



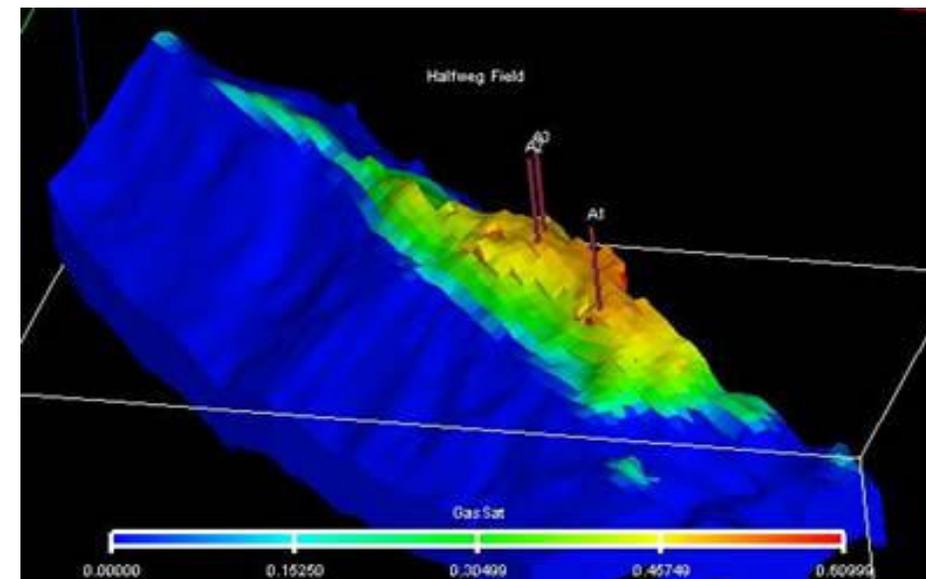
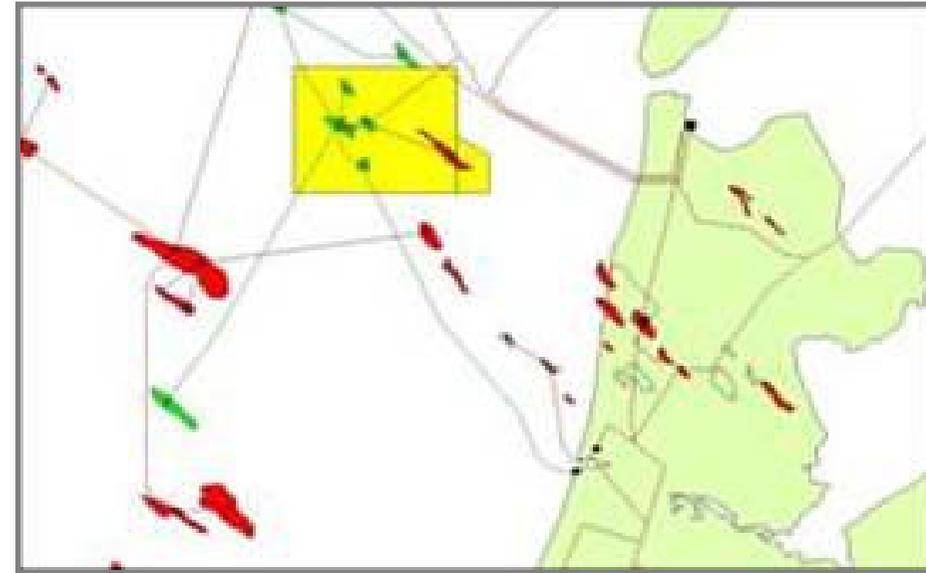
Q/1-Q/2c Halfweg Tight Gas field history case

