Cretaceous 'USM' Reservoir, F-O Gas Field, Offshore South Africa: Sedimentological Factors Affecting Economic Viability*

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Abstract

The F-O Field (Bredasdorp Basin) is a seismically defined, low-relief antiform. The last two of the four drilled wells found surprisingly poor porosity (<12%) in clean sands of the 'Upper Shallow Marine' (USM) reservoir, highlighting the need for a reliable predictive sedimentological model. Subsequent wireline correlations, core facies analysis and diagenetic studies have revealed or confirmed the following interpretations. (1) The depositional environment was a shallow marine tidal sand sheet (dunefield), for which suitable analogs are the modern North Sea and the Peninsula Formation of South Africa (Paleozoic, e.g. Table Mountain). Net-sand mapping for each of eight reservoir zones defined from log-shape correlations reveals lateral shifts in the sand-sheet axis. (2) The base of the USM is a sequence boundary, probably representing the 126 Ma eustatic superlow (Valanginian), consistent with imprecise USM microfossil dating. (3) The top of the USM is a diachronous flooding surface overlain by shales. (4) Not far (<100 m) above the USM is a low-relief angular unconformity (evident on dipmeter), formed during F-O antiform growth, reflecting Hauterivian early transpressive movement on the Agulhas-Falklands Fracture Zone, after USM "quiescent rift" deposition. The USM is partly to entirely eroded at the unconformity when traced laterally. (5) Porosity is secondary and generally poor due to deep burial (currently 3.5 km). Enhanced porosity (12-16%) can occur in the cleanest facies (central dunefield sand), but only near (<40 m below) the unconformity, indicating that it is telodiagenetically related. Overlaying of two isopach maps (net sand, and "sub-unconformity overburden") will help to guide future well placement. Reservoir modeling and frac-suitability studies are underway.

Cretaceous ‘USM’ reservoir, F-O Gas Field, Bredasdorp Basin, offshore South Africa: sedimentological factors affecting economic viability

Dr Roger Higgs

on contract to

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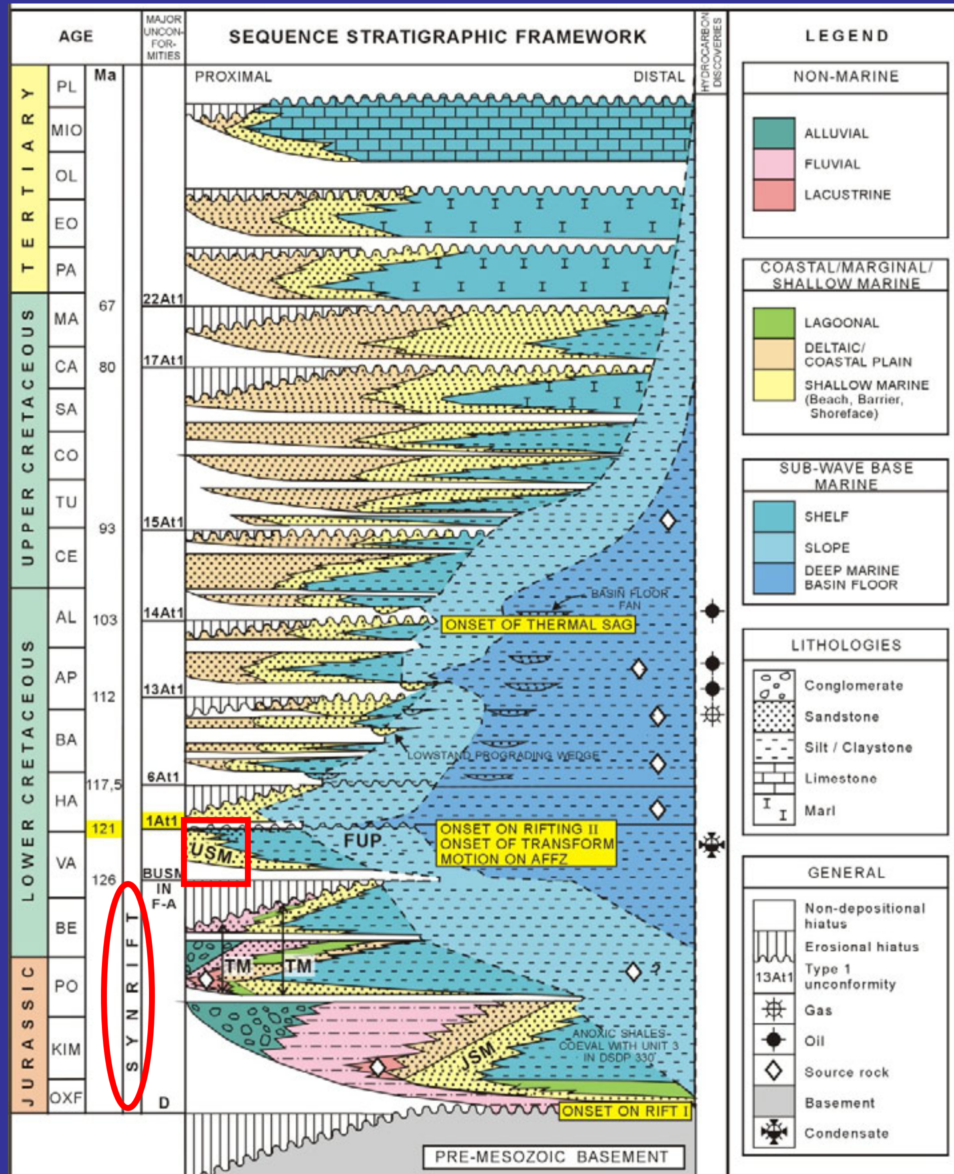
ISSUE

-Deep (c. 3.5 km), undeveloped gas field, 4 wells

-First 2 wells yielded enhanced porosity (12-16%) near top of reservoir (DST 31.5 MMcf/d)

-Next 2 wells did not

-How to predict good porosity in future wells?

