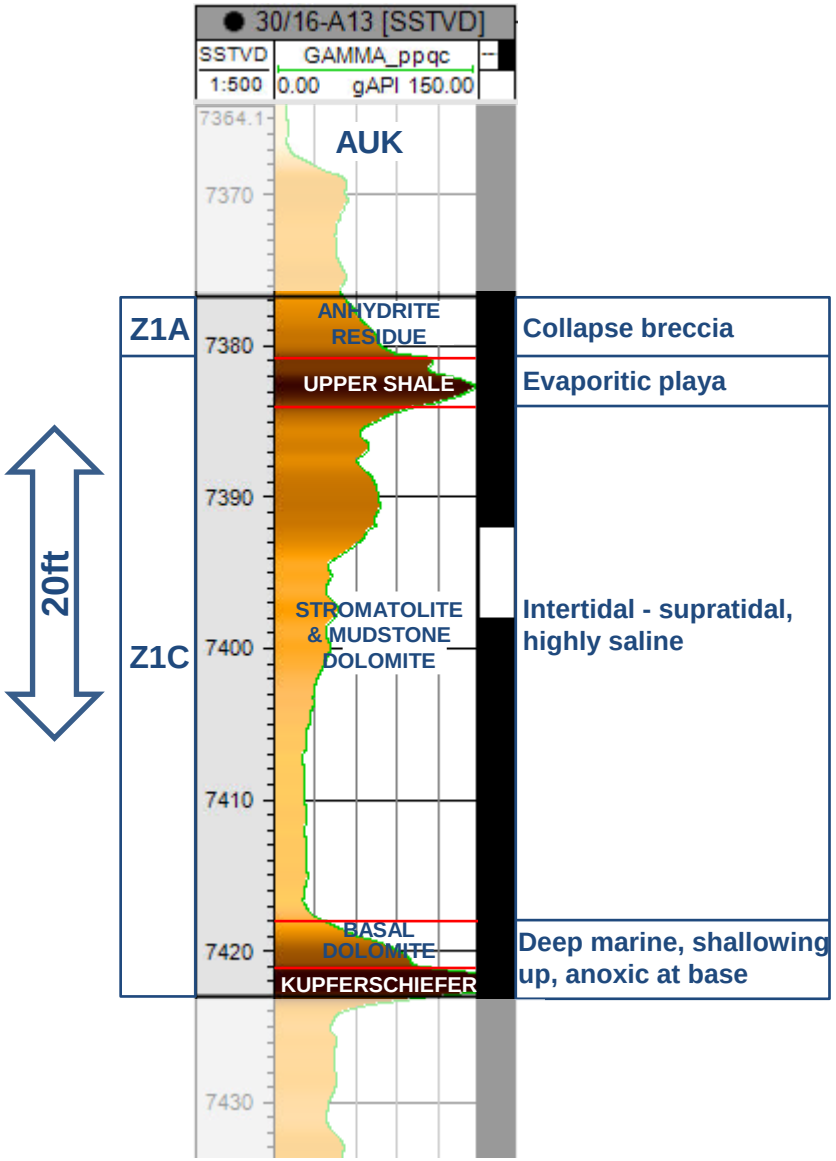
Original Depositional Model



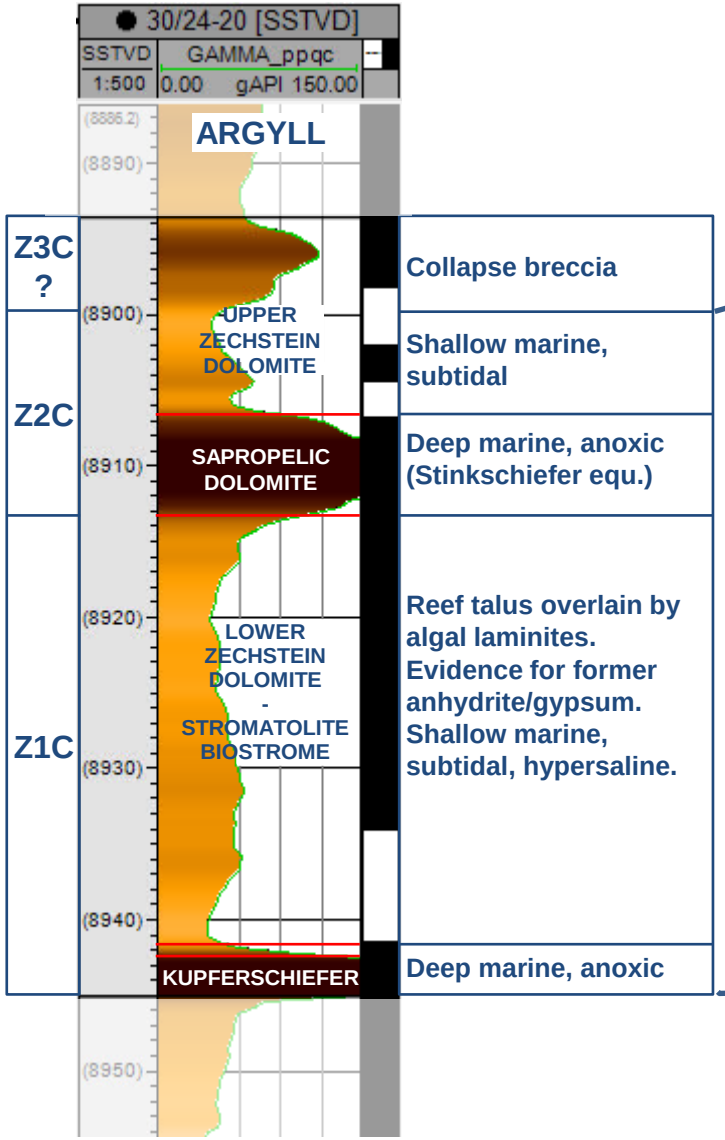
Original depositional model