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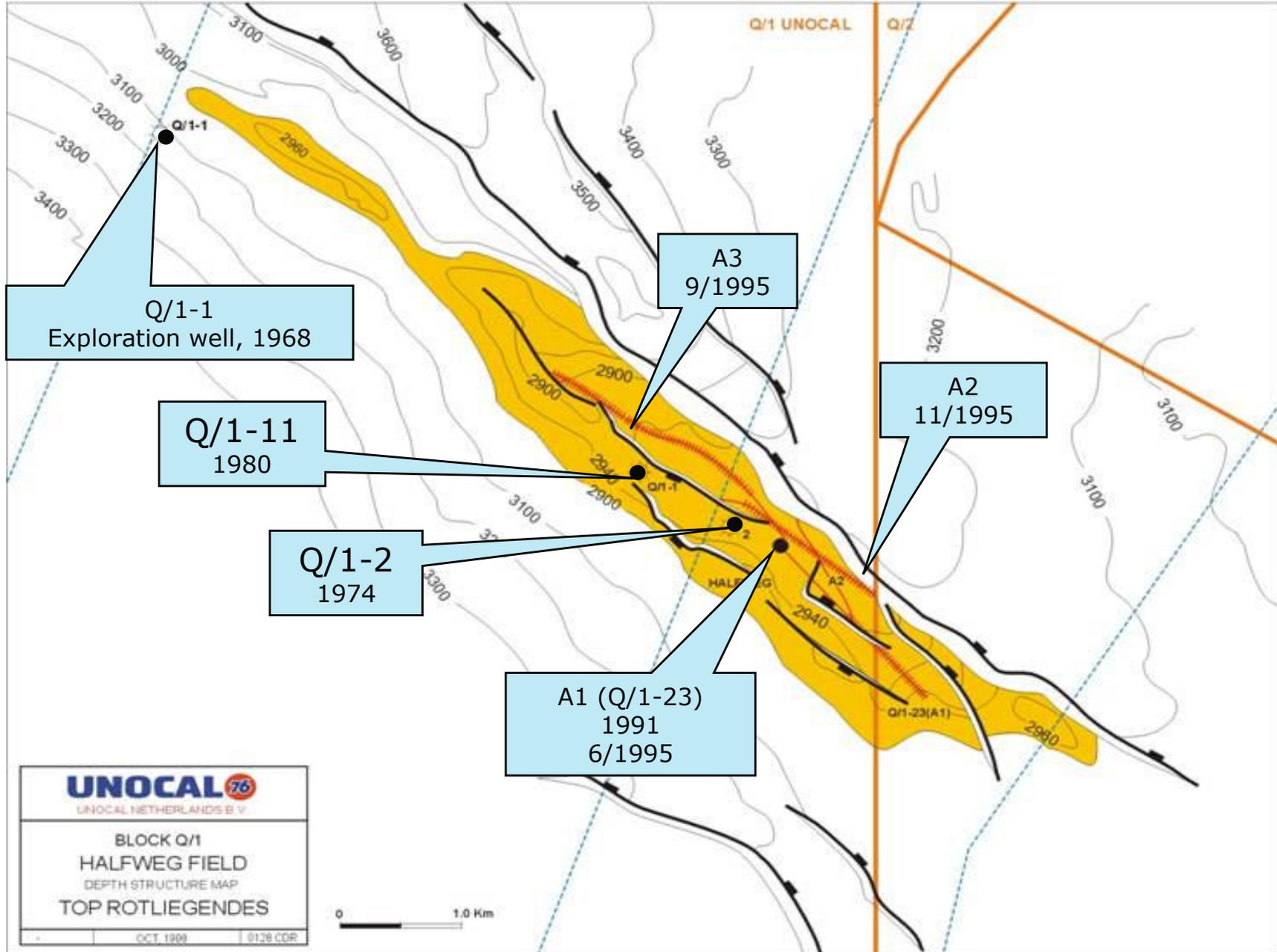
19 September 2006

Halfweg Field data

- Halfweg Gas field located 25 km west of Den Helder on boarder Q/1-Q/2
- Reservoir: Rotliegend Sandstone, southwest dipping fault block, 8 x 1.1 km, bounded by fault to the northeast side. 300 m thick sand. Maximum gas column 200m.
- Sandstone consists of foresets and bottomsets
- Permeability range results from flow tests 0.02 – 0.5 mD
- Three vertical wells and three horizontal wells drilled into the structure