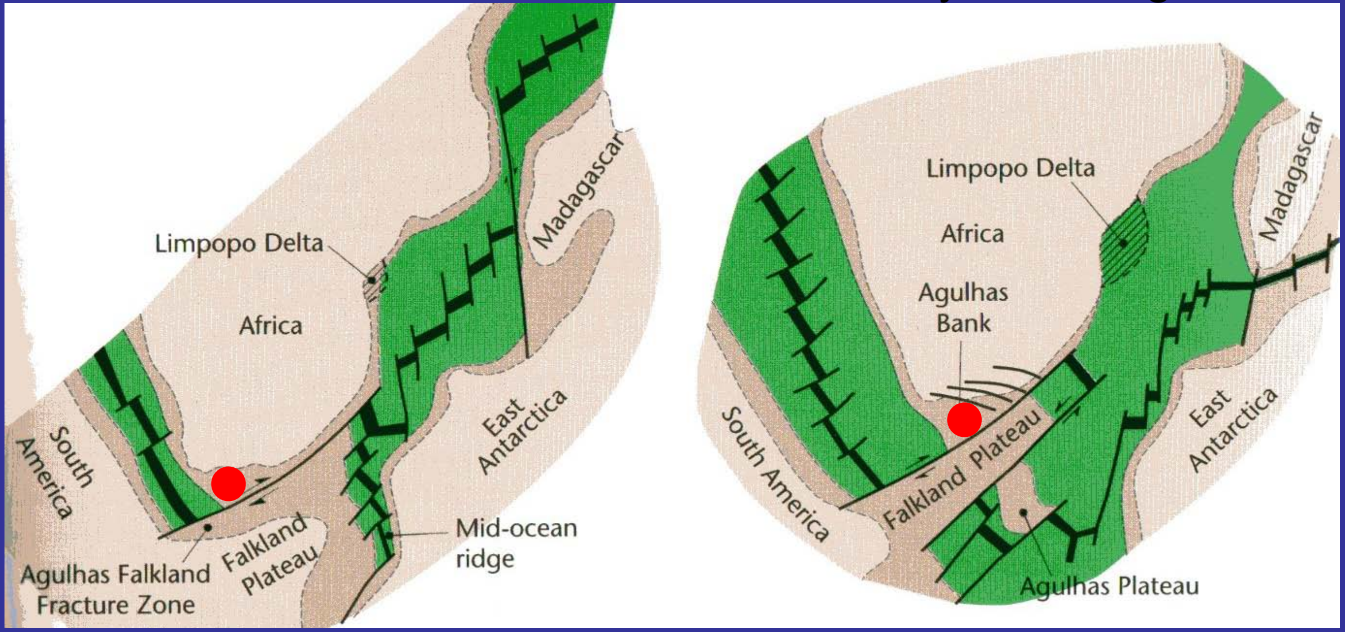


Jungslager (1999)

informal name of reservoir interval:

“Upper Shallow Marine Sandstone”

McCarthy & Rubidge 2005



c. 120 Ma, Hauterivian c. 110 Ma, Aptian

Tectonic setting: pre-oceanic trantensional rift basin

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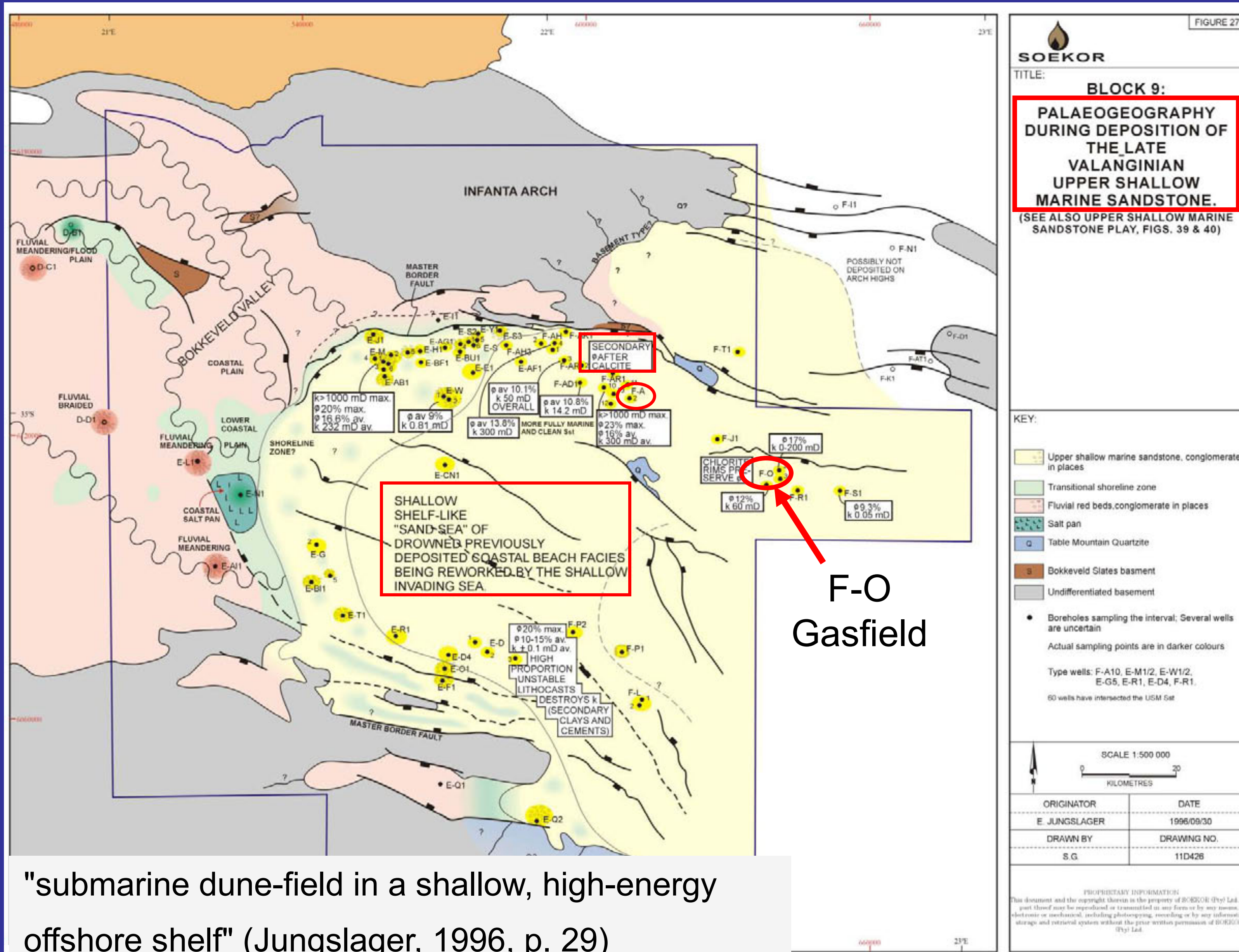

"submarine dune-field in a shallow, high-energy offshore shelf" (Jungslager, 1996, p. 29)

