Detection of shallow gas from gas-field projects offshore Norway

(or shallow gas in glacial sediments)

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presented by Philip Ringrose, Statoil/NTNU

2nd Combined Meeting of the Modelling and Monitoring Networks
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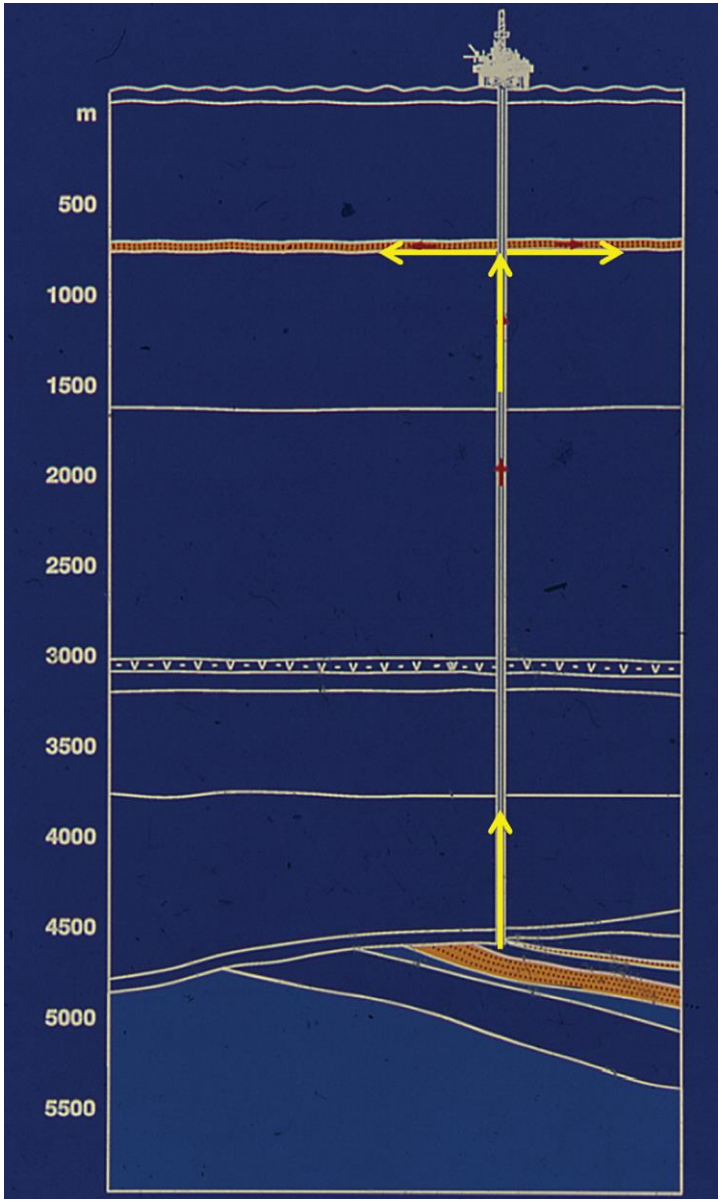
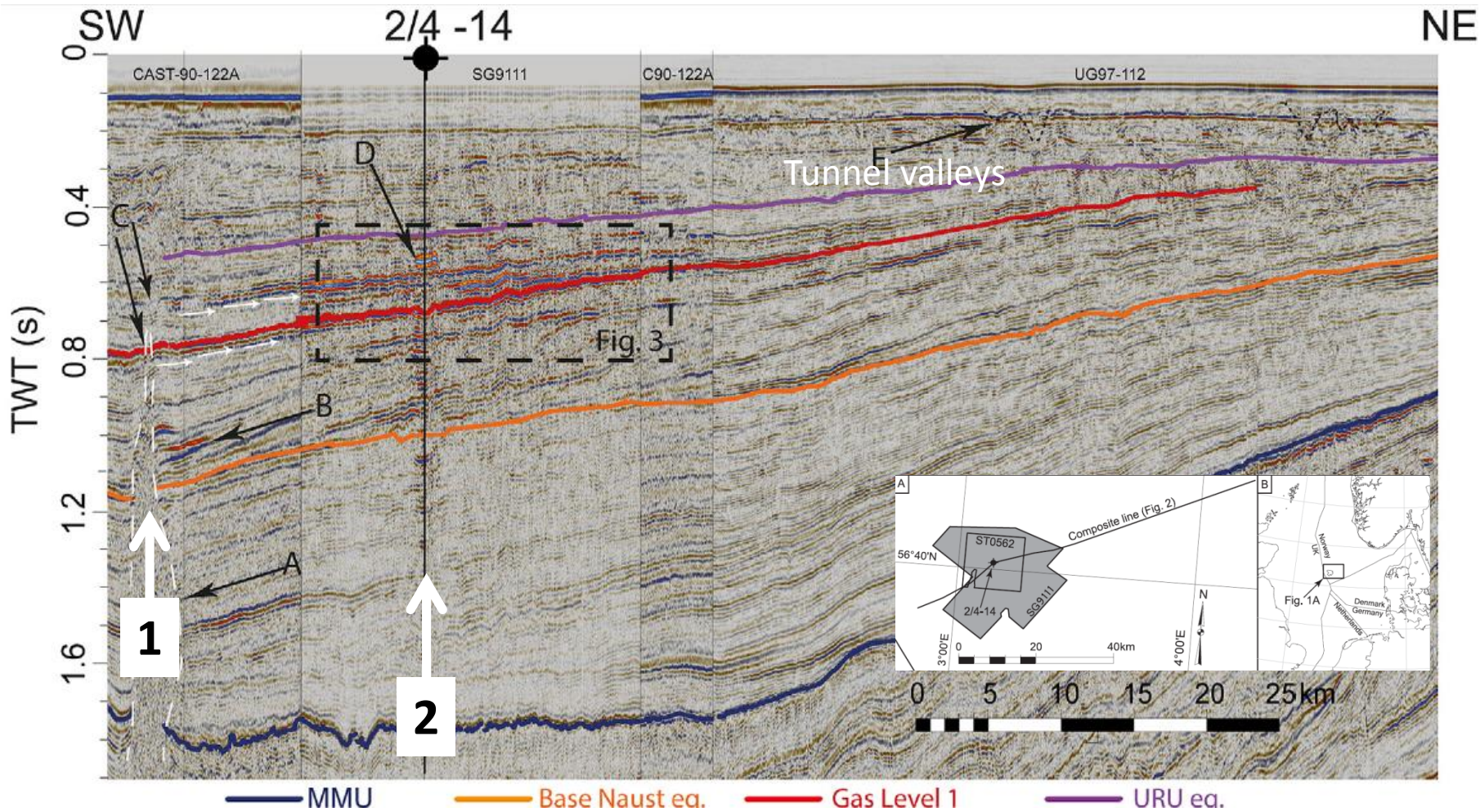
History and context