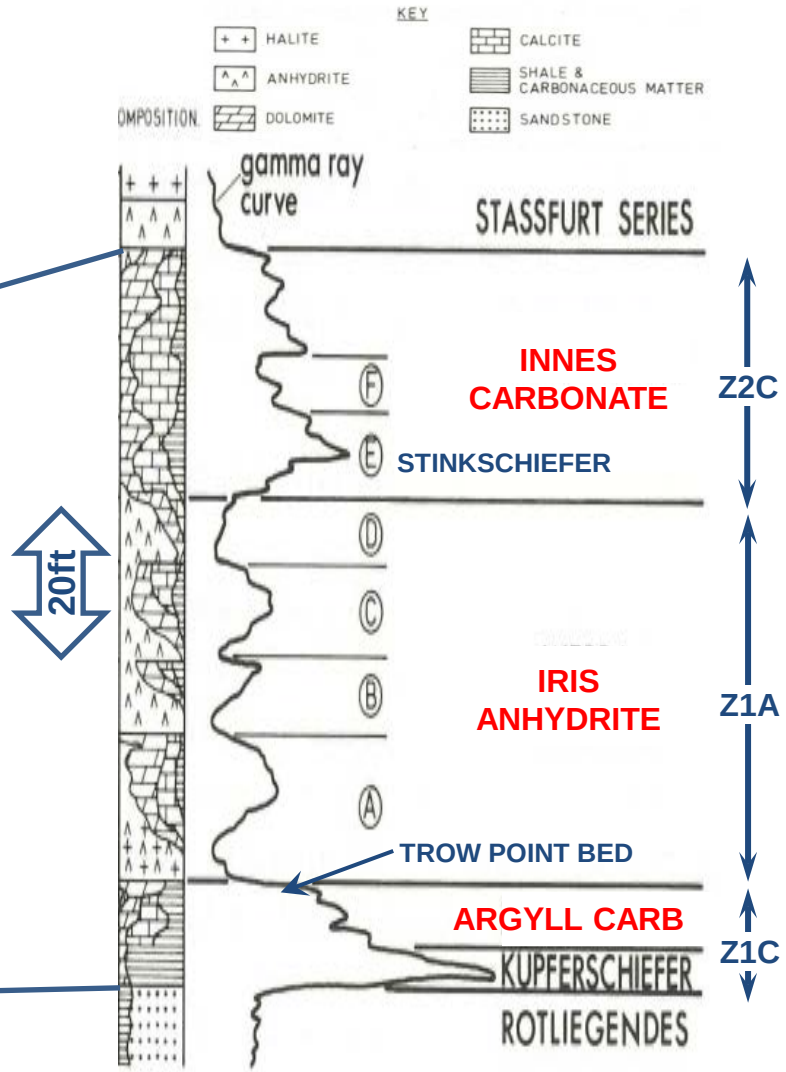
Southern Permian Basin Analogue



Based on Vahenkamp (1995)



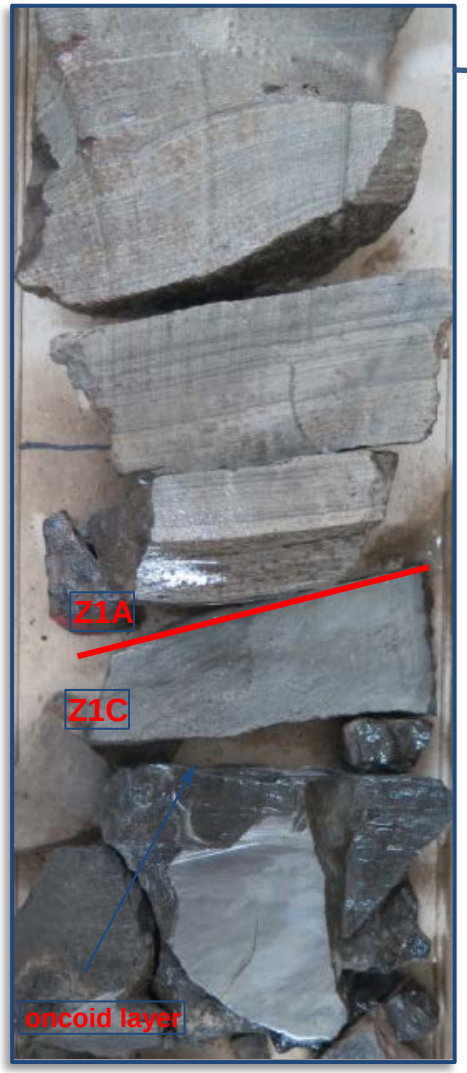
Based on Bifani & Smith (1985)



