DISPLAY B3

Modelling Fine-scale Sedimentological Heterogeneity for Optimal Production from the Neptune Field, Aeolian Gas Reservoir UKCS

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The Neptune Field lies on the NW margin of the Southern North Sea gas basin in block 47/4b and extends into blocks 47/5a and 42/29. Following development drilling of the field, a rebuild of the deterministic reservoir simulation model failed to provide a reasonable history match except for Flowing Bottom Hole Pressures (FBHP). The poor dynamic history match was due to the modelling not incorporating the permeability heterogeneity seen in the aeolian sandstones of the Neptune Field. A stochastic reservoir model was produce that captured the broad range of scales of critical facies and petrophysical heterogeneities present within this aeolian reservoir.

The challenge for the stochastic reservoir model was to capture the key heterogeneities in this high net to gross system. Facies modelling was undertaken using the General Mark Point Processing in Roxar's RMS. Dunes were modelled as prolate ellipsoids with long axes alignment constrained by dip-meter interpretation. Dune dimensions were estimated from outcrop analogues and were conditioned to well data. Aeolian sandsheet and damp interdune facies were modelled as sheet-like oblate ellipsoids inclined at similar dips to the aeolian dunes.

Permeability variations due to lamina grain size segregation in aeolian dune foresets were modelled using sector models to capture cross lamina permeability (kx, kz) and lamina parallel flow (ky). The results of sector modelling were incorporated into the stochastic petrophysical realisations where spatial variation in permeability within dunes was modelled using object specific linear piecewise trend porosity and permeability transformations. Dunes were simulated with low permeability dune bases, high permeability lower dune slipfaces and moderate to low permeability upper dune slipfaces. Other minor aeolian and fluvial facies were assumed to be petrophysically isotropic.

The stochastic permeability map gave a better BHP response and history match at the development wells than any deterministic permeability distribution modelled.

Plate A

Well: UKCS 47/4b-6 Interval: 9818 ft – 9821 ft

Fine-grained, massive to indistinctly stratified sandstones with scattered grey mudclasts. This interval is interpreted to have been deposited by localized sheetflood reworking of aeolian sands. Permeabilities are low, as is permeability heterogeneity.

This interval forms the base of reservoir layer N1a (9820.8'). This layer is modelled with reworked aeolian sands forming the background facies. The low proportion of aeolian dune and sandsheet sands identified in other wells are modelled discretely.

Plate B

Well: UKCS 47/4b-6 Interval: 9821 ft – 9824 ft

Fine to medium-grained sandstones. The upper section comprises wind-ripple laminated sands (9821 - 9823') that overlie thin, aeolian dune sands. The thick wind-rippled bundle was deposited on an aeolian sandsheet. The sandsheet facies is characterised by moderate permeabilities, but heterogeneity is high reflecting the appreciable grain size variation between wind-ripple laminae. Moderate permeability dune slipface facies are separated by a thin low permeability wind-rippled dune apron unit (9822.9 – 9823.2 ft).

This interval forms the top of reservoir layer N1b, an aeolian-dominated zone in which aeolian dunes are modelled discretely as prolate ellipsoids. Aeolian sandsheets were modelled as oblate ellipsoids.

Plate C

Well: UKCS 47/4b-6 Interval: 9830 ft – 9845 ft

A succession of fine to medium-grained, aeolian dune sandstones characterised by wind-ripple dominated dune aprons (up to 3ft thick) that pass upwards into grainflow laminated dune slipface sandstones. Coarse-grained lenticular grain flows are concentrated at the bases of the slipface where they interdigitate with wind-ripple laminated sands. Upwards through the slipface the grain size of the grainflow laminae decreases. The principal dune genetic unit (9832.6 – 9843.0ft) in this interval is characterised by a low to moderate permeability dune apron (ca 3ft thick, capped by moderate to high permeability coarse-grained grainflow laminae (ca 4ft thick) that grades upwards into a low permeability upper dune slipface.

The dune elements are interpreted as simple dunes that migrated across deflated, dry interdune areas.

Lamina-scale heterogeneity was modelled using Heriot-Watt's Geopseudo Atlas to determine K_x, K_y and K_z. These properties were then incorporated into an RMS model in which dune elements were modelled as discrete prolate ellipsoids elongate parallel to the palaeo-wind direction. In this high net:gross environment an aeolian dune background was used to avoid dispersion of lower permeability genetic units to the margins of the model. Permeability within the dune elements was modelled using a linear piecewise trend to capture the idealised vertical permeability profile through the dunes.