- In 1989, exploration well 2/4-14 developed a blowout that lasted for 326 days
  - Southern North Sea, Saga Petroleum
- Blowout eventually stopped using high-density drilling mud.
- Shallow seismic used to monitor the blowout
  - 10 surveys during and after the blowout
- In 2009, some of the 2D lines were repeated
- Gives a valuable case study on migration and detection of shallow gas
- Most of the gas appears to remain in the same shallow layers as in 1990
  - some lateral gas migration observed
- Reported in several papers:
  - Landrø, 2011
  - Langseth & Landrø, 2012



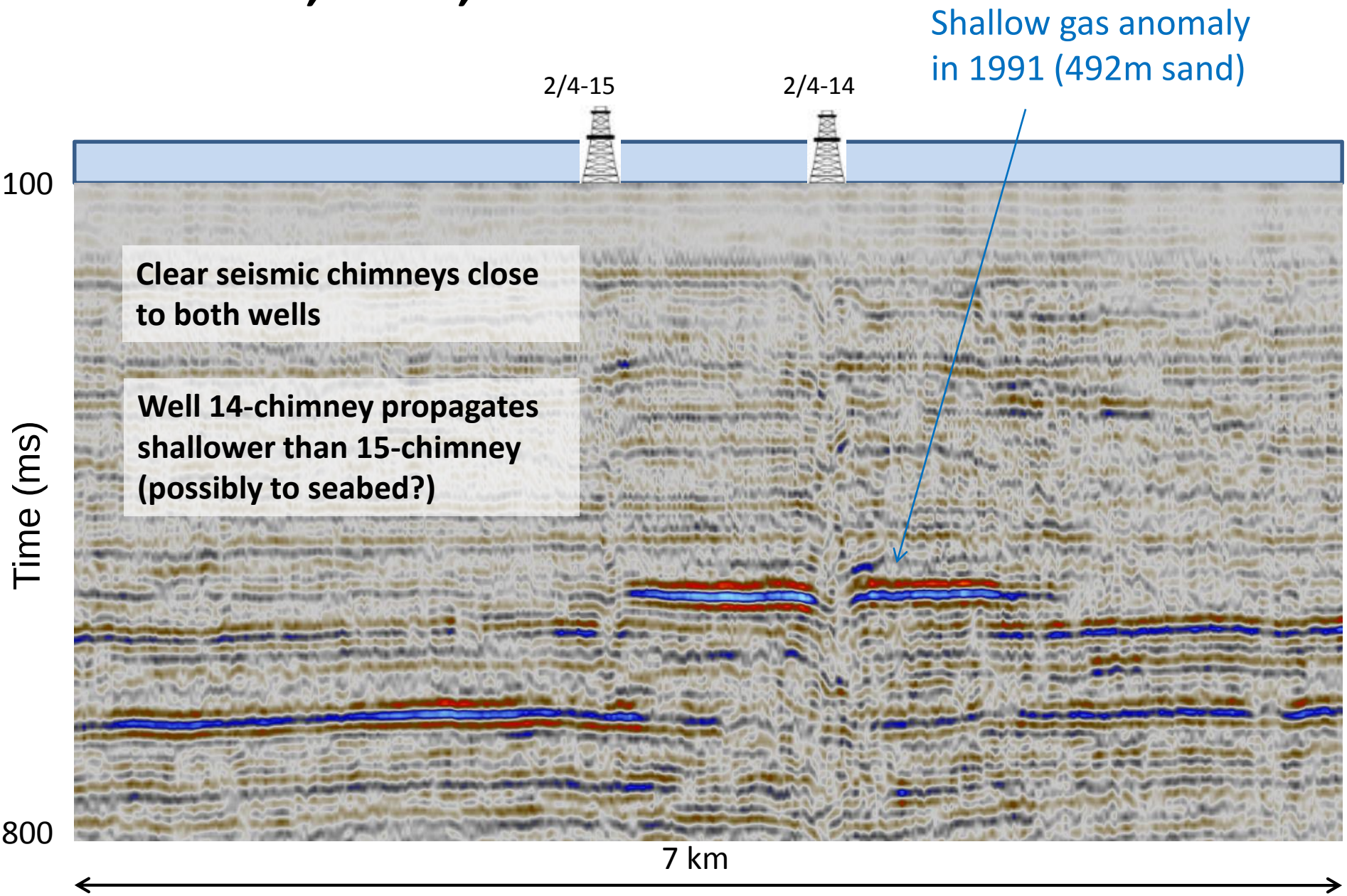
Long random line through the blowout well