Basinal log signature in Southern Permian Basin
(Taylor, 1980)

Trow Point Bed Equivalent Identified in NPB

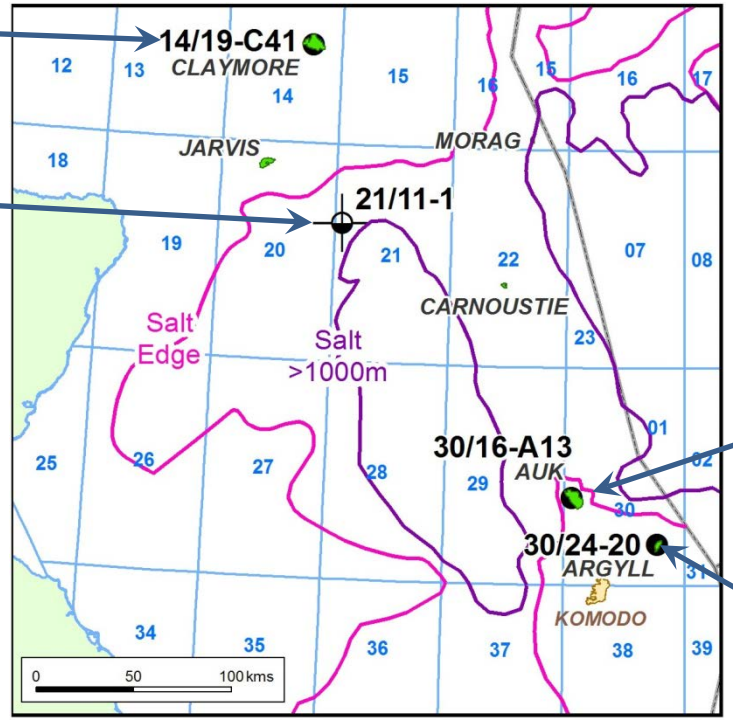
14/19-C41 (Claymore)

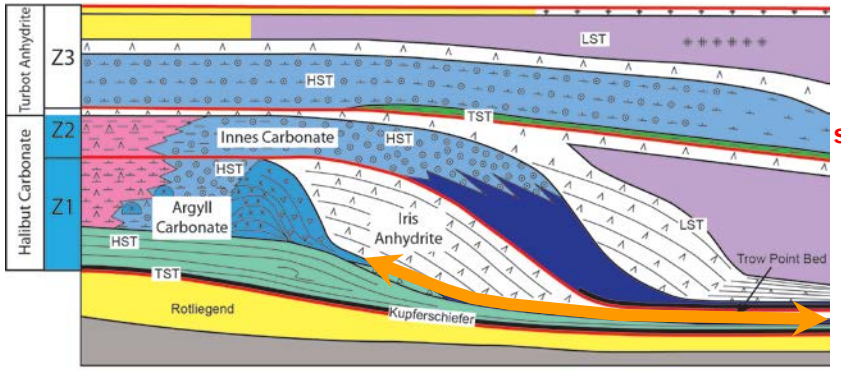


Core diameter 4"/10cm

21/11-1

Core diameter 2"/5cm





30/16-A13 (Auk)

Core diameter 2.5"/6.5cm

30/24-20 (Argyll)

Core diameter 4"/10cm

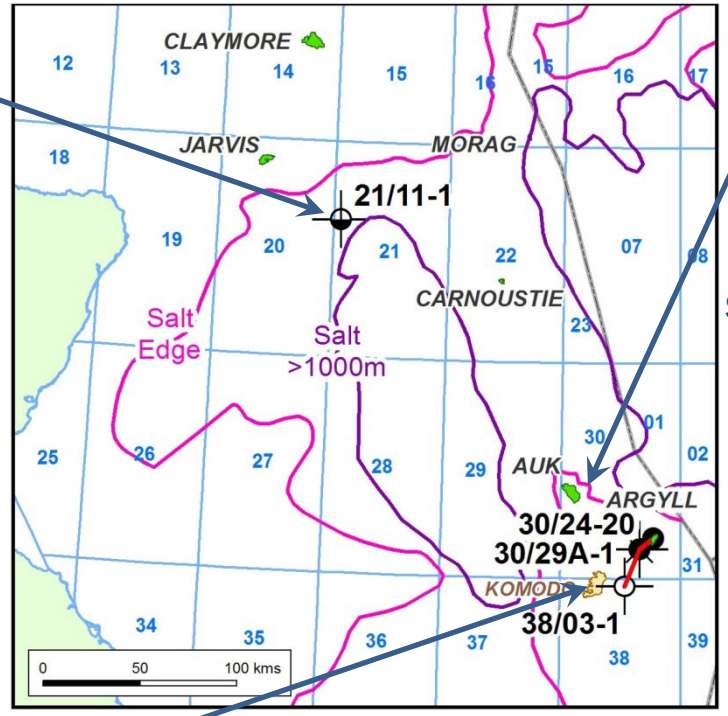
Association Between Microbialites & Anhydrite