Plate D

Well: UKCS 47/4b-6 Interval: 9857 ft – 9863 ft

A fine to medium-grained grainflow lamina dominated interval. The lower most dune genetic unit (9859.35 – 9863.3ft) is characterised by a marked reduction in permeability upward that reflects a corresponding reduction in the number of coarser-grained grainflow laminae. The deflation granule lag at the top of this bed marks a stepped increase in permeability in the base of the overlying dune genetic unit. Permeability increases further between 9857 - 9858ft in association with a 1ft thick interval of medium-grained grainflow laminae.

The presence of granule lags between thin dune units suggests that the aeolian dunes were deposited as simple dunes migrating across an interdune area.

The vertical permeability profile present in the core is captured in the reservoir model using the linear piecewise trend within the dune genetic units. However, note that this approach provides an idealised characterisation of the aeolian dune elements and the thickness and continuity of dune aprons and high permeability grainflow lamina packages varies appreciably.

Plate E

Well: UKCS 47/4b-6 Interval: 9937 ft – 9940 ft

Medium to coarse-grained grainflow dominated sandstones that form the basal part of a 19.6ft thick interval of cross-stratified sands. This interval comprises medium to coarse-grained grainflow lamina of high permeability.

This unit represents the base of reservoir layer N1b and rests on a regionally correlatable superbounding surface. The interval forms part of a large cresentic bedform (draa) with a single slip face. Notably the permeability profile through the thick draa deposits is similar to that in the simple aeolian dunes that characterise the upper part of layer N1b. In consequence for reservoir modelling purposes no distinction was made between the dune and draa deposits.

Plate F

Well: UKCS 47/4b-6 Interval: 9940 ft – 9946 ft

The top 0.8ft of the interval comprises bimodally sorted medium grained, wind-rippled sandstones that formed the apron to the overlying draa deposits. These sandstones rest on fine-grained, weakly laminated and slumped sandstones with possible carbonaceous clasts.

The weakly laminated and slumped sandstones form the uppermost part of reservoir layer N2. The presence of extrabasinal clasts at the base of this reservoir layer suggest that this interval is most likely to have been waterlain (sheetflood).

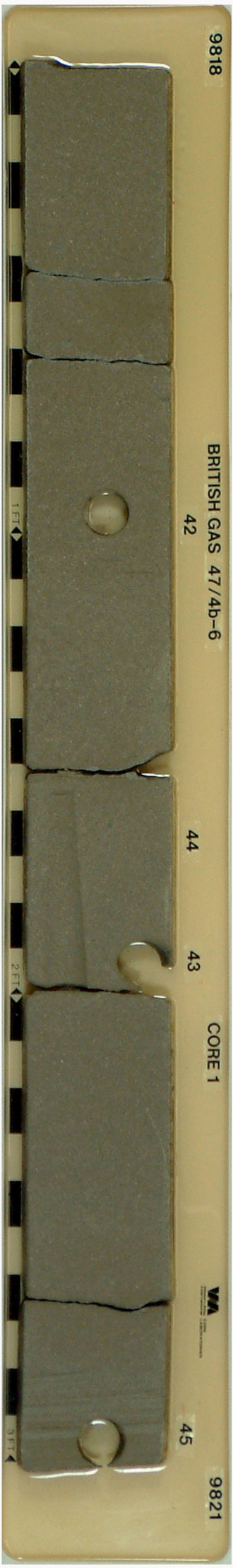
The apron facies are characterised by a downward reduction in permeability of 2 orders of magnitude relative to the overlying grainflow laminated sands. The waterlain deposits are characterised by low permeability and low permeability heterogeneity.

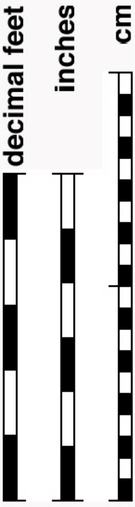
This represents the contact between reservoir layers N1b and N2. N2 is sheetflood dominated with thin damp interdune and aeolian dune units. In this layer the background was modelled with sheetflood properties, with the scarce aeolian and interdune deposits were modelled discretely.