Haavik and Landrø 2014, Quarternary Science Reviews, 103

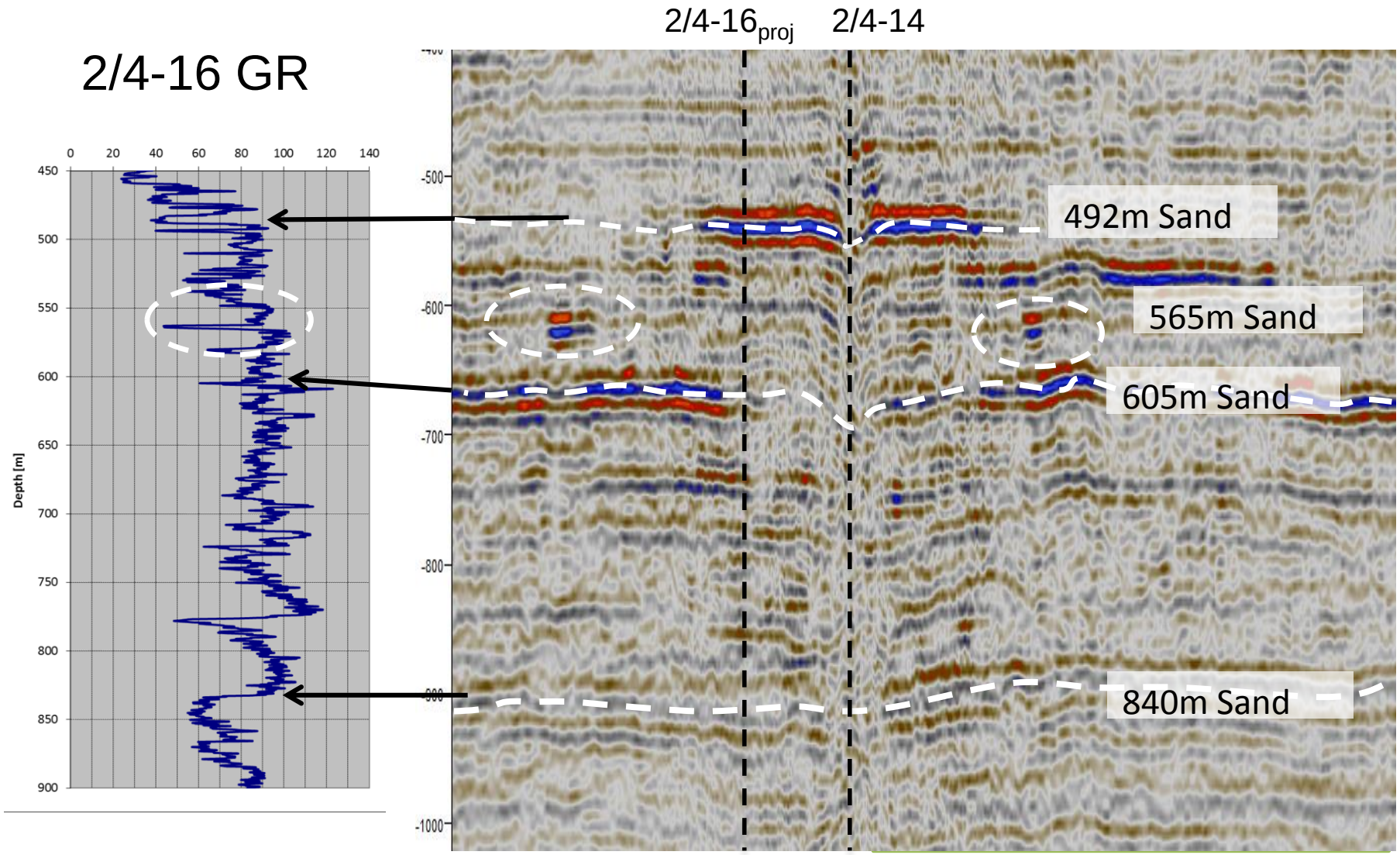
Two sources for shallow gas accumulation: 1 and 2 (1989)

3D seismic, 1991, random line

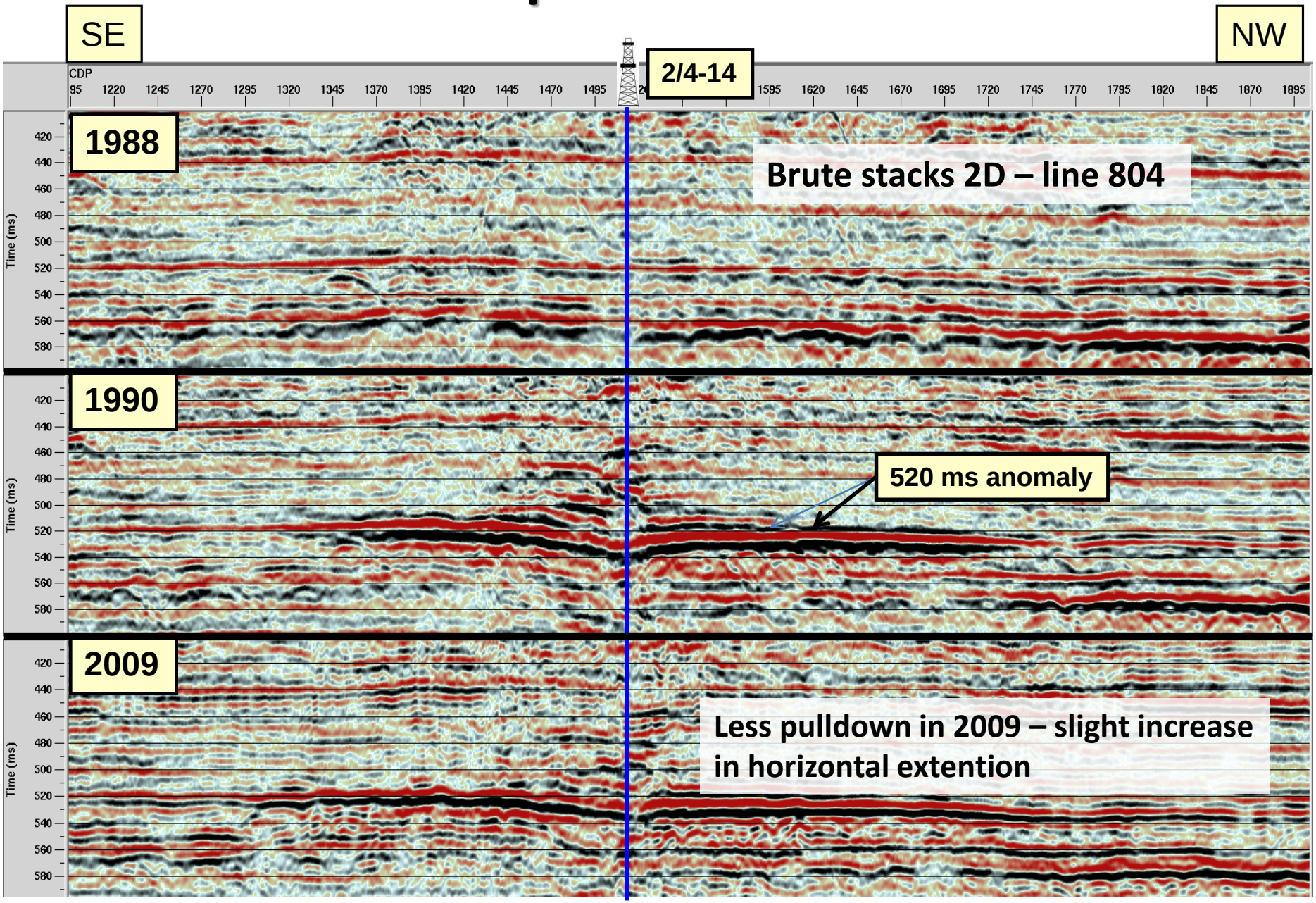


Sand layers and shallow gas

605m layer gas was observed in well data but no gas encountered in the 492m and 828m sands