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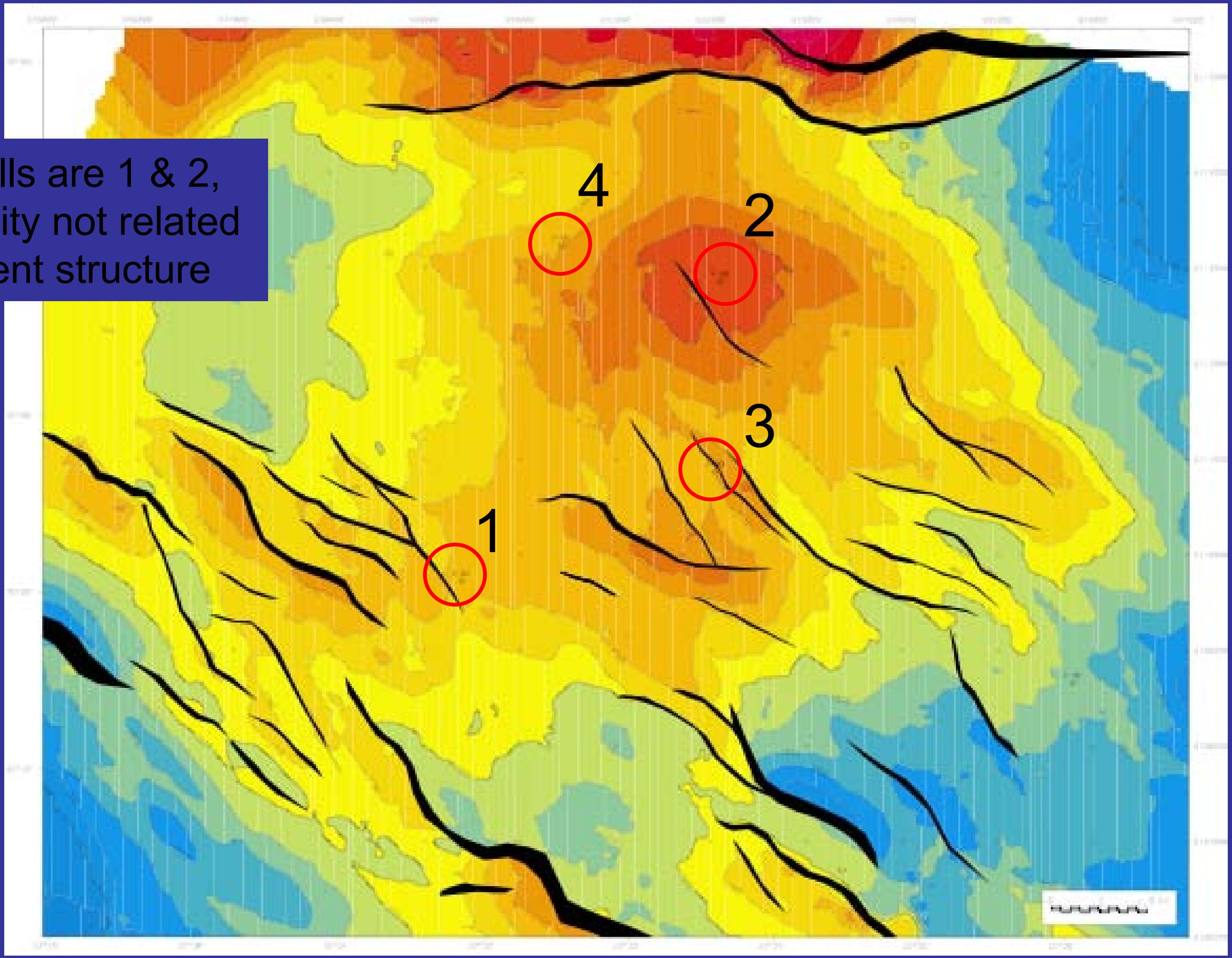
Best wells are 1 & 2, i.e. porosity not related to present structure



PGS 2001

Time-structure, top of USM reservoir ("1At1 unconformity"), F-O Gas Field.

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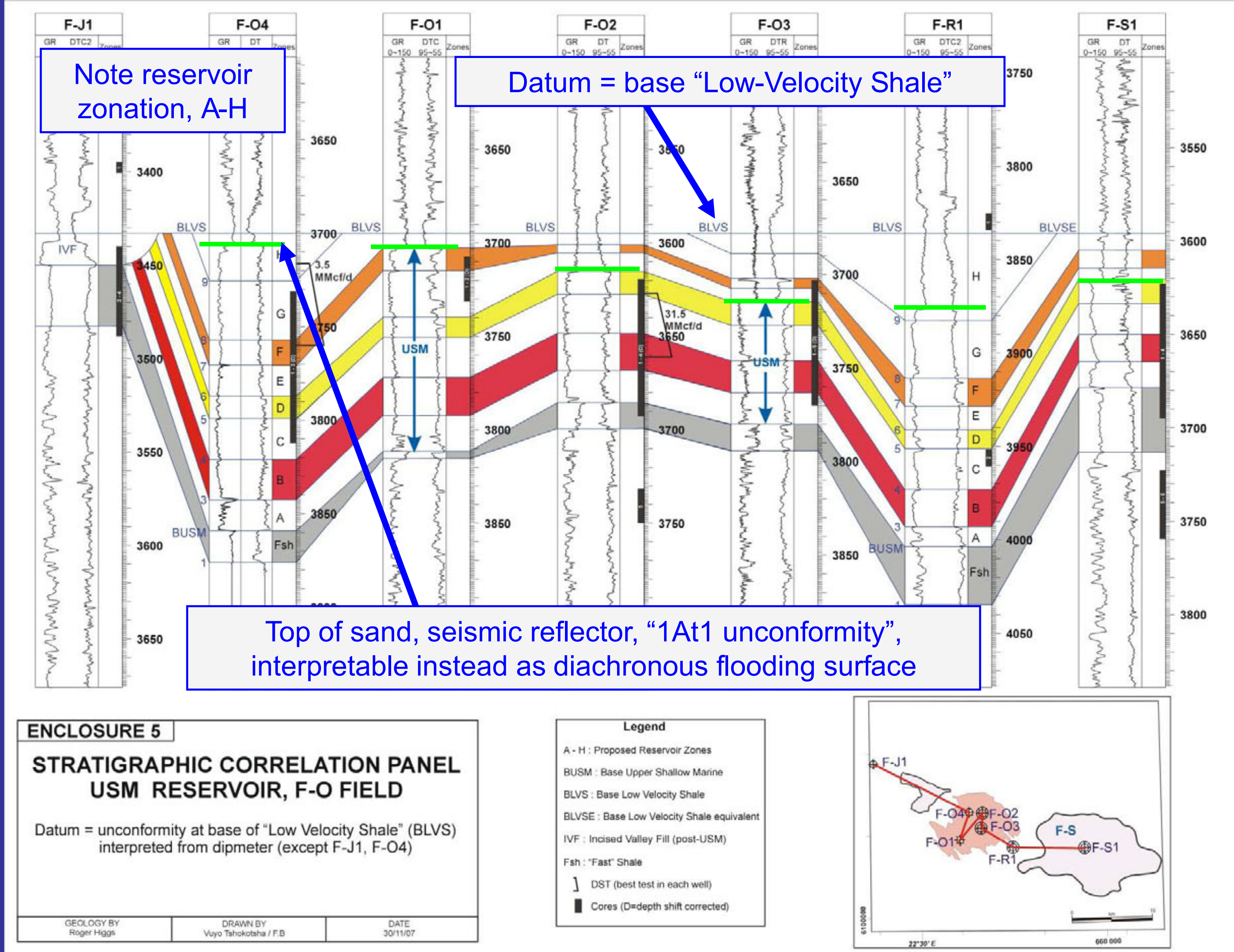