Display B3 Plate A

Well UKCS 47/4b-6

9818 ft





Core photography and digital processing by
Robert Leppard (*Leppard Sedimentology Ltd*)
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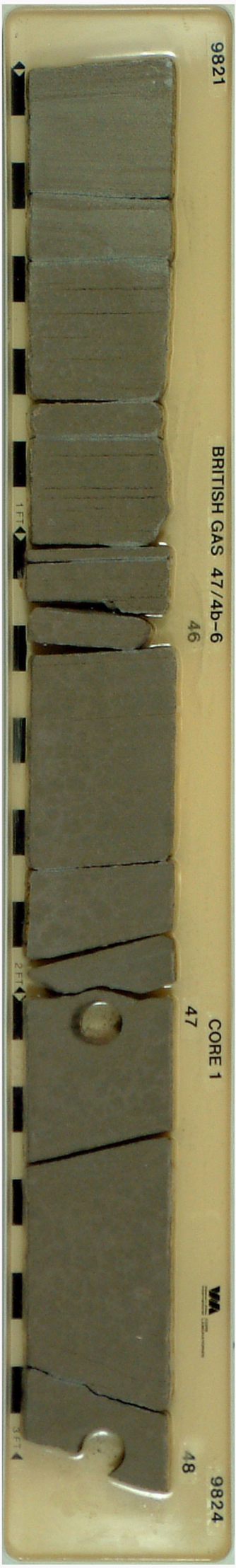
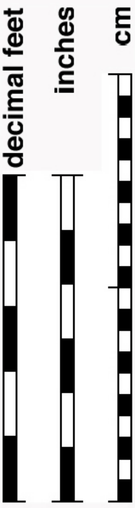
Colin Oakman (*Colin Oakman Associates*)

Display B3 Plate B

Well UKCS 47/4b-6

9821 ft





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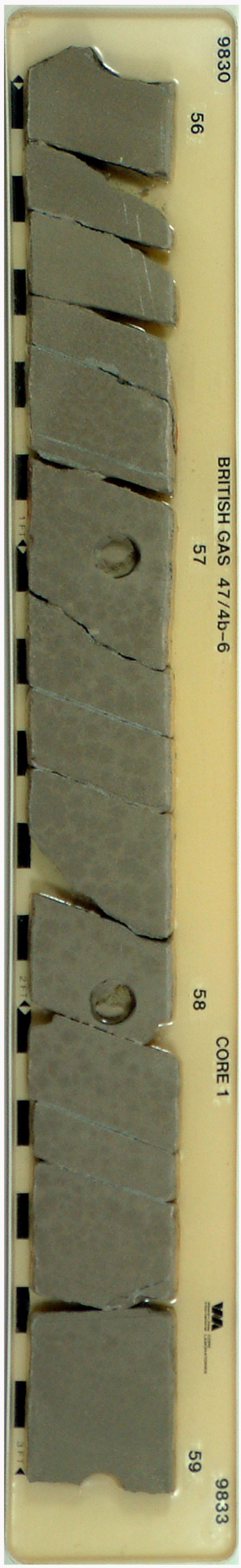
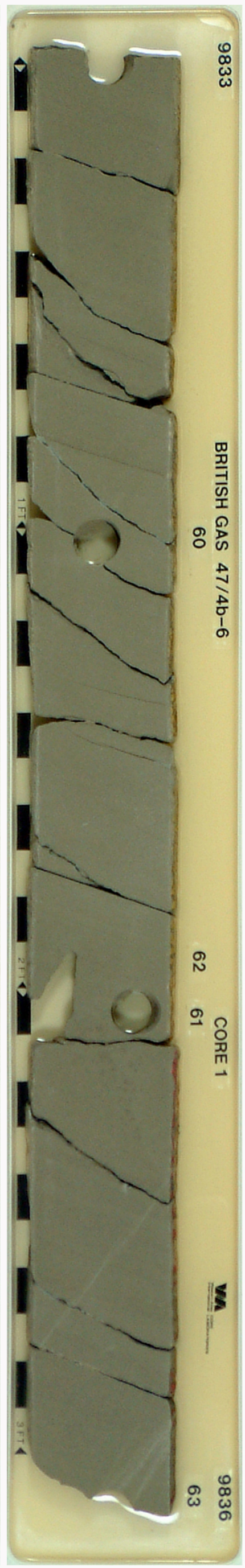
Display B3 Plate C