21/11-1

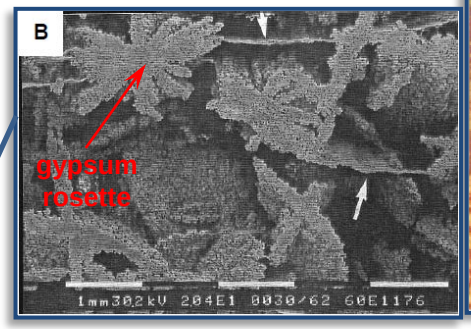
Core diameter 2"/5cm

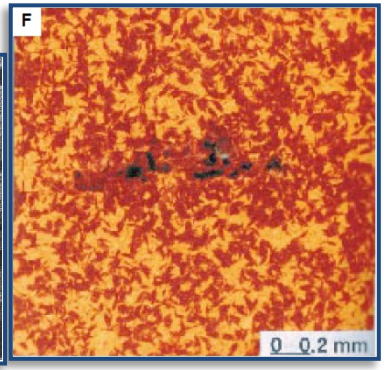
30/24-20 (Argyll)

Core diameter 4"/10cm

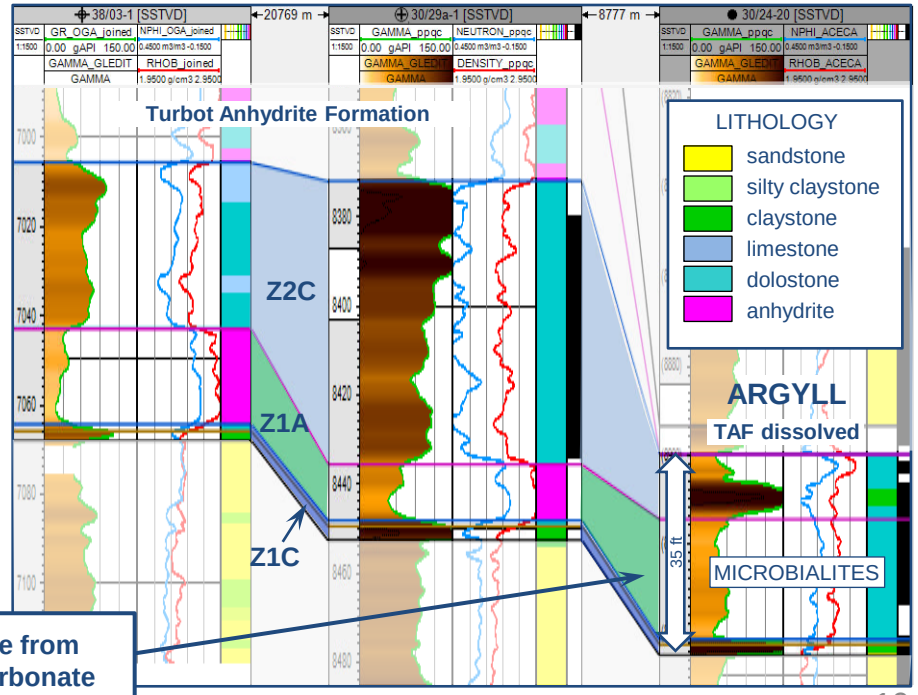


Auk: vugs after dissolved gypsum
(Vahrenkamp, 1995)