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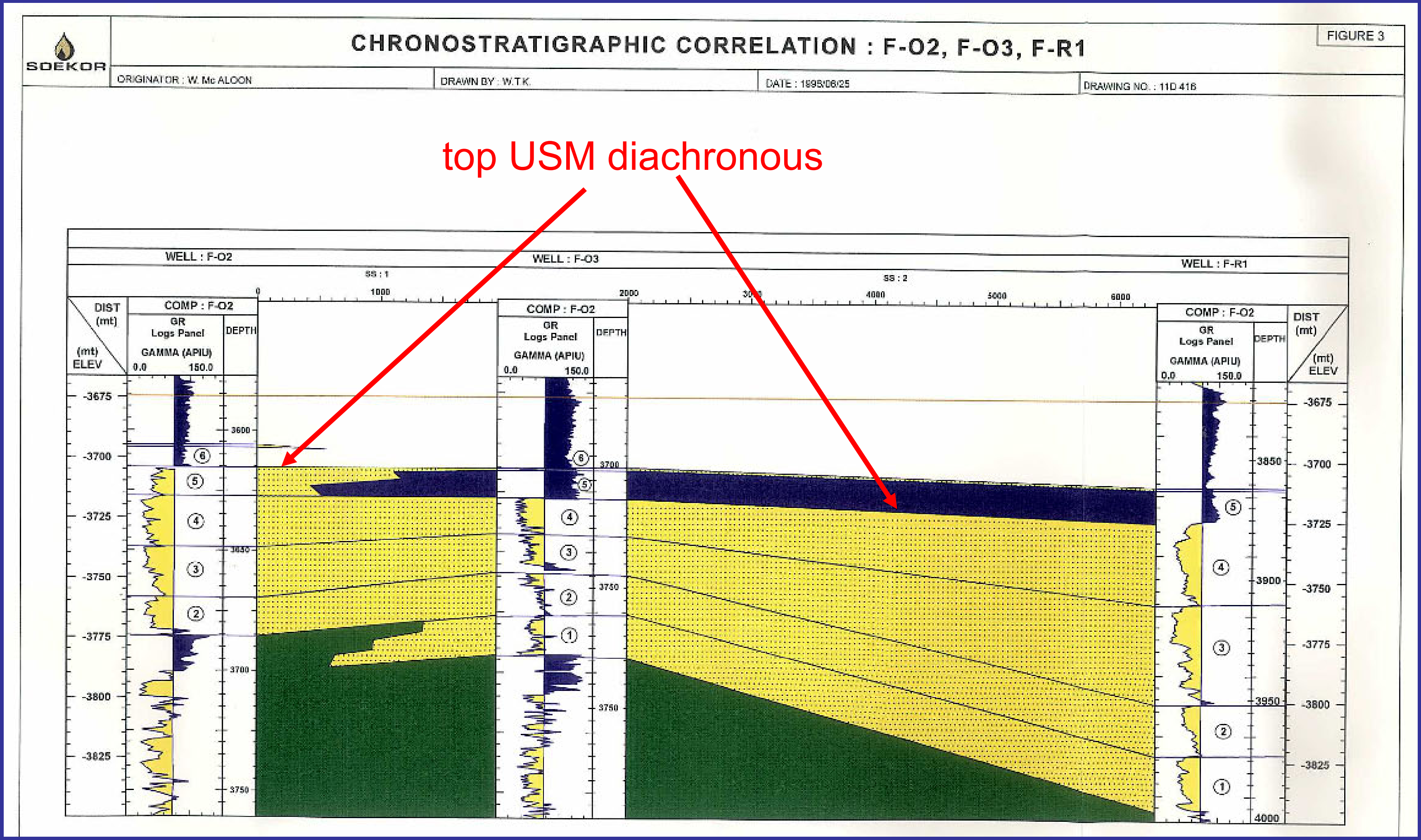
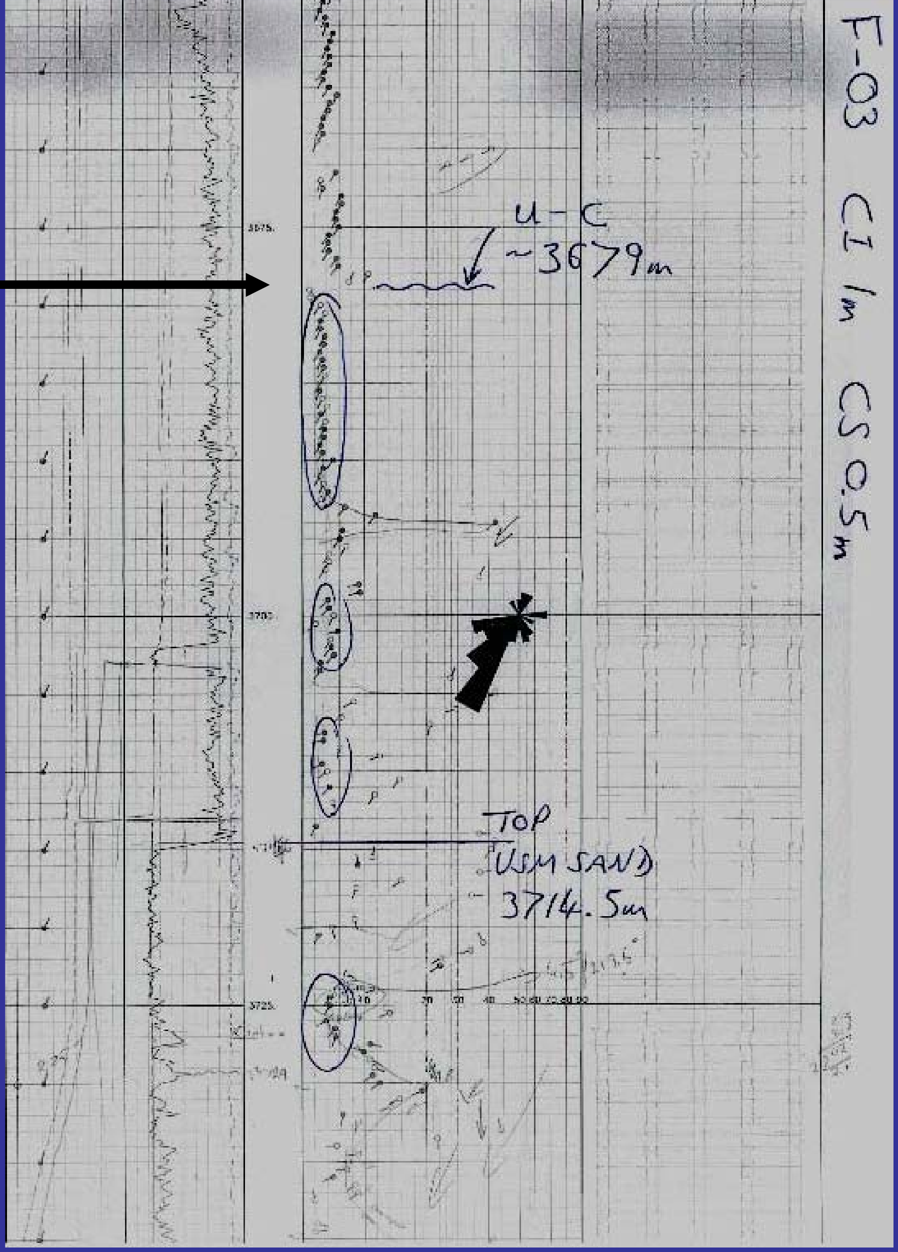
McAloon 1996