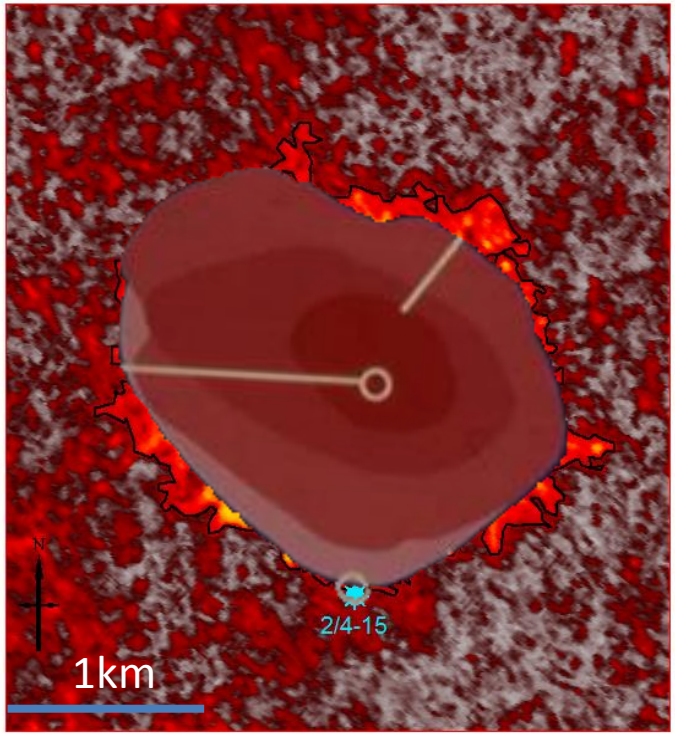
Time-lapse effects in 2009



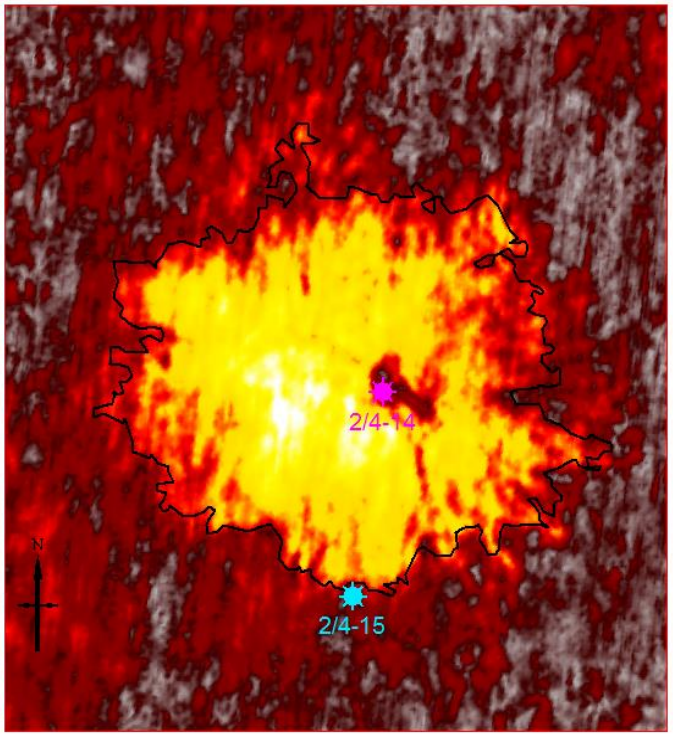
Gas in the 492 m sand (3D and 2D)

Amplitude extraction in 24 ms window centered on horizon

Overlay show interpretation by Saga based on 2D site survey data prior to the 1991 acquisition of the 3D data – a remarkably good fit!

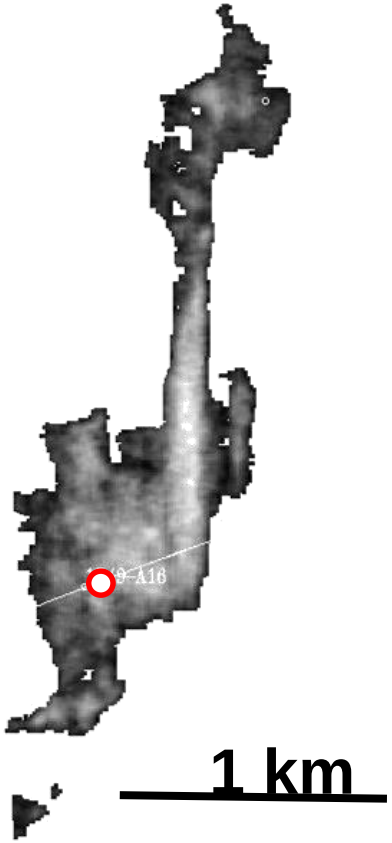


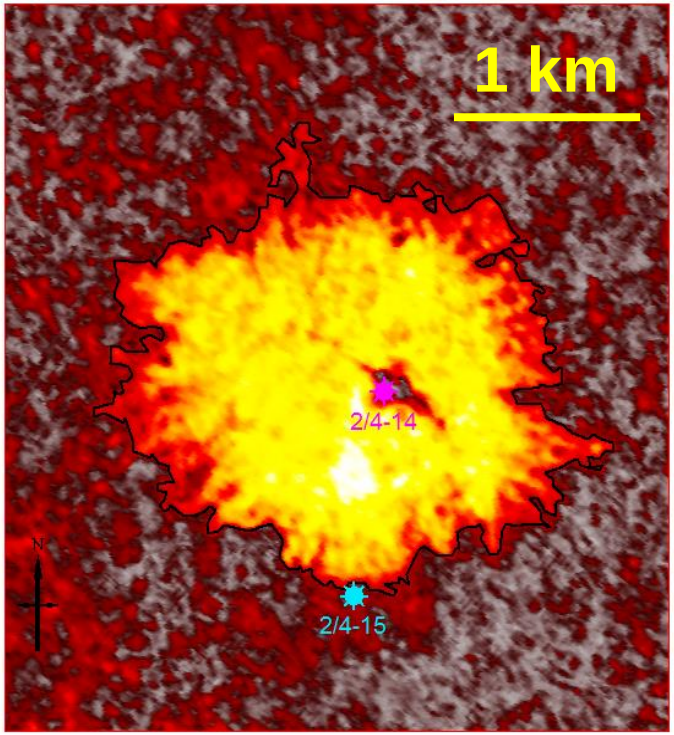
1991 (2 years)



2005 (16 years)

Comparing Sleipner CO2-plume (upper layer) and shallow gas leakage from the 2/4-14 blow out in 1989