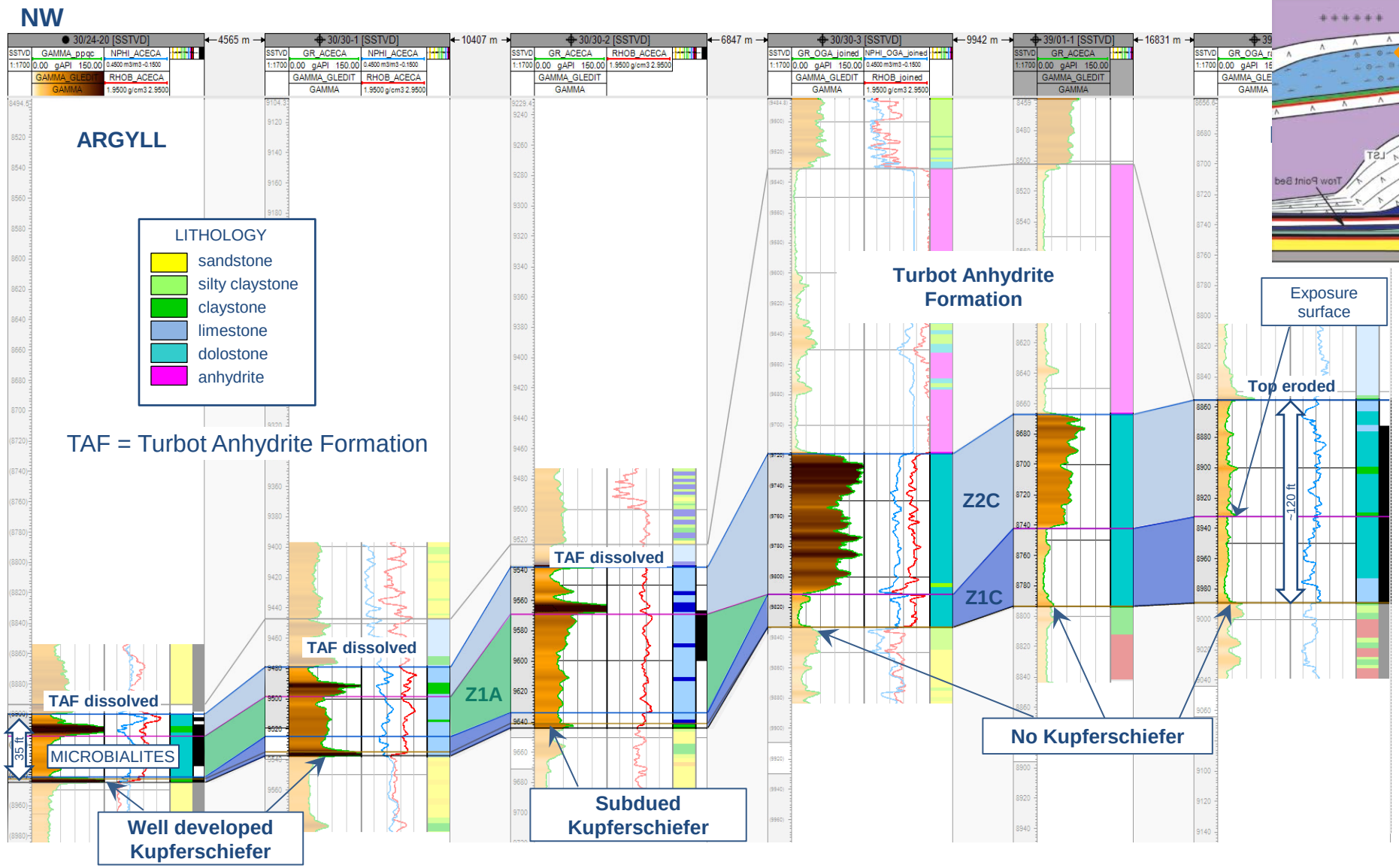


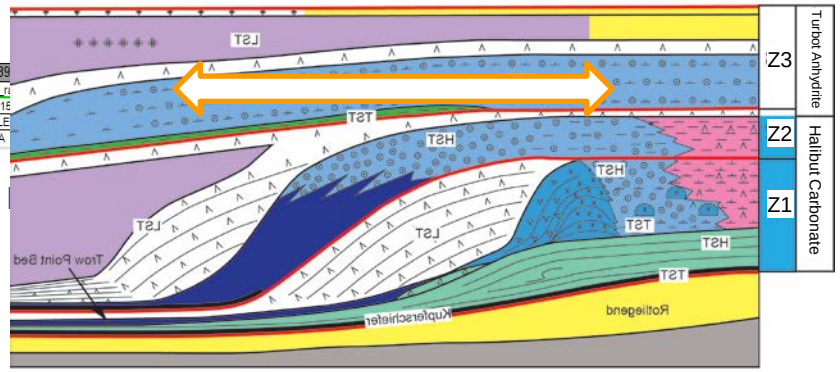
SW NE

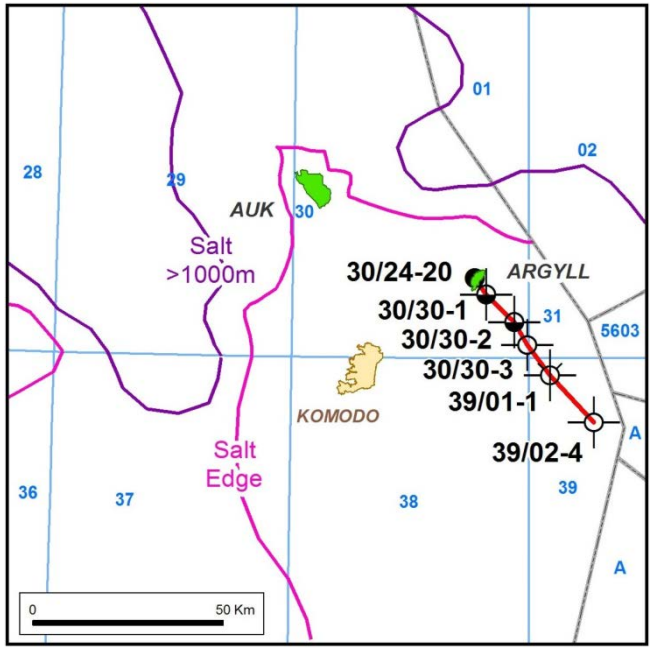


Lateral change from anhydrite to carbonate

Basin Scale Geometry







Komodo Interpretation Post-drill

SW

NE

KOMODO

ARGYLL

LITHOLOGY
- sandstone
- silty claystone
- claystone
- limestone
- dolostone
- anhydrite