Well UKCS 47/4b-6

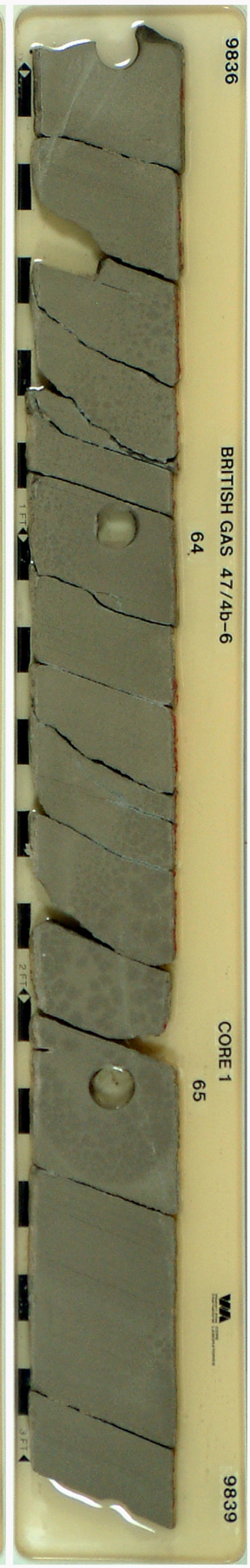
9830 ft



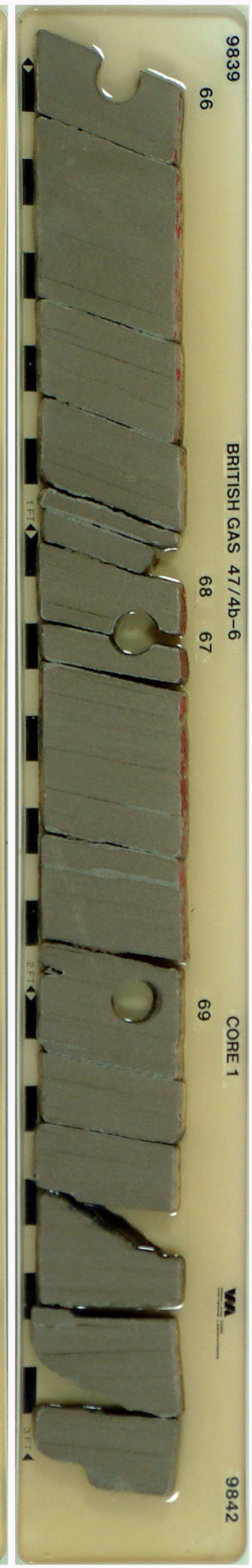
9833 ft



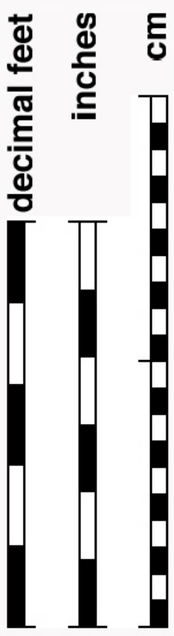
9836 ft



9839 ft



9842 ft



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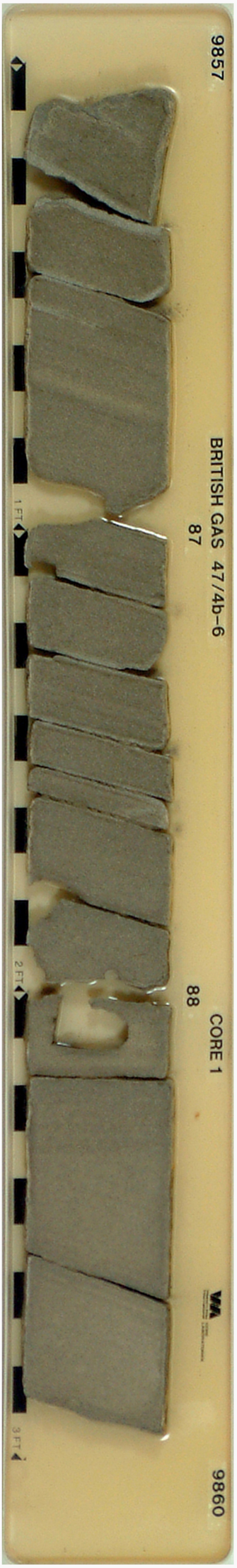
Display B3 Plate D