DIPMETER

angular (erosional) unconformity, at base of low-velocity shale



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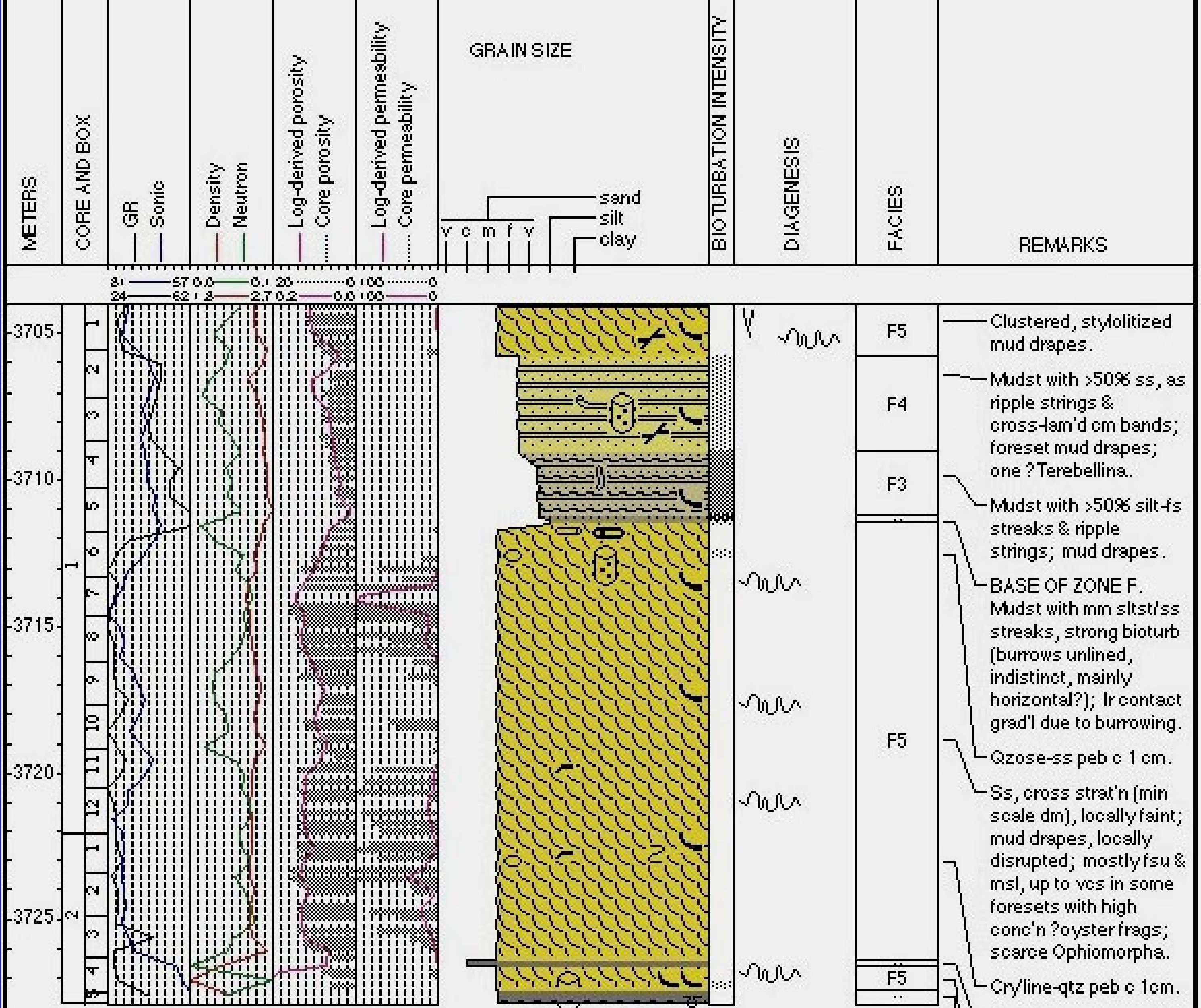
USM FACIES ANALYSIS



cleanest sand (lowest GR) is Facies 5

Cross-stratified sandstone containing a cluster of foreset mud drapes (including couplets), indicating tidal slack-water episodes

USM FACIES ANALYSIS

OBSERVATION	INTERPRETATION
Cross strat with mud drapes	Tide dominated
Ammonites; no roots or paleosols	Marine; entirely subaquatic
Rare HCS & sym ripples	Wave-influenced