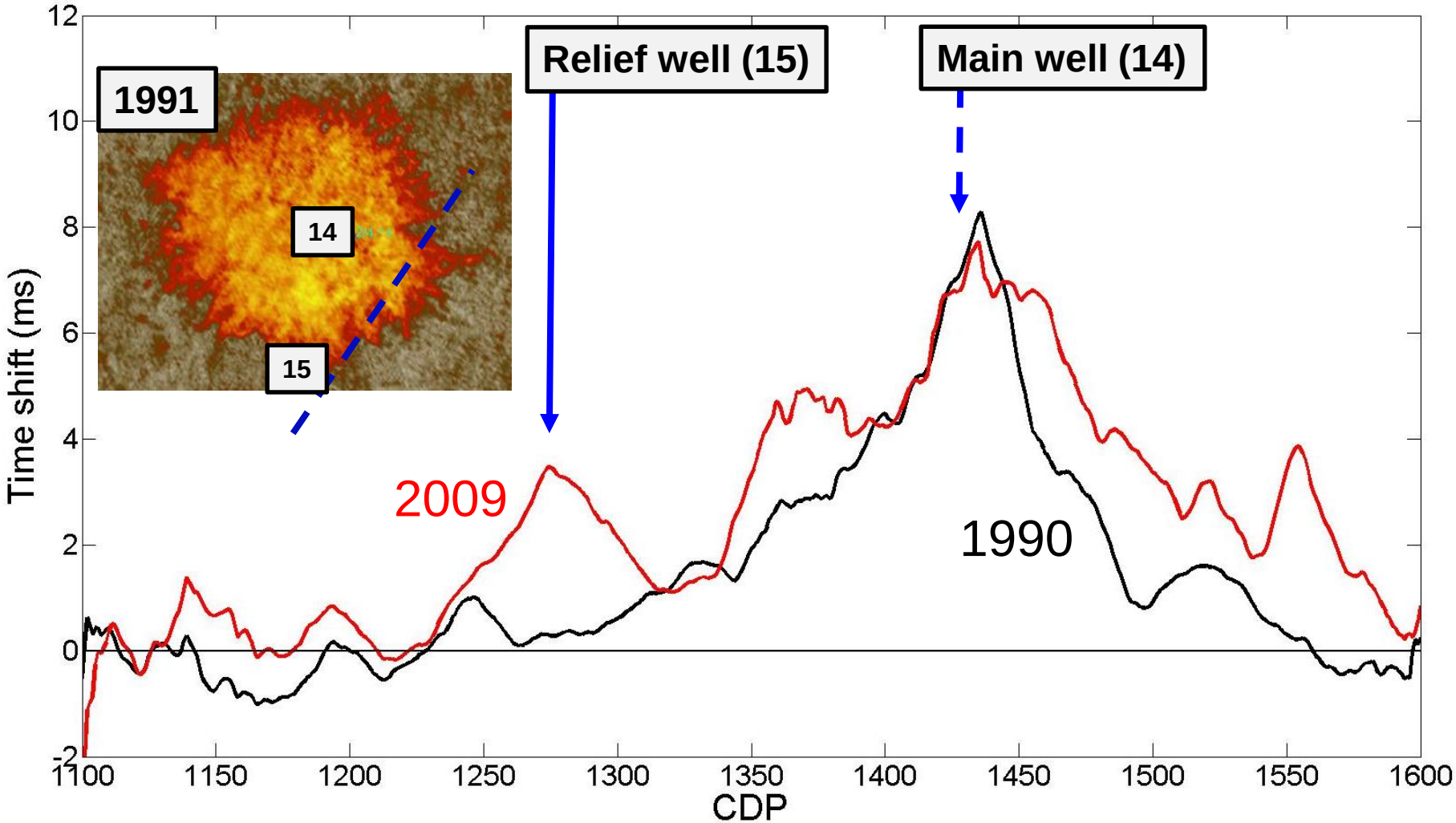




Low pressure => plume dominated by top structure – 800 m depth

High pressure => circular plume – not dominated by structure – 490 m depth

Smoothed timeshifts – line 602 (upper sand)



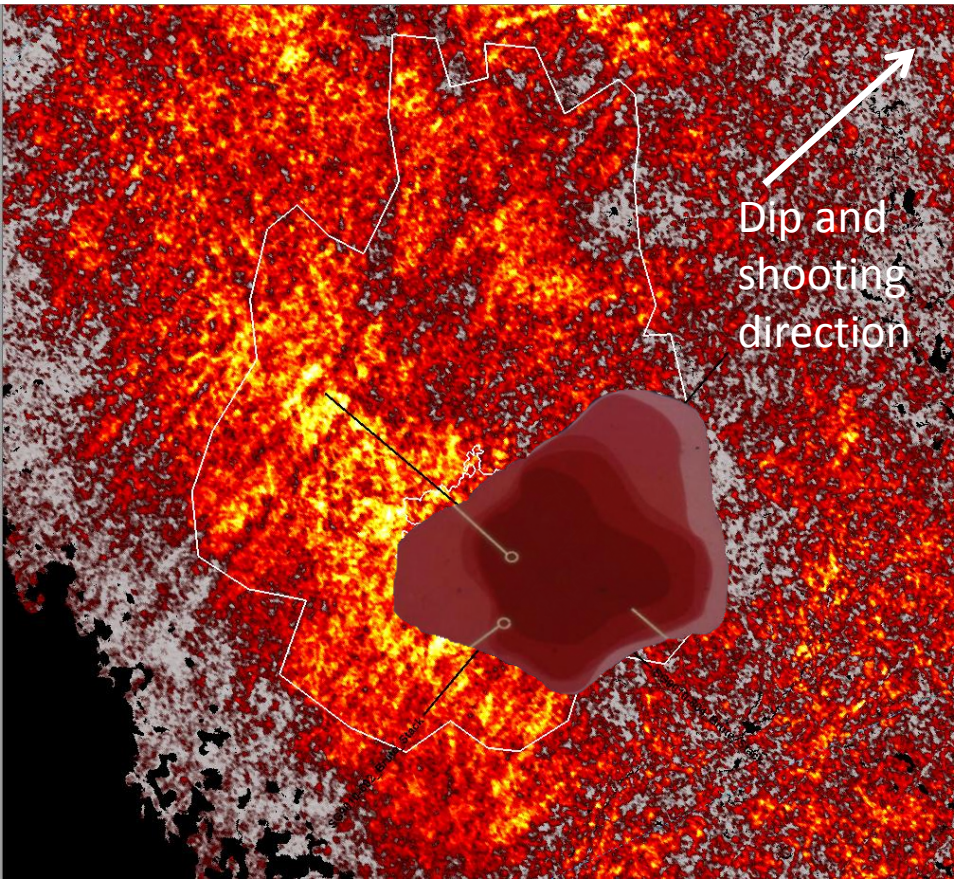
Significant time shift increase close to relief well between 1990 and 2009