Halfweg Top structure map

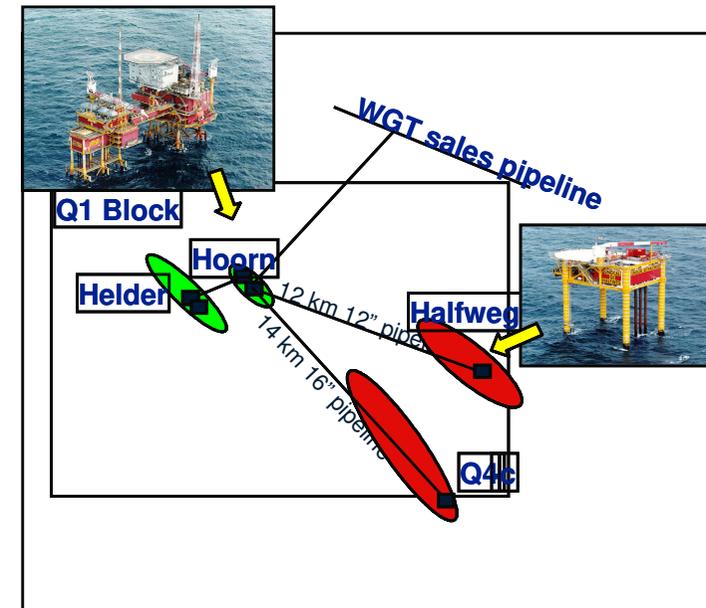


Halfweg Well test data

- Q/1-1 :
 - Welltest showed mainly water with gas shows
 - Based on these results, continued further appraisal
- Q/1-2
 - Welltest rates in the order of 1.9 MMscf/d [52Mm³/d]
 - Permeability in the order of 0.5mD
- Q/1-11
 - Welltest rates in the order of 0.9 MMscf/d [24Mm³/d]
 - Permeability in the order of 0.09mD
- Q/1-23 (A1)
 - Welltest economic rates that triggered the development of Halfweg

Halfweg facility layout

- Halfweg Satellite connect with 12 3/4" pipeline to Hoorn facility
- Water separation and processing takes place on Hoorn facility
- Three Halfweg wells produce via one manifold into pipeline
- Flowmeter and pressure gauge on Xmas tree per well
- Total gas flow metered at Hoorn
- Self installing platform to reduce installation cost



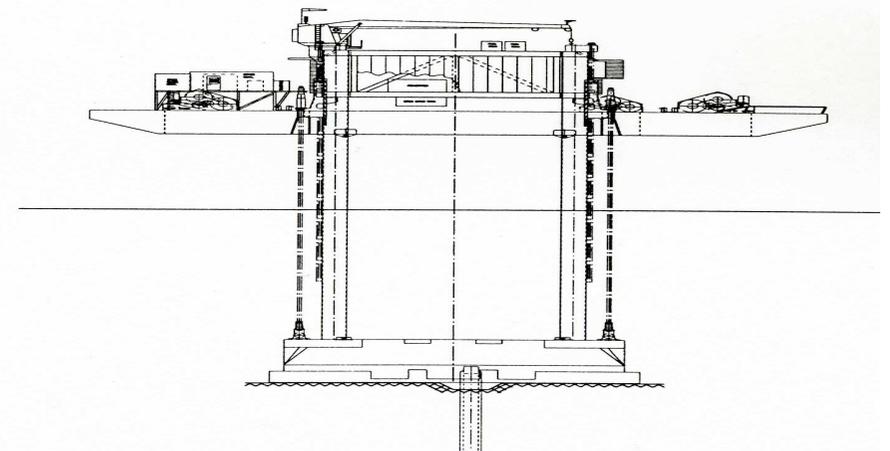
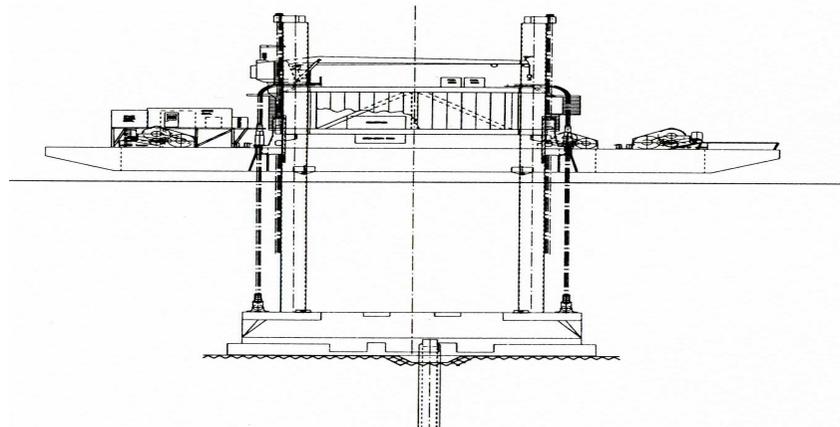
Halfweg facility