INTERPRETED ENVIRONMENT: Shallow marine, storm-influenced tidal sand sheet

MODERN ANALOG: North Sea

ANCIENT ANALOGUE: Peninsula Fm , Paleozoic, South Africa

PREDICTED SAND-BODY GEOMETRY: Stacked sand sheets, area 100s km x 10s km

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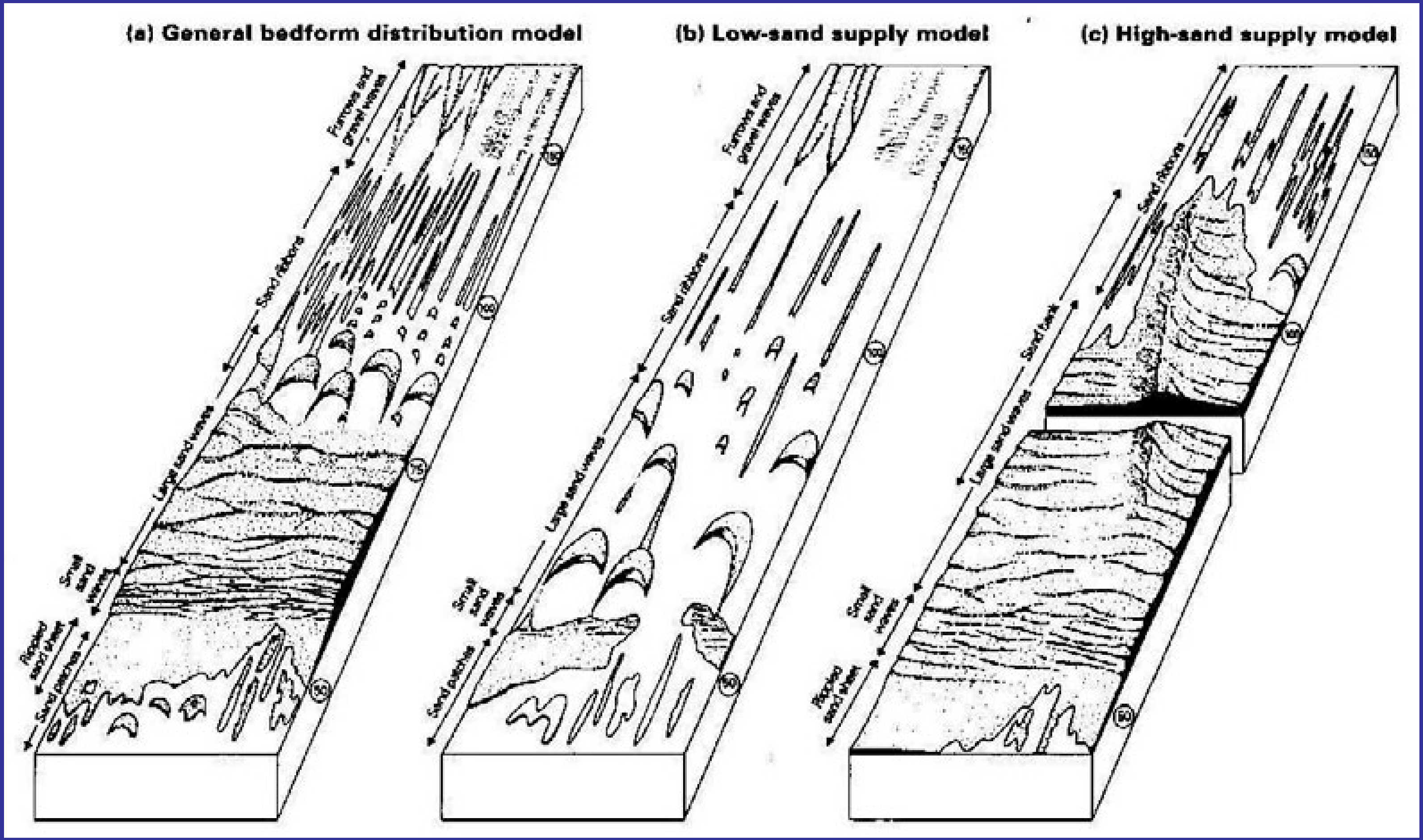
Johnson & Baldwin 1996, after Belderson *et al*. 1982



Depositional models for a tidal sand transport path in a shallow sea, based on NW European shelf.

MODERN ANALOG

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ANCIENT ANALOG - Peninsula Fm (Lr Pzc)

Largely interpreted as tide-dominated shallow marine (Hobday & Tankard 1978).

Table Mountain more proximal in the sand sheet (pebbly sandstone common; mud drapes rare) than F-O? More analogous to F-A Field?

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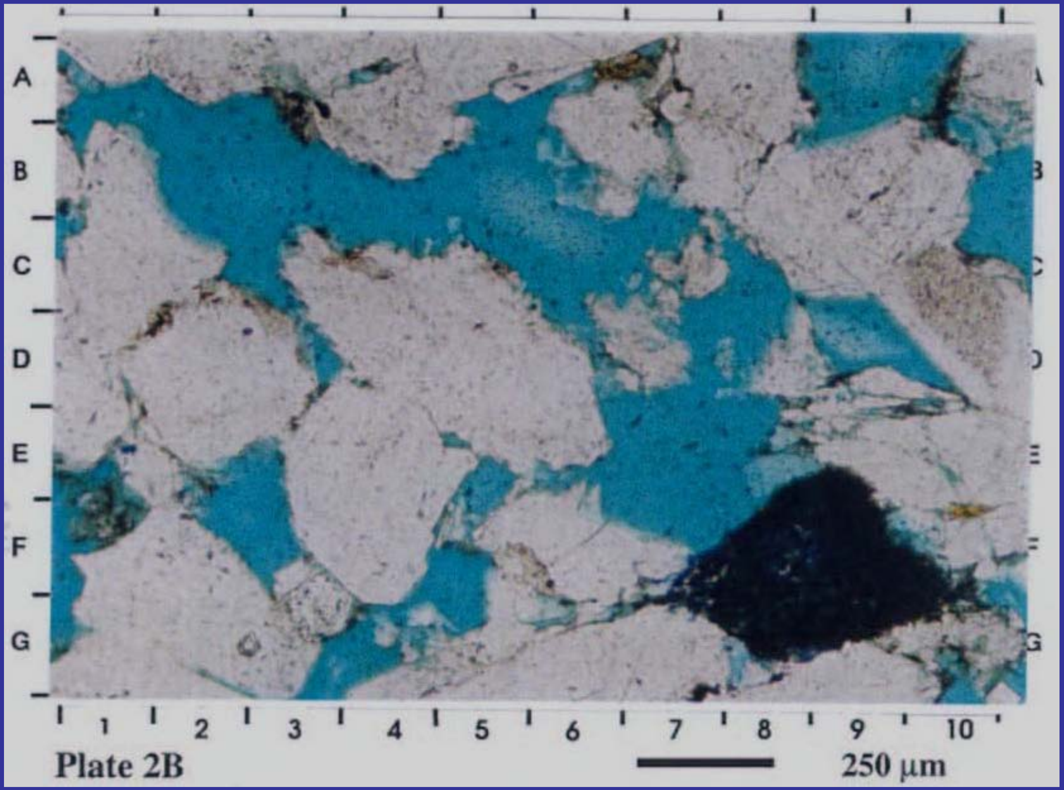
USM DIAGENESIS ANALYSIS



Core Lab
2001

Enhanced porosity, F-O1, 3714.89 m, Facies 5

Diagnostic attributes of secondary porosity:

-oversize pores

-micro-pitted quartz borders

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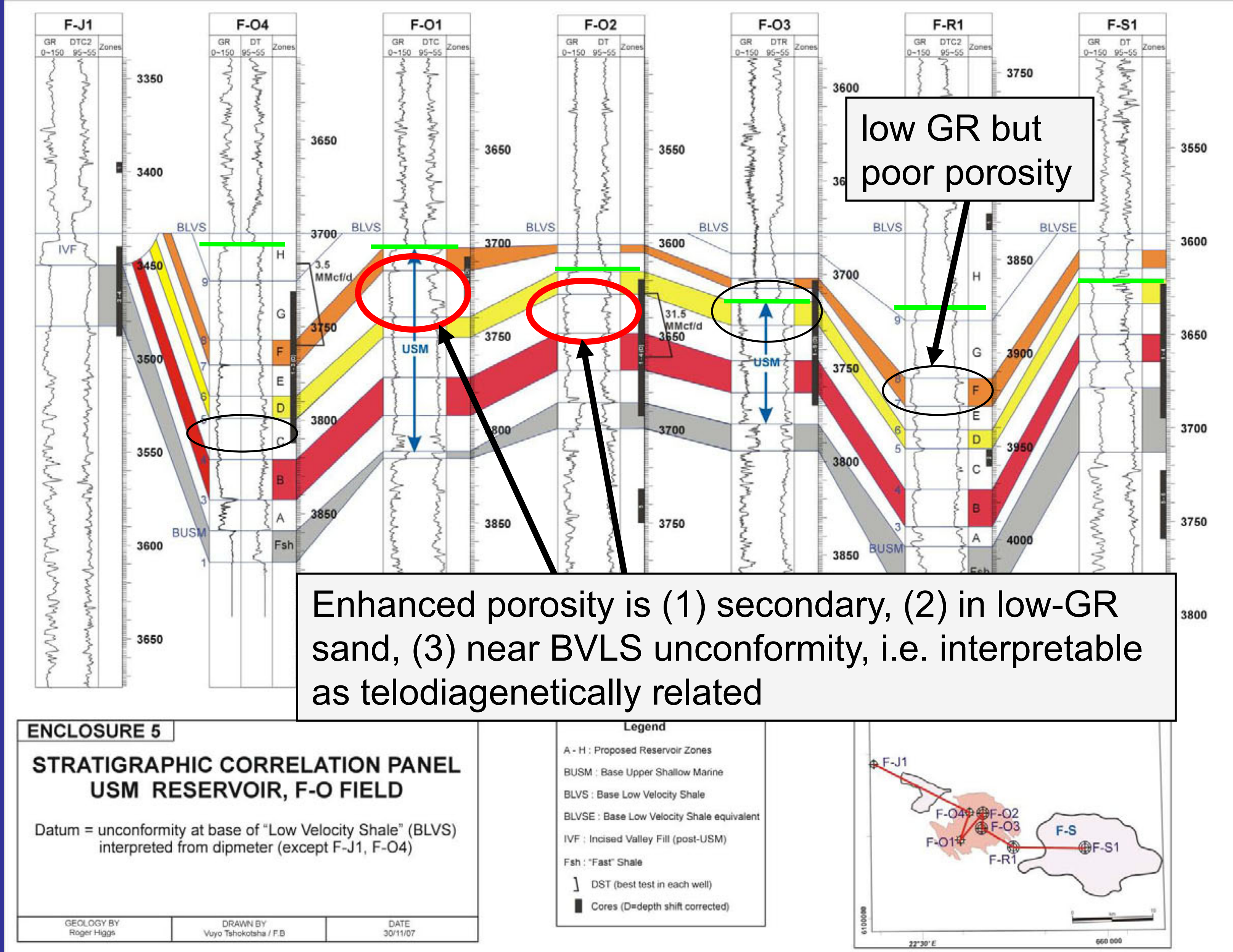
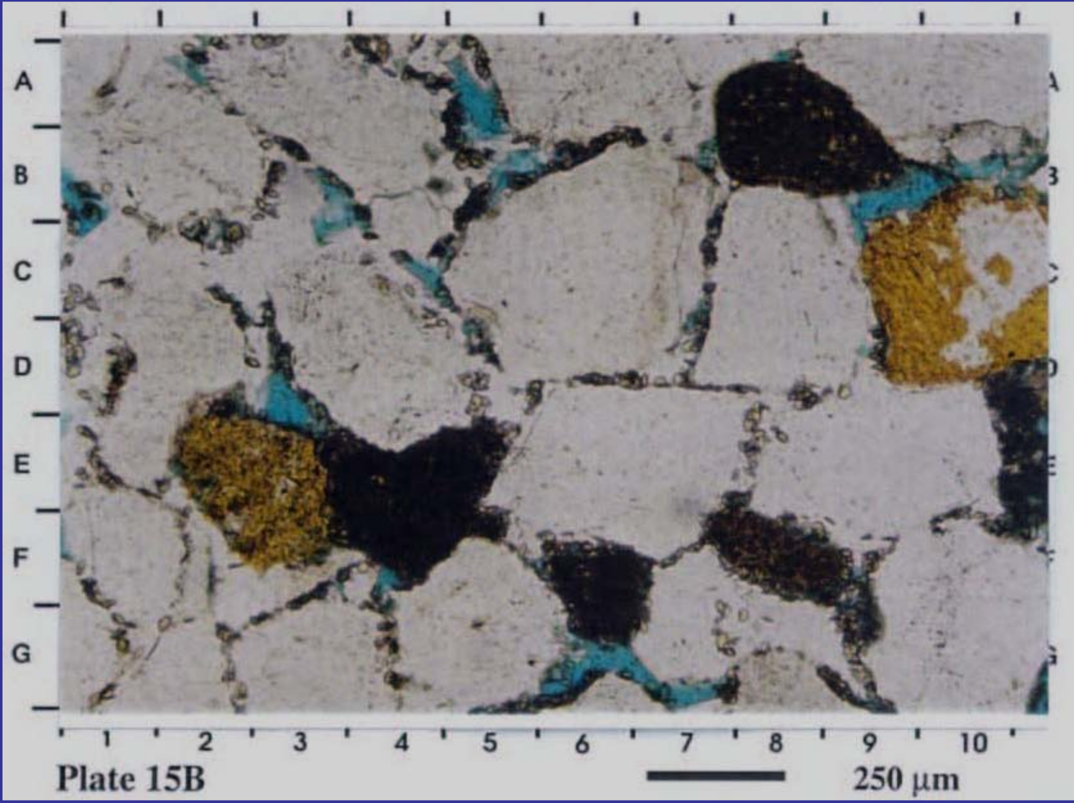


F-J1
F-O4
F-O1
F-O2
F-O3
F-R1
F-S1
GR 0–150
DTC2 95–55
DT 95–55
DTC 95–55
DTR 95–55
Zones
BLVS
BLVSE
BUSM
IVF
USM
H
G
F
E
D
C
B
A
Fsh
3.5 MMcf/d
31.5 MMcf/d
low GR but poor porosity
Enhanced porosity is (1) secondary, (2) in low-GR sand, (3) near BVLS unconformity, i.e. interpretable as telodiagenetically related
ENCLOSURE 5
STRATIGRAPHIC CORRELATION PANEL
USM RESERVOIR, F-O FIELD
Datum = unconformity at base of "Low Velocity Shale" (BLVS) interpreted from dipmeter (except F-J1, F-O4)
GEOLOGY BY Roger Higgs
DRAWN BY Vuyo Tshokotsha / F.B
DATE 30/11/07
Legend
A - H : Proposed Reservoir Zones
BUSM : Base Upper Shallow Marine
BLVS : Base Low Velocity Shale
BLVSE : Base Low Velocity Shale equivalent
IVF : Incised Valley Fill (post-USM)
Fsh : "Fast" Shale
DST (best test in each well)
Cores (D=depth shift corrected)
F-S