Gas in the 840 m sand

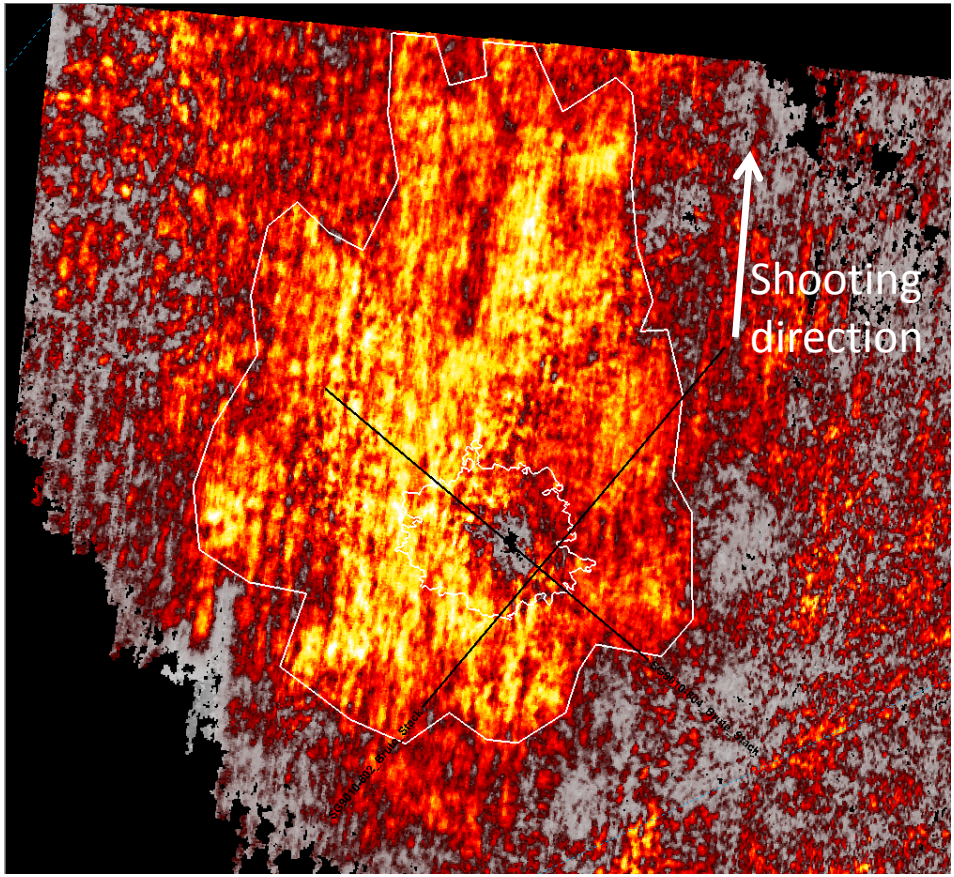
Amplitude extraction in 24 ms window

Overlay show interpretation by Saga based on 2D site survey data prior to the 1991 acquisition of the 3D data – underestimated plume extent

1991 (2 years)

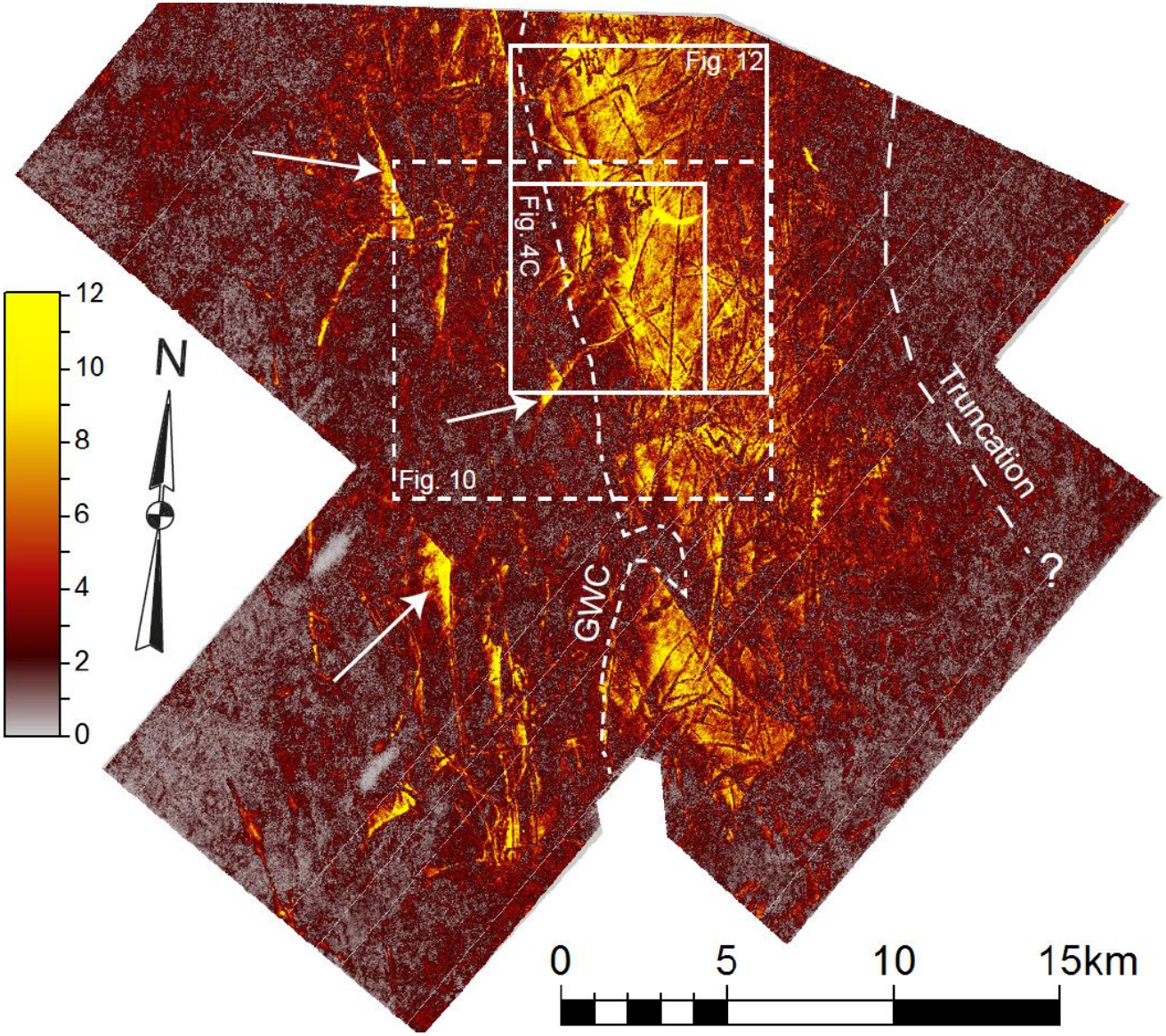


2005 (16 years)