4 piles with two decks and concrete base

Towed on location
used barge to install structure

4 winches pulled deck (& barge) in position. Weight of barge was used to set enough load on seabed



Halfweg PVT data

Gas specific gravity = 0.664 (rel.to air)

$B_g = 236 \text{ scf/ft}^3$

Reservoir $P_i = 4549 \text{ psia @ GWC (313 Bara)}$

Reservoir Temp.= $231^{\circ}\text{F (110 }^{\circ}\text{C)}$

Dew point = $2700 \text{ psia (186 Bara)}$

Condensate / Gas ratio = $4.2 \text{ bbl/MMscf (ini.tests)}$
 $(0.025 \text{ m}^3/\text{Mm}^3)$

Formation water SG = 1.06

Halfweg Reservoir: Details

- Three reservoir units A, B, C
- Large transition zone (>150m)
- Interdune beds act as permeability barriers
- Foresets and bottomsets result in low vertical permeability
- Condensate drop out near wellbore

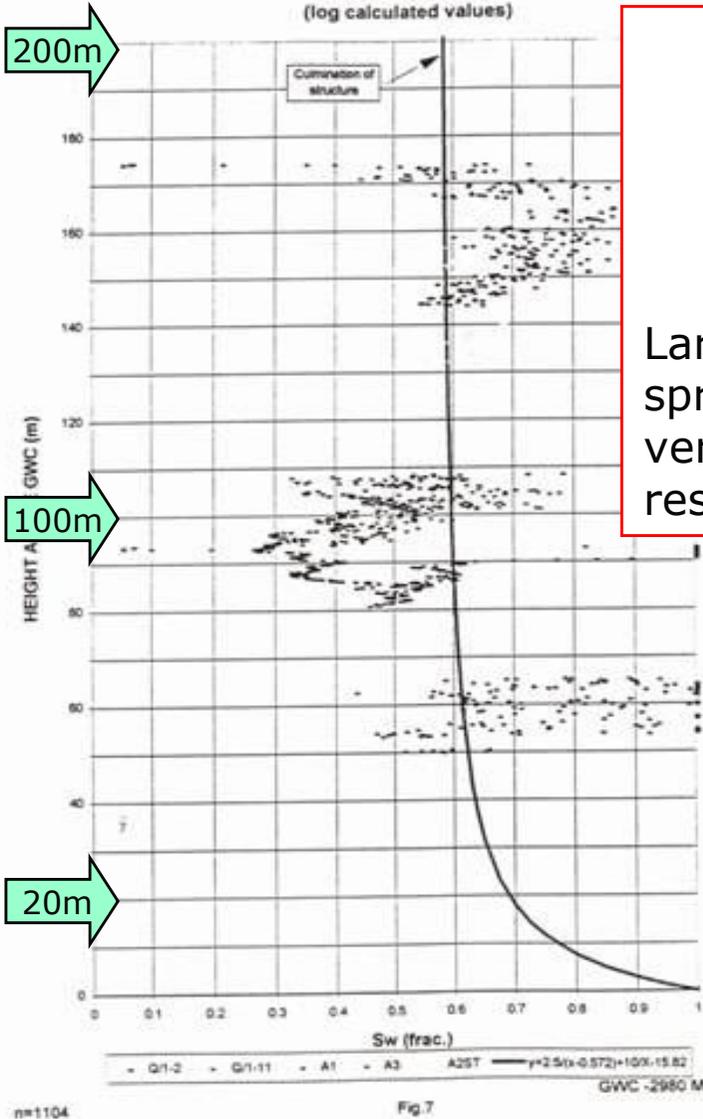
Unit	A	B	C
Thickness	18-30m	60-110m	Remaining, mainly below GWC
Porosity	11%	15-19%	14-16%
Permeability	<0.5mD	<1mD	0.5 < K < 5mD
Sw	60%	45%	55-100%