Turbot Anhydrite Formation

~165 ft

TAF dissolved

Z2C

Z1C

Turbot Anhydrite Formation

Z1A

TAF dissolved

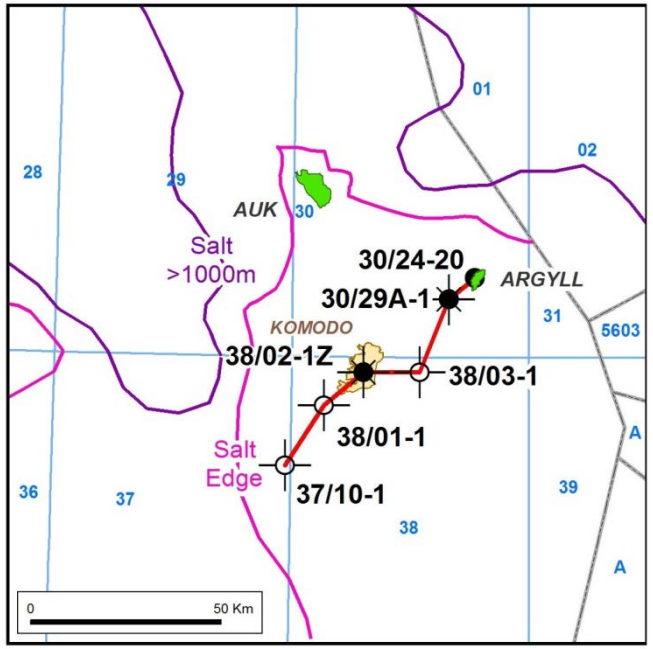
35 ft

MICROBIALITES

No Kupferschiefer

Subdued Kupferschiefer

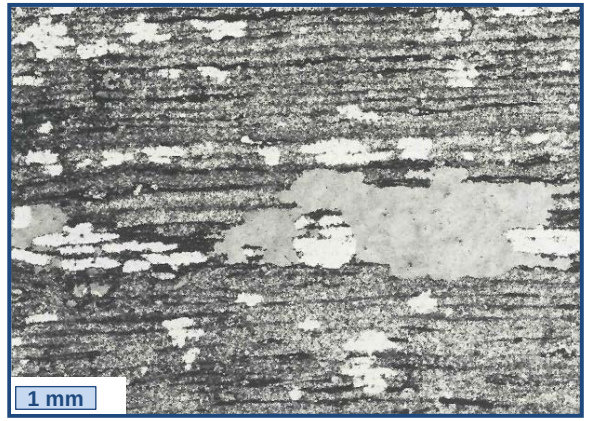
Well developed Kupferschiefer



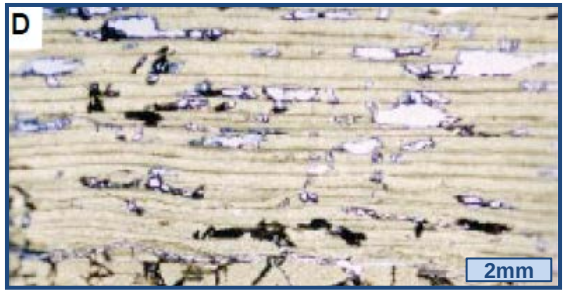
TAF = Turbot Anhydrite Formation

Subaqueous Origin of Z1 Microbialites

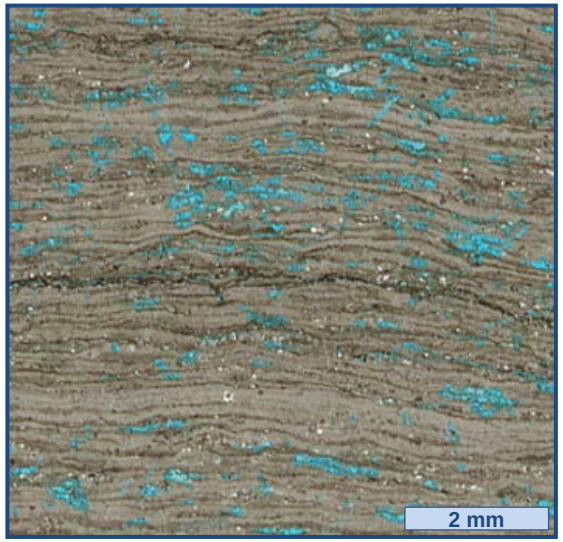
- SPB evaporite platforms required 100's m of water in the basin centre to form, although water levels likely highly unstable
- The above implies that the NPB was also flooded during lowstands, although possibly to shallower depths
- Microbialites lack desiccation features, suggesting microbialites deposition subaqueous
- Widespread uniformity in microbial facies suggests a distal setting
- 'Stromatolitic' facies from Auk looks similar to basinal laminated carbonates from the Middle Carbonate Member of the Z1 Anhydrite, Denmark, which is of deep water origin
- Micobialites are laterally equivalent to up-dip anhydrites, although evidence of evaporite platforms on the scale of the SPB is limited



SPB basin centre mm-bedded carbonate mudstones, Middle Carbonate Member, Z1 Anhydrite, Denmark (Clark , 1980)