Well UKCS 47/4b-6

9857 ft



9860 ft

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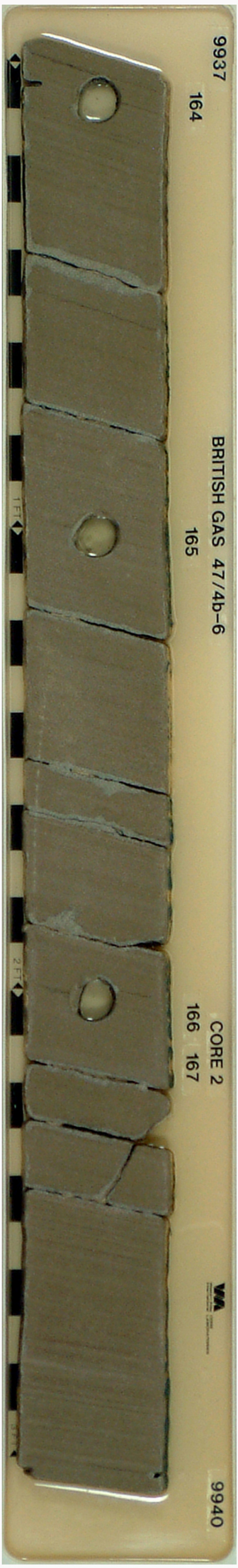
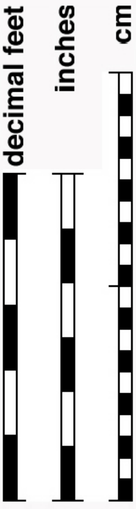
Display B3 Plate E

Well UKCS 47/4b-6

9937 ft





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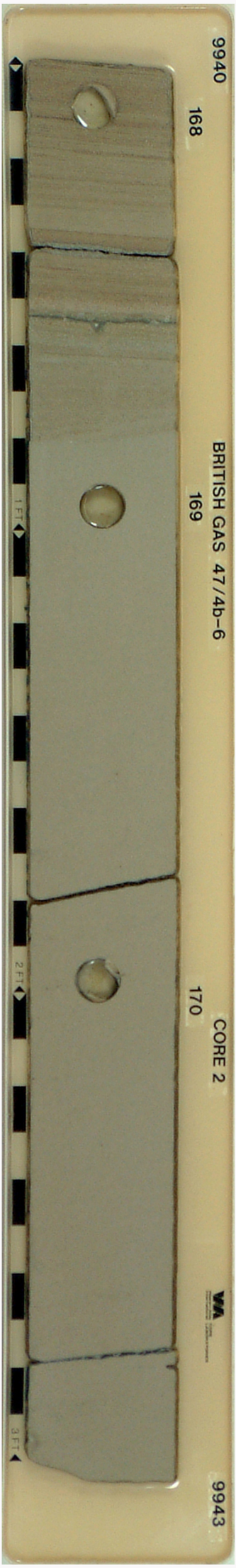
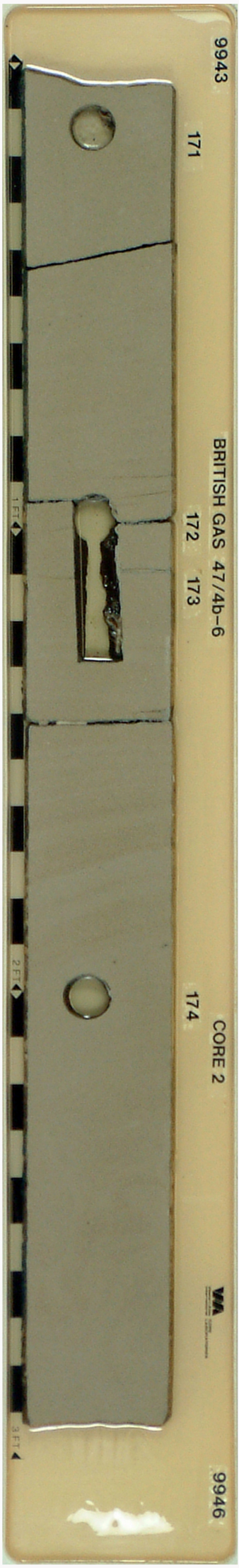
Display B3 Plate F

Well UKCS 47/4b-6

9940 ft



9943 ft



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