Halfweg Transition zone

Halfweg A unit

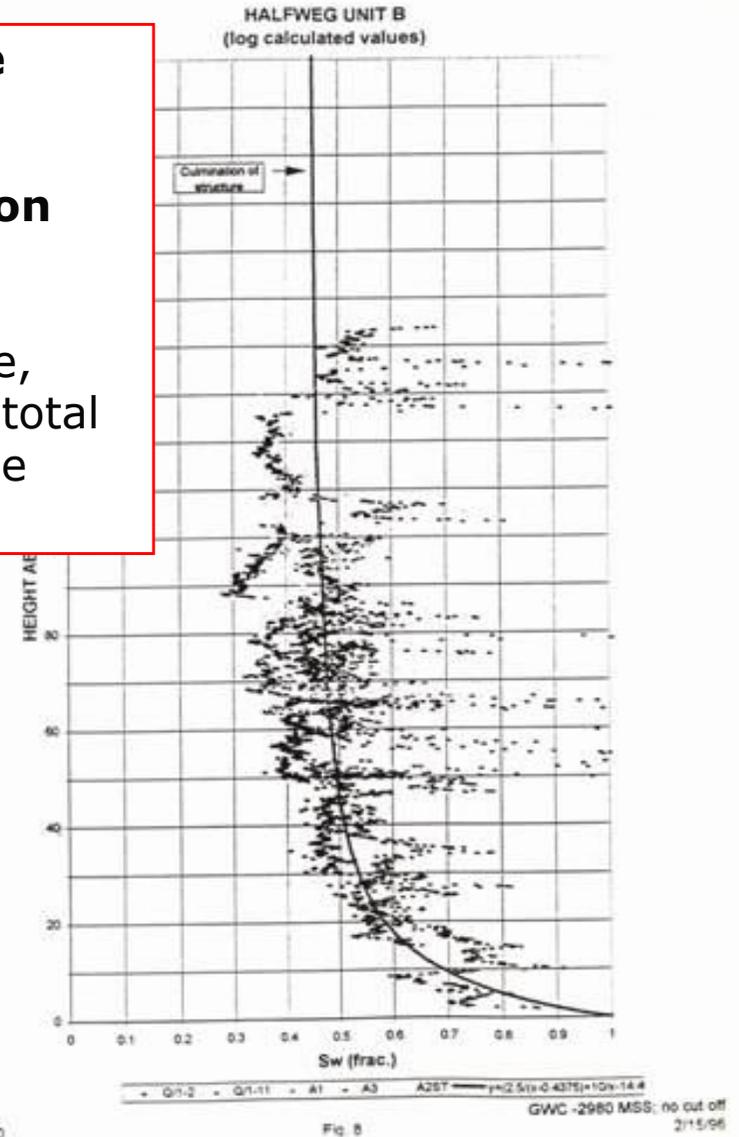
Halfweg B unit

Meter above GWC

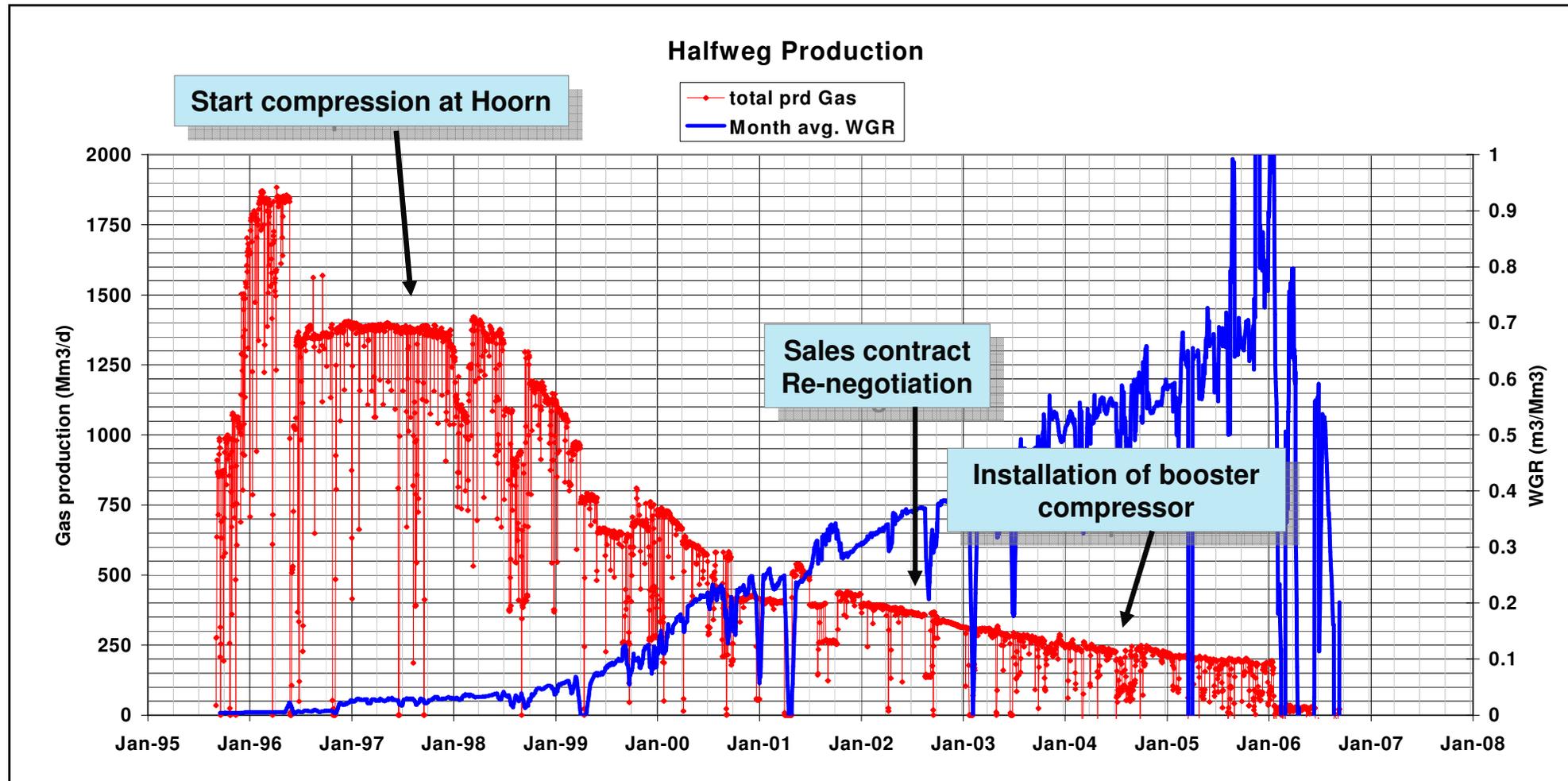


Height above GWC versus Water saturation

Large transition zone, spread out over the total vertical section of the reservoir.