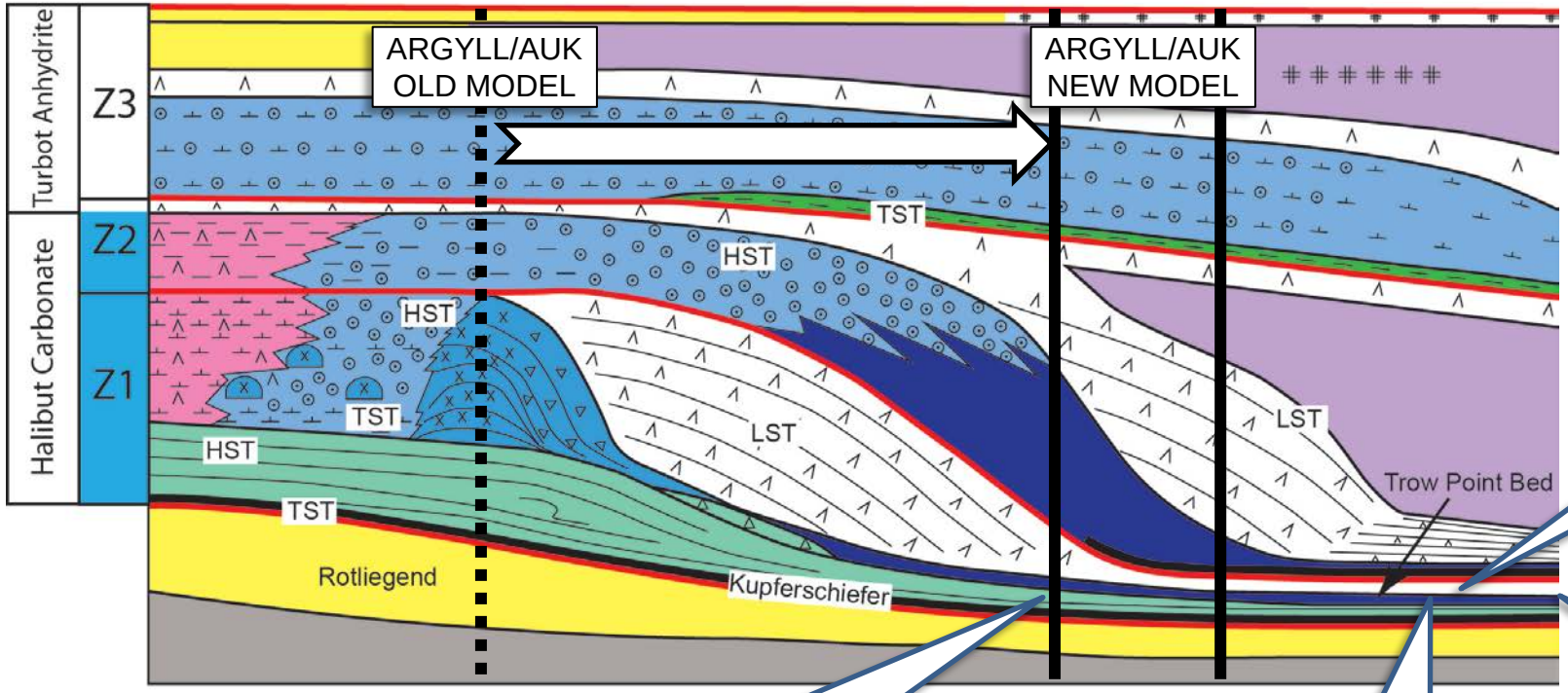


30/16-A11B: 'stromatolitic' algal laminae (Vahrenkamp, 1995)



14/19-B2: Z1 lowstand laminated facies

Revised Zechstein Understanding



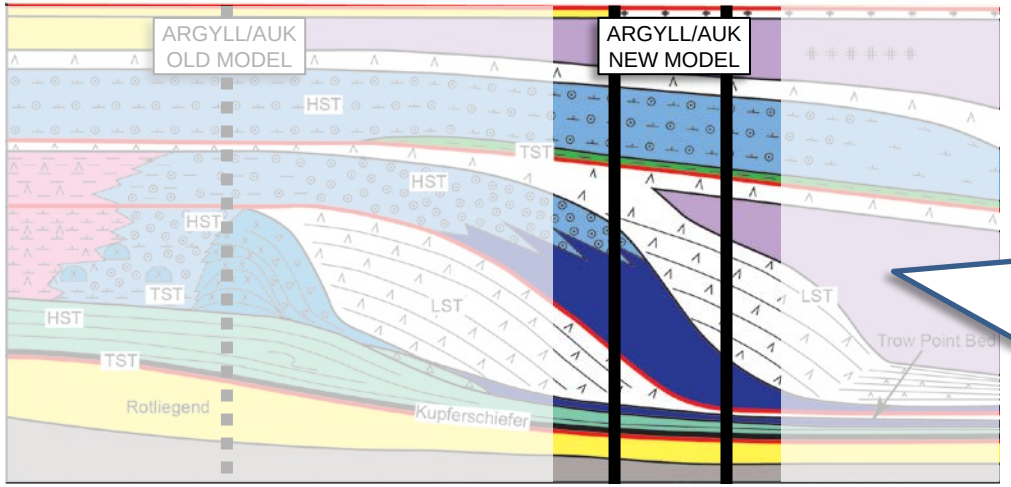
A Z1 lowstand system tract is analogous to that of the Southern Permian Basin and is present throughout the Northern Permian Basin

Abrupt change from basinal mudstones to laminated microbialites explained

Argyll & Auk are interpreted to be in a basinal position with the microbial unit representing the Z1 lowstand systems tract

An equivalent to the Trow Point Bed is widely present in the Northern Permian Basin

Same Data, Two Models – Why?



