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**The UPPER CARBONIFEROUS RESERVOIR FAIRWAYS over the DUTCH  
OFFSHORE CLEAVER BANK HIGH: STRATIGRAPHY, SEDIMENTARY  
DEVELOPMENT and RESERVOIR POTENTIAL**

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### **Introduction**

A detailed study of the Upper Carboniferous in the Dutch offshore Cleaver Bank High (southern D and E, northern J and K blocks) and Schill Grund High (G blocks) was carried out to identify fairways for further exploration. Only the Cleaver Bank High (CBH) is discussed here.

### **Database, seismic interpretation, stratigraphic scheme and core analysis**

All data used in this study are in the public domain. The database of the CBH comprises of 42 wells and ten 3D seismic surveys over the CBH. Sixteen UK wells have been included for reference. Cores were available from 24 wells.

An intra-Carboniferous seismic reflector at the base of a high-reflective seismic unit (corresponding to the Maurits litho-unit), labelled W520, was interpreted throughout the area (5500 km<sup>2</sup>).

Correlating the clastic and coal-bearing successions of the Upper Carboniferous in the southern North Sea is a well-known problem. We have generated a high-resolution stratigraphic well-to-well correlation framework using the log-based method of Climate Stratigraphy (De Jong et al., 2007 and references therein) and integrated this with the results from conventional wireline log correlation techniques and palynological and seismic interpretations (Figure 1). Time-equivalent changes in the vertical lithofacies successions - or depositional trends - have been identified and correlated between the wells. Well marker W4210pbs corresponds to seismic marker W520. The high-resolution stratigraphic subdivision was converted to a scheme of litho-units, which, in turn, were input to the geological model (Figure 1).

A facies study was carried out with the focus on the large-scale sedimentary development. For that purpose a core-based standard facies scheme was erected.

### **The Petrel Geological Model**

A 3D geological model for the CBH was created in Petrel. Depth maps, preserved thickness maps and net-to-gross sand maps have been made for the litho-units (Figures 1 to 3). In addition, a subcrop map at the Base Permian Unconformity (BPU) and cross-sections have been constructed. Two depth converted surfaces from seismic interpretations were the input to the model: 1) top Carboniferous (BPU) and 2) base Maurits litho-unit (= seismic horizon W520). The model layers were built conformably from the base Maurits upward and downward. The BPU, well marker W6000 and well marker W7000 have been defined as erosional surfaces.