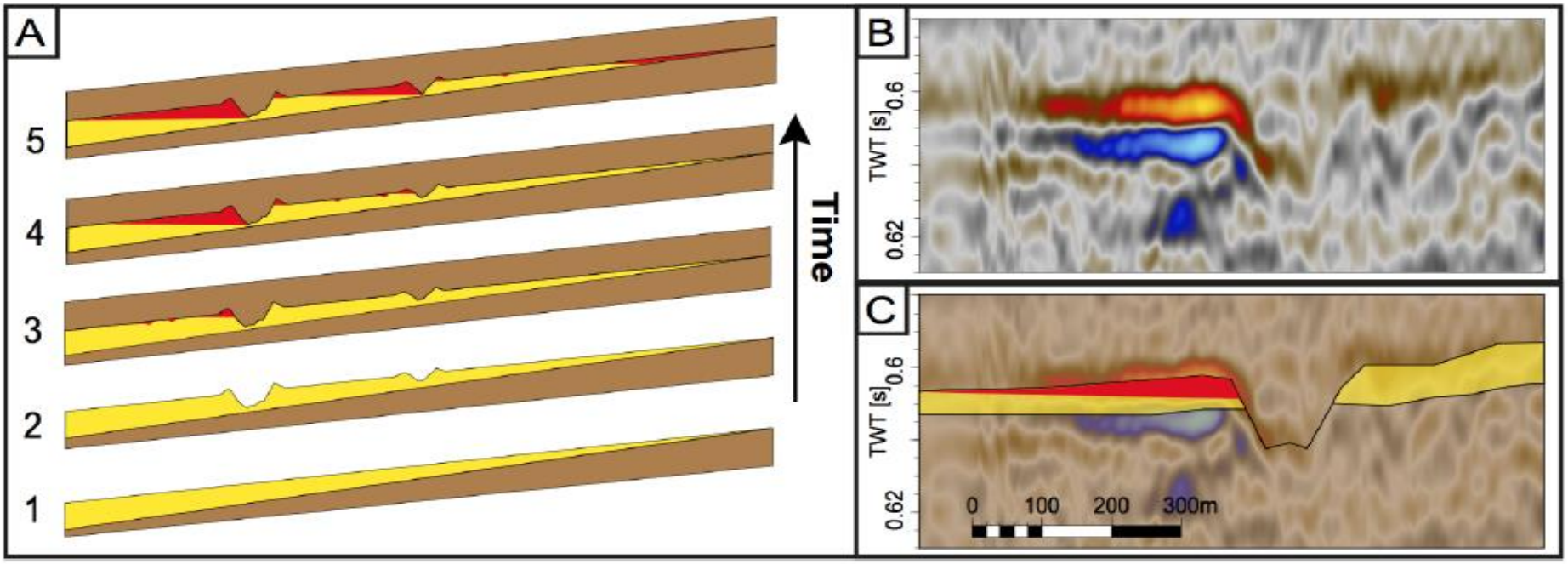


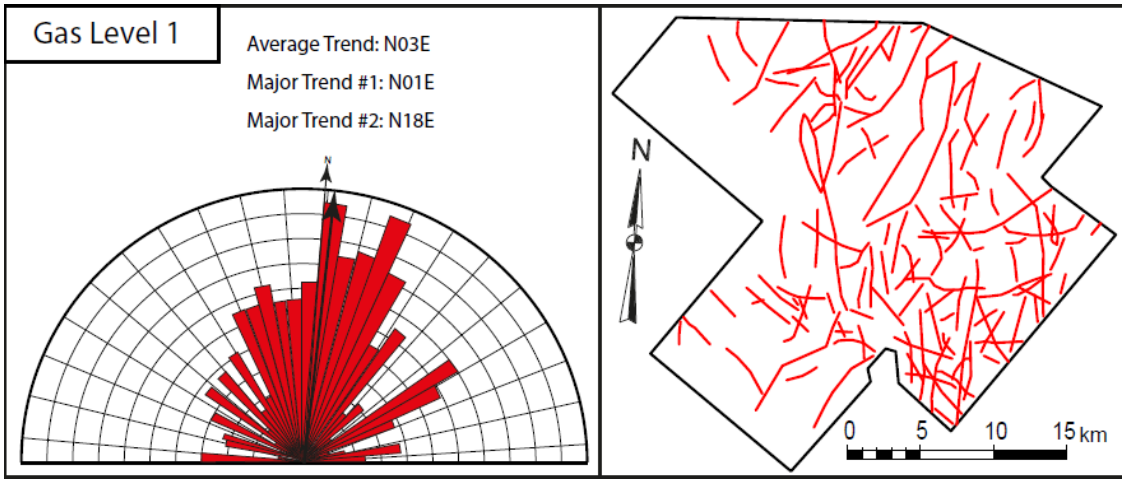
Overburden monitoring: Amplitude map

Top of 10m thick sand @ 600 m depth – brightening caused by shallow gas



Ice scours create traps when the intersect dipping layers

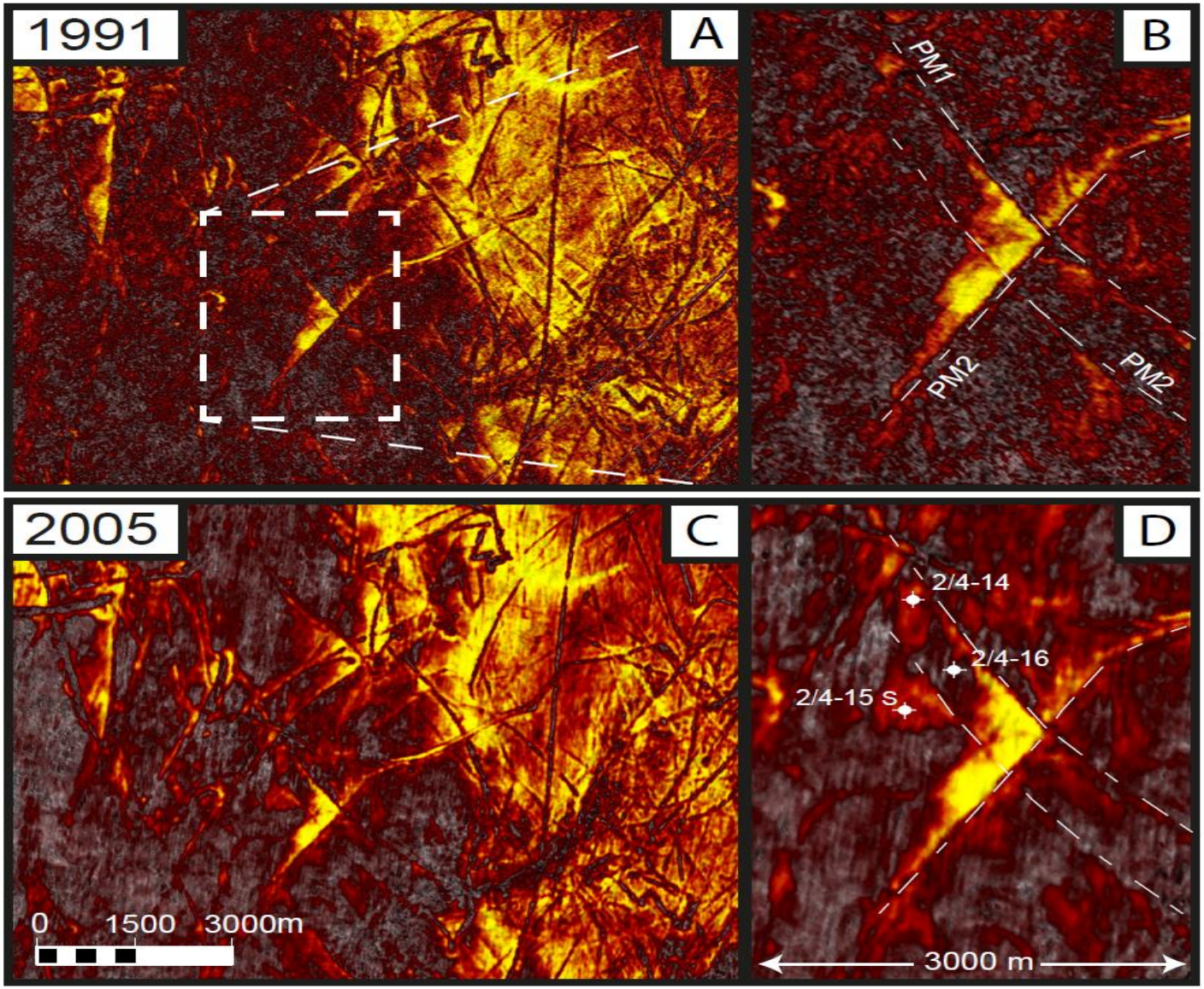