Depositional models for small areas of a basin have to make sense in terms of the sequence stratigraphic architecture of the basin as a whole and the geometrical constrains that imposes

The rocks are important and the details matter

Analogues need to be understood and leveraged to their maximum

Important details in original publications are often lost in transcription to databases compiled from public domain data

The Trow Point Bed—a deposit of Upper Permian marine oncoids, peloids and columnar stromatolites in the Zechstein of NE England

D.B. Smith

SUMMARY: An extensive thin bed of oncoids, peloids and columnar stromatolites occurs at the top of the Cycle 1 carbonate of the English Zechstein sequence in NE England; here termed the Trow Point Bed, it lies on the lower part of the basin-margin slope, basinward of a linear shelf-edge reef in the Ford Formation. The bed is generally 0.05–0.20 m thick but locally ranges to 0.60 m; it rests on an uneven surface that has a local relief of up to 15 m and slopes exceeding 35° in places. It contains a sparse marine fauna of foraminifera, ostracods and bivalves; there are only a few traces of current action and sorting, and terrigenous sediment nowhere comprises more than 2% of the bed.

The Trow Point Bed is generally similar to deposits described at a comparable stratigraphical position in Germany and Poland and although environmental indications are partly mutually contradictory, it seems likely that the bed accumulated in oxic conditions on the basin floor under water perhaps 25–100 m deep.

Stratigraphy and distribution

The Trow Point Bed is an extraordinarily extensive thin dolomitized bed of oncoids, peloids and subsidiary columnar stromatolites at the top of the Cycle 1 carbonate of the Zechstein sequence in NE England (Fig. 1); it ranges from 5 m to more than 20 m above the base of the EZ 1 carbonate according to the stratigraphic level of an underlying slide plane (see Smith 1970b). The bed lies on the lower part of the basin margin slope, entirely basinward of a linear shelf-edge reef in the Ford Formation; it has not been recognized within 3 km of the foot of the reef wall.

Oncoids at this stratigraphical position in the English Zechstein sequence have been recognized (Smith & Francis 1967, plate 13A; Magraw 1975, 1978; unpublished National Coal Board records) in the cores of several National Coal Board offshore boreholes (see Fig. 2 for distribution); elsewhere oncoids at a similar stratigraphical position have been reported from cored boreholes in the southern North Sea (Taylor & Colter 1975), northern Germany (Fuchtbauer 1968; Richter-Bernburg 1982) and Poland (Peryt & Peryt 1975 and other authors).

On land in NE England the oncoid bed is exposed for about 1 km in coastal cliffs between Trow Point (NZ 386 667) and Frenchman's Bay, South Shields, and less continuously for a further 0.3 km to the SE (Smith 1970a, p. 76); farther north it has been reported in Marden Quarry near Cullercoats (Land 1974, p. 110). Trow Point has been chosen as the type locality because the bed is readily accessible there and displays most of its typical range of variation; it differs at Trow Point from most of its offshore provings, however, in that it has been partly or wholly dedolomitized during or after dissolution of the overlying Hartlepool Anhydrite.

Thickness and field relationships

The Trow Point Bed is unusually varied in thickness. At outcrop it is most commonly 0.05–0.20 m, but ranges locally to 0.60 m; it is absent from or not readily recognizable over perhaps 5–10% of its outcrop. This variation in thickness is closely related to the hummocky character of the top of the underlying slide sequence (Smith 1970b, fig. 8), the bed being thickest and most uniform in the hollows and thinning sharply against and over the steepest and tallest slide blocks and other eminences (Fig. 3); in places it clings to primary slopes of 40° or more. Variation in thickness appears to be less sharp offshore, presumably because there the bed rests on more distal (less hummocky) parts of the slide sequence. Some variations in the thickness partly result from stylolitization.

In the South Shields area the base of the Trow Point Bed has a medium-scale primary relief of at least 15 m, partly because of drape over slide blocks but mainly because of the irregularity of the underlying slide plane. Its base is also uneven in detail and in offshore boreholes B2 and B8 it features cracks up to 8 cm deep and 1 cm across that are partly filled with sediment of the bed itself; in a surface exposure (3941 6602) 1.1 km SE of Trow Point the surface bears a 3–8 cm pattern of grooves resembling desiccation cracks. Cracks

From Harwood, G.M. & Smith, D.B. (eds), 1986, *The English Zechstein and Related Topics*, Geological Society Special Publication No. 22, pp. 113–125. 113

An abrupt change from deep to shallow water deposition cannot be described as a shallowing upward succession

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