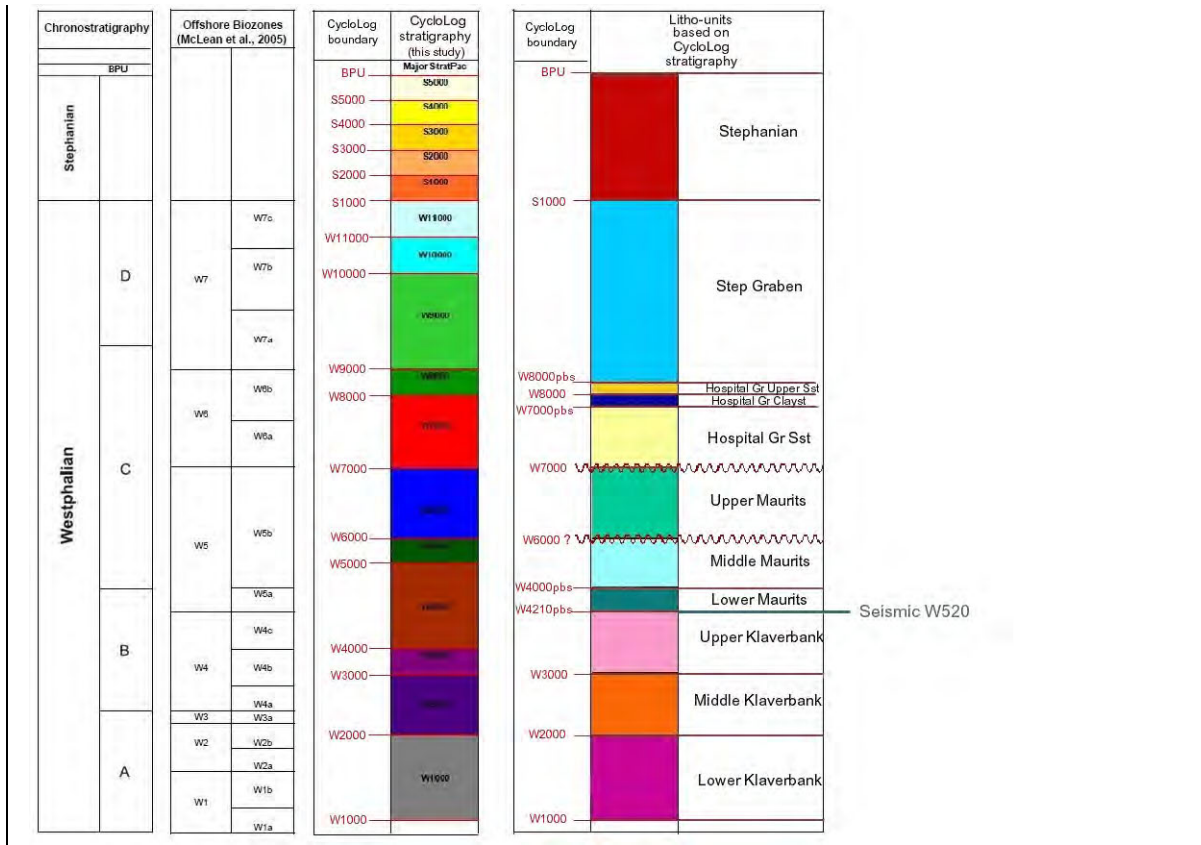


Figure 1: Stratigraphic scheme developed for this study.

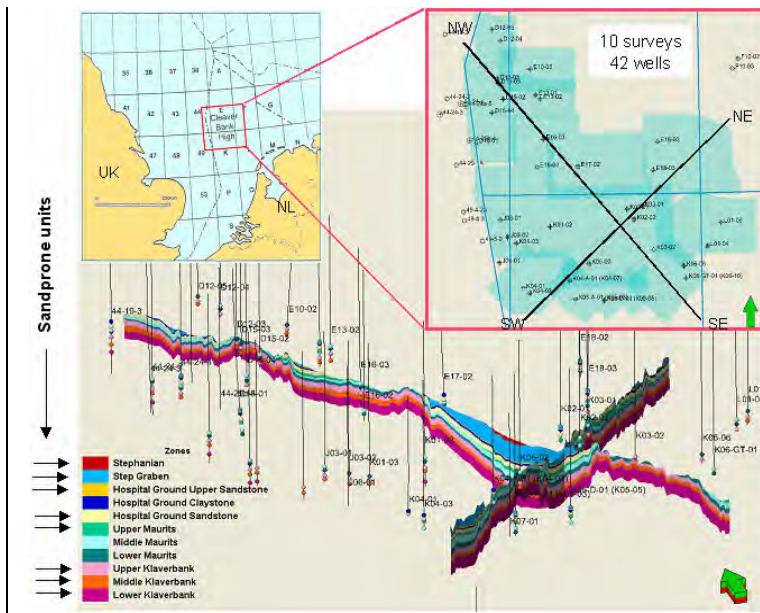


Figure 2: Two cross-sections across the CBH, generated in the Petrel geological model. Sand-prone litho-units are indicated by arrows.