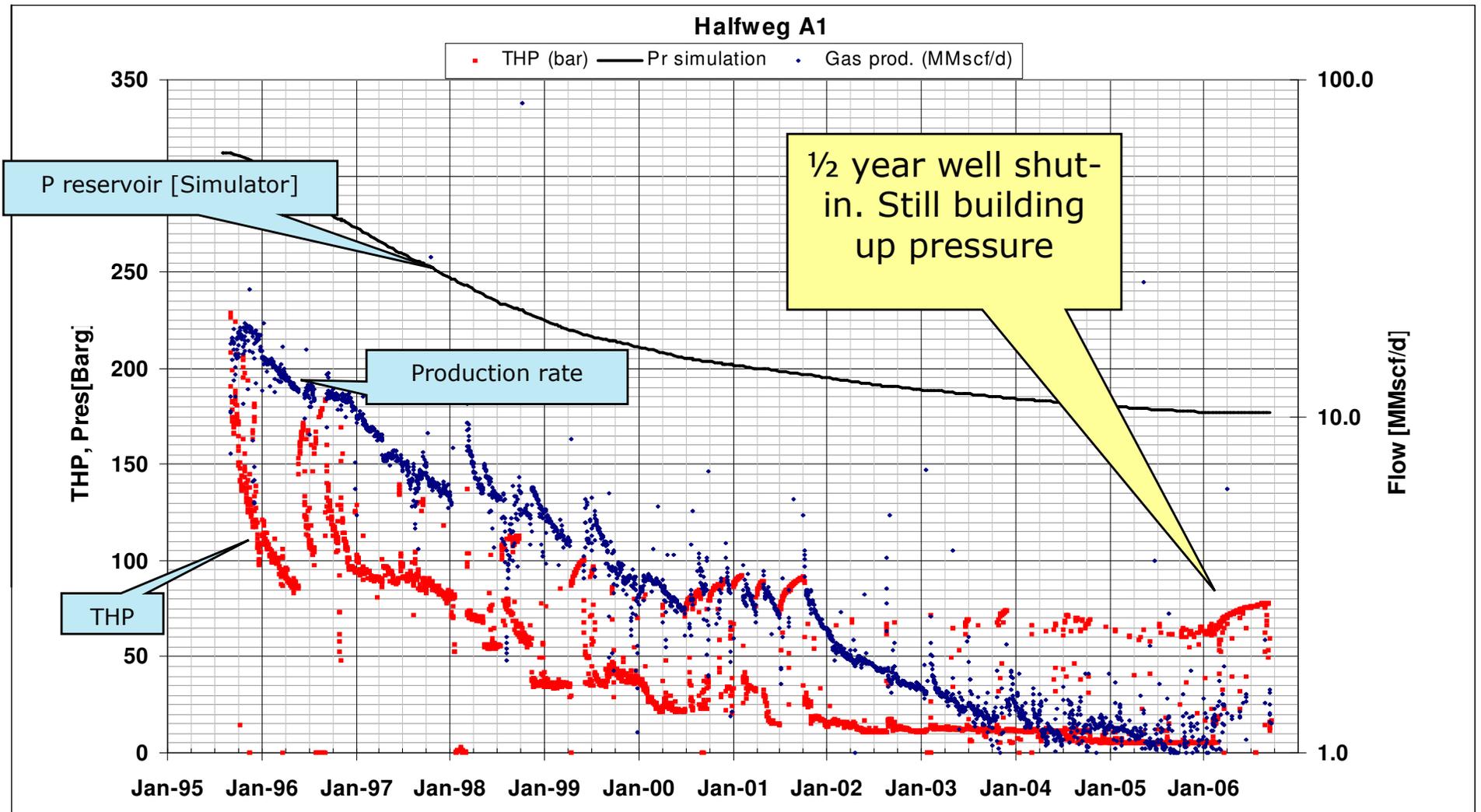


Halfweg production behaviour

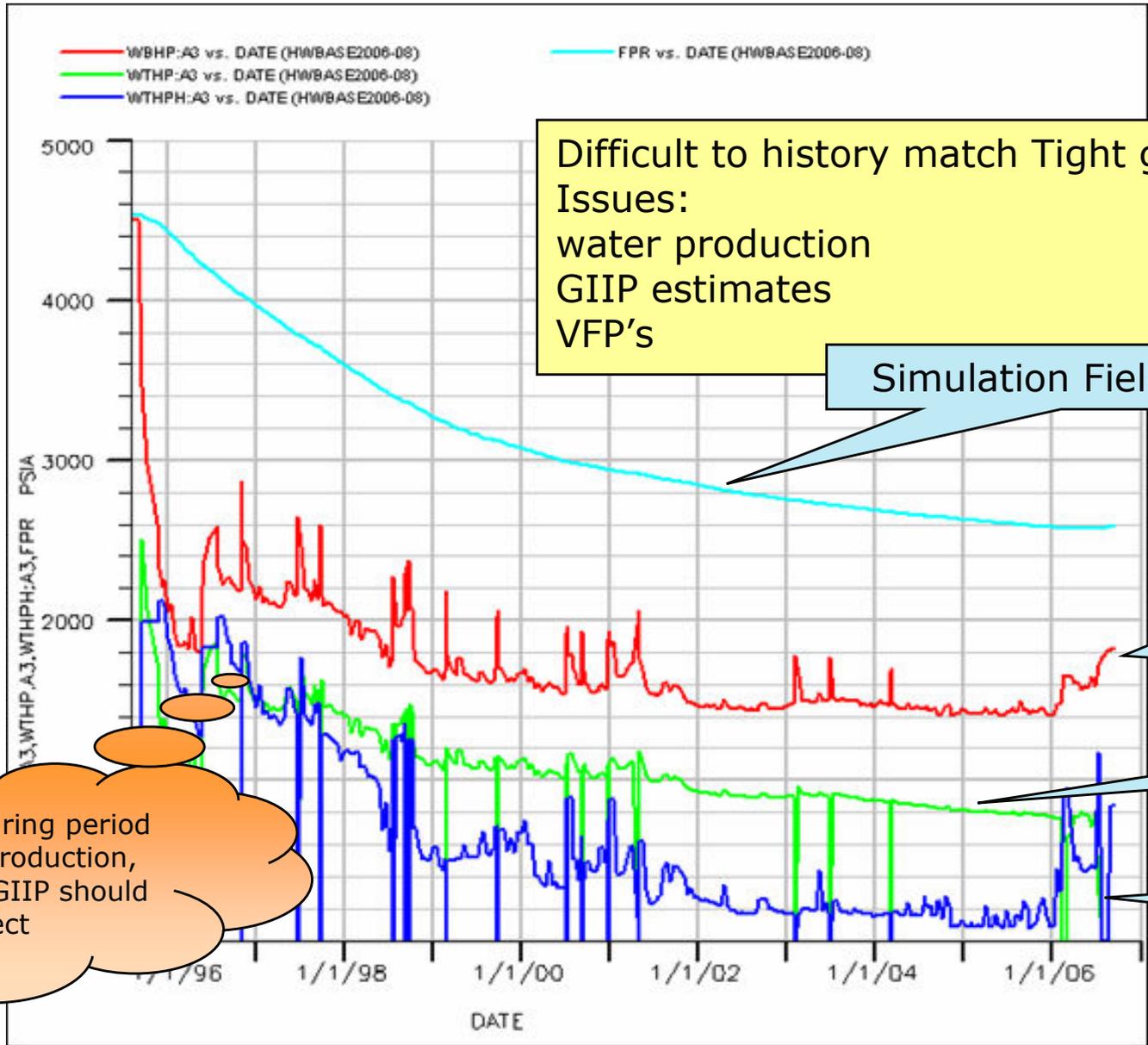


- 1997 Start compressor at Hoorn
- 2002 re-negotiated sales contract
- 2003 Booster compressor at Halfweg

Halfweg Long Pressure build-up



Halfweg simulation work



Difficult to history match Tight gas fields.
 Issues:
 water production
 GIIP estimates
 VFP's

Simulation Field Pressure

Simulation BHP

Simulation THP

History THP

Match on THP during period with no water production, indicating that GIIP should be correct

Success and issues of Halfweg

Success

- Horizontal wells that can produce at economical rates
- Installation of a simple small satellite fit for purpose, to reduce capital cost

Issues

- Difficult to collect reservoir data during production life of the field
 - No downhole pressure data
 - No individual well production test data
- Limit access due to small platform / crane