Core Lab
2001

F-O4, 3737.35 m, Facies 5. Advanced cementation by interlocking quartz crystals

Optimum future well locations found by overlaying two maps (per zone): (1) isopach of net clean sand; & (2) isopach to base LVS

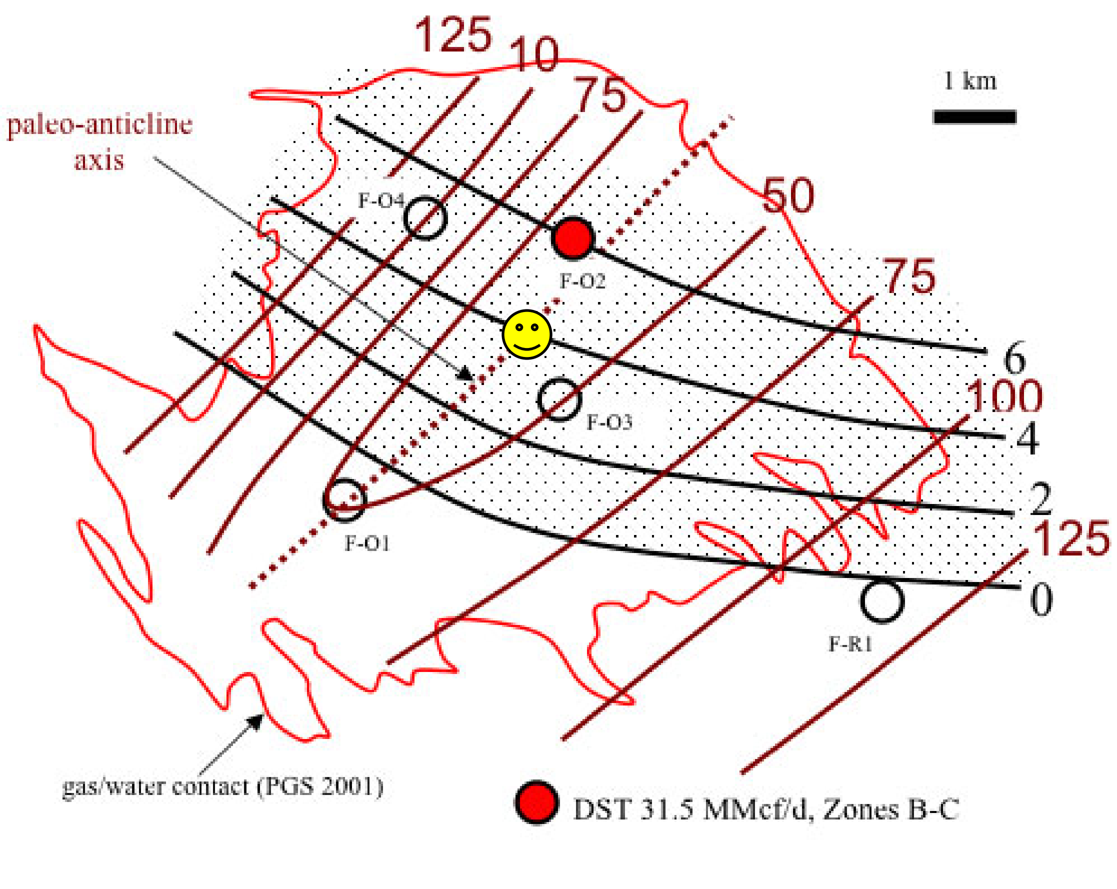


Figure 27. BLVS to top of Zone C (USM) isopach (m; brown contours), overlaid on Zone C net-sand isopach (m; black; 10% GR cutoff), F-O Field.

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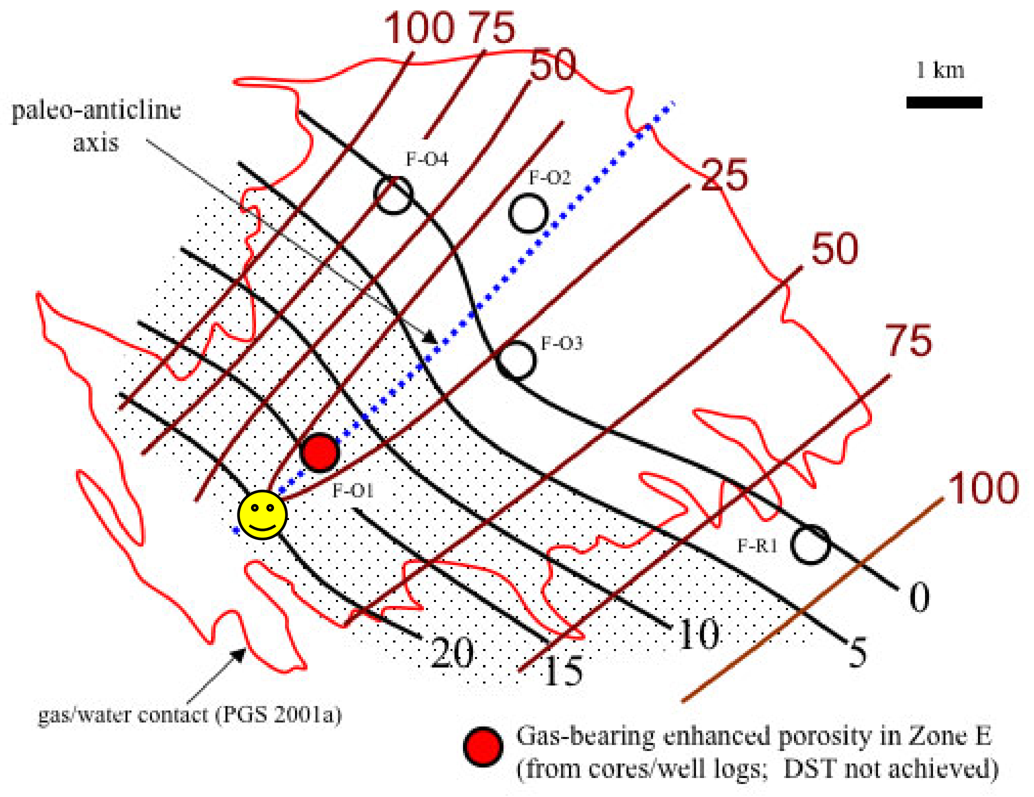

Figure 28. BLVS to top of Zone E (USM) isopach (m; brown contours), overlaid on Zone E net-sand isopach (m; black; 10% GR cutoff), F-O Field.

CONCLUSIONS

Two conditions required for "enhanced porosity"...

-cleanest facies (central dunefield sand)

-less than 40 m below the BLVS unconformity

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References

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Thank you