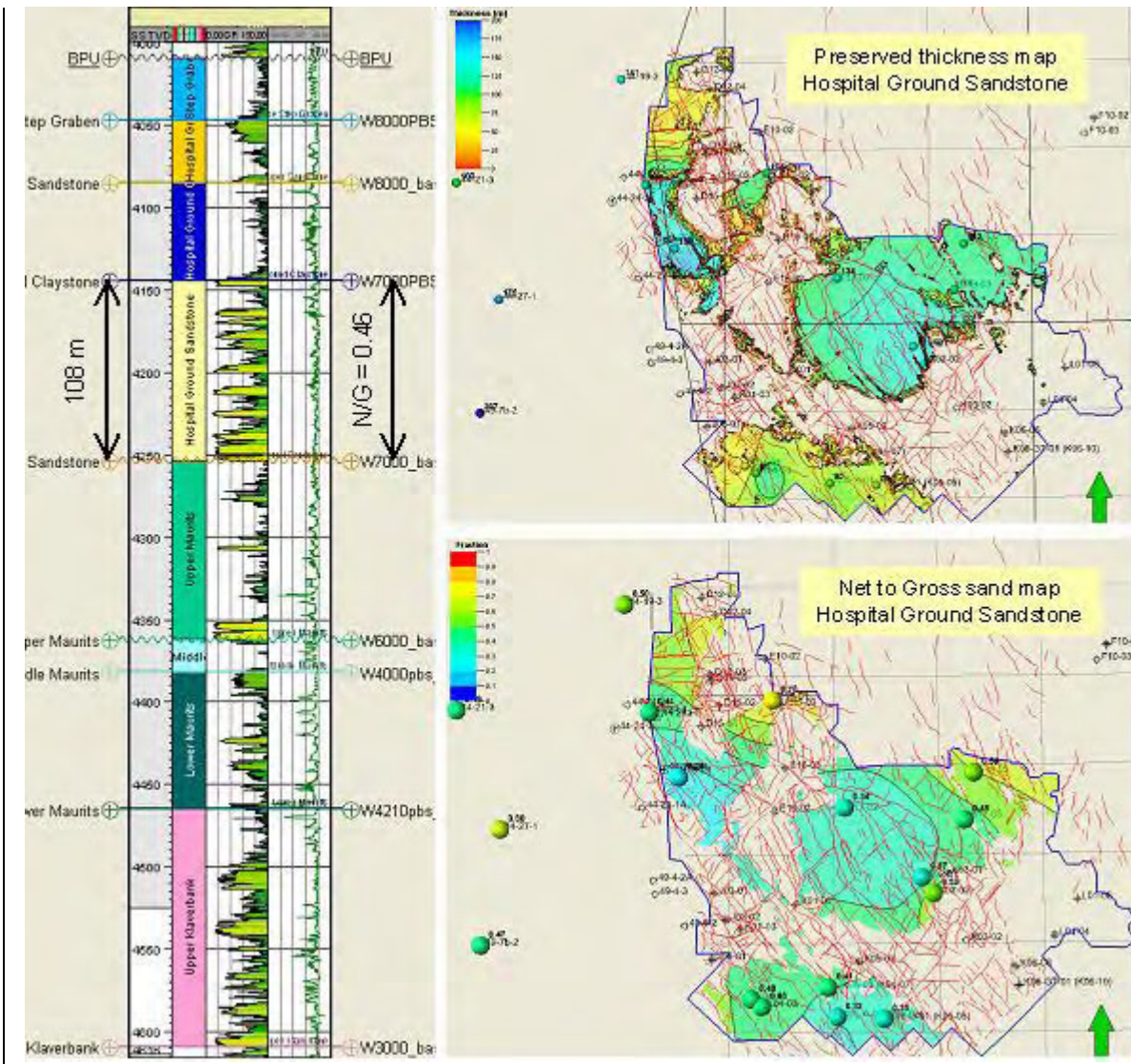


Figure 3: Stratigraphy and lithology of an example well is to the left The Hospital Ground Sandstone litho-unit has been indicated. To the right are example maps of the preserved thickness and N/G sand map of the Hospital Ground Sandstone litho-unit..

## Sedimentary Development

Deposition of the sediments in our study area took place in a large basin between the Variscan orogenic chain in the south and faulted highs in the north. The N/G sand values suggest a dominantly northern source throughout the Westphalian A to D in the CBH area. There are indications for a possible sediment supply from the south in the southern part of the study area, especially toward the late Westphalian. The following sequence of events was reconstructed:

- 1) Formation of Westphalian A and early Westphalian B deposits (Klaverbank litho-units) took place in an alluvial-fluvial depositional environment. Braided fluvial systems progressively built out southward across distal grey-coloured muds and peat-dominated sediments in a number of large-scale cycles, followed by rapid retreat.
- 2) During the late Westphalian B to early Westphalian C (Lower and Middle Maurits) the area was characterized by the deposition of grey-coloured muds and peat (coal), with little influence of fluvial systems. The relatively sudden inactivity of the early Westphalian fluvial system was possibly the result of widening of the basin, whereby sediment-supply areas were flooded and/or rivers were forced to retreat northward.
- 3) The upper Westphalian C (Upper Maurits) grey-beds show an increased content of coarse-grained sediments and few coals, suggesting a reversal of the large-scale depositional trend, back to an overall progradational fluvial setting, although sandstone percentage remains generally low. The base of this unit (W6000, Upper Maurits) may be a minor unconformity.
- 4) An unconformity occurs at the base of the Hospital Ground Sandstone (base W7000), possibly linked to a tectonic event. The overlying Westphalian C-D and Stephanian sequence consists of alternating thin conglomeratic sandstones and fine-grained red-beds; coals and organic-rich shales are rare. Sandstone-dominated intervals alternate with mudstone-rich intervals on a large scale.
- 5) Following the deposition of Stephanian strata major tectonism occurred, with deformation and uplift, ultimately resulting in the formation of the BPU. Widespread erosion of primarily Stephanian and to a lesser extent Westphalian strata occurred.

### **Reservoir potential**

Potential reservoir fairways are defined by the sand-prone intervals below the BPU. Sand-prone units are the three Klaverbank litho-units, the Hospital Ground Sandstone, the Hospital Ground Upper Sandstone and, possibly, the Step Graben and the Stephanian litho-units. Sand prone units have been indicated by arrows in Figure 3.

### **References**

- Jong, M. De, Nio, S.D., Smith, D. and Böhm, A., 2007. Subsurface correlation in the Upper Carboniferous (Westphalian) of the Anglo-Dutch Basin using the climate stratigraphic approach. *First Break*, 25, December 2007, p. 49-59.