Ice scours orientation to North, sand layer dipping to West => perpendicular directions

Haavik and Landrø, 2014

4D effects: gas movements in overburden

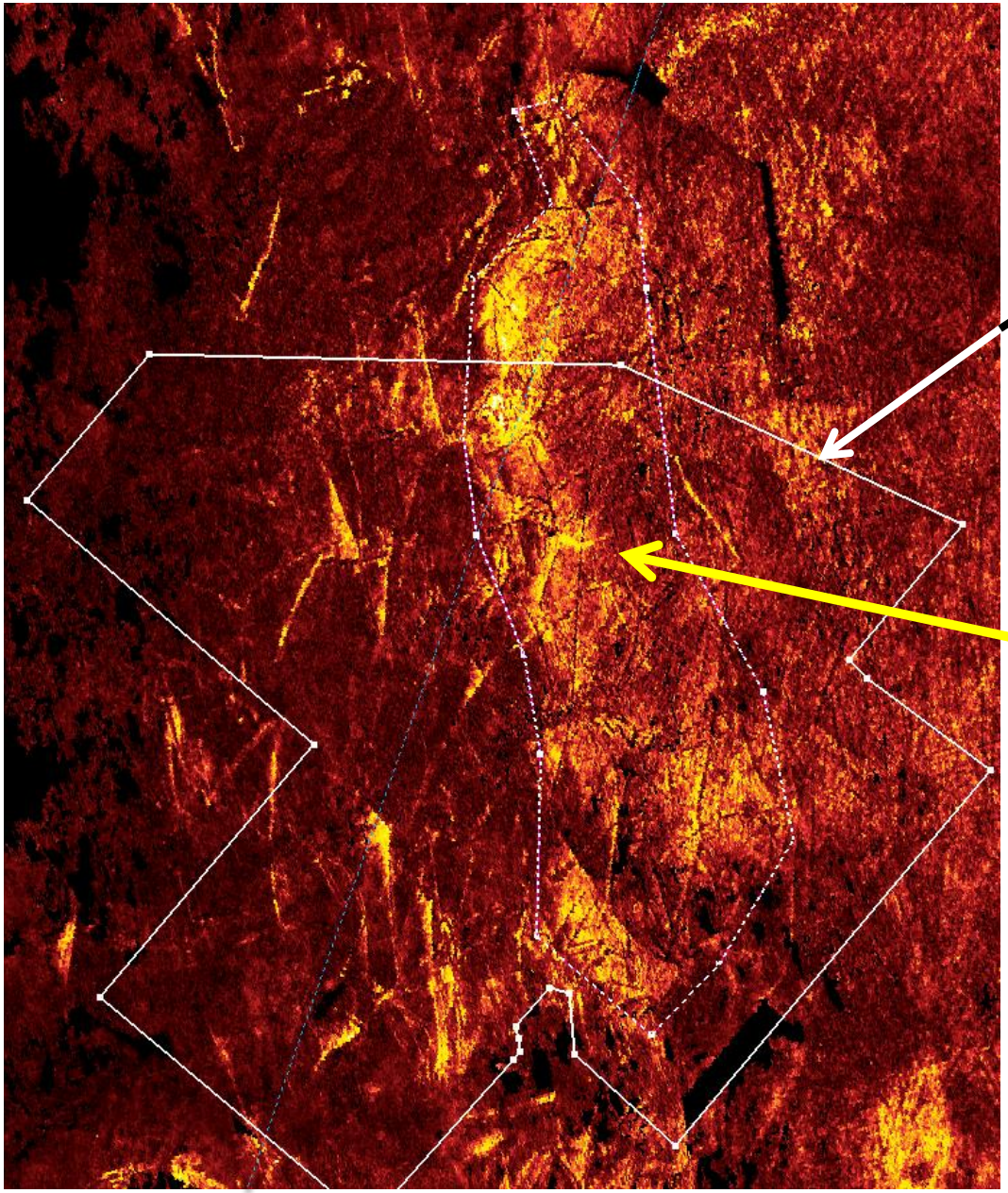


Blowout: 1989

Gas has migrated into new sandlayers between 1991 and 2005!

Haavik and Landrø, 2014

Using several merged 3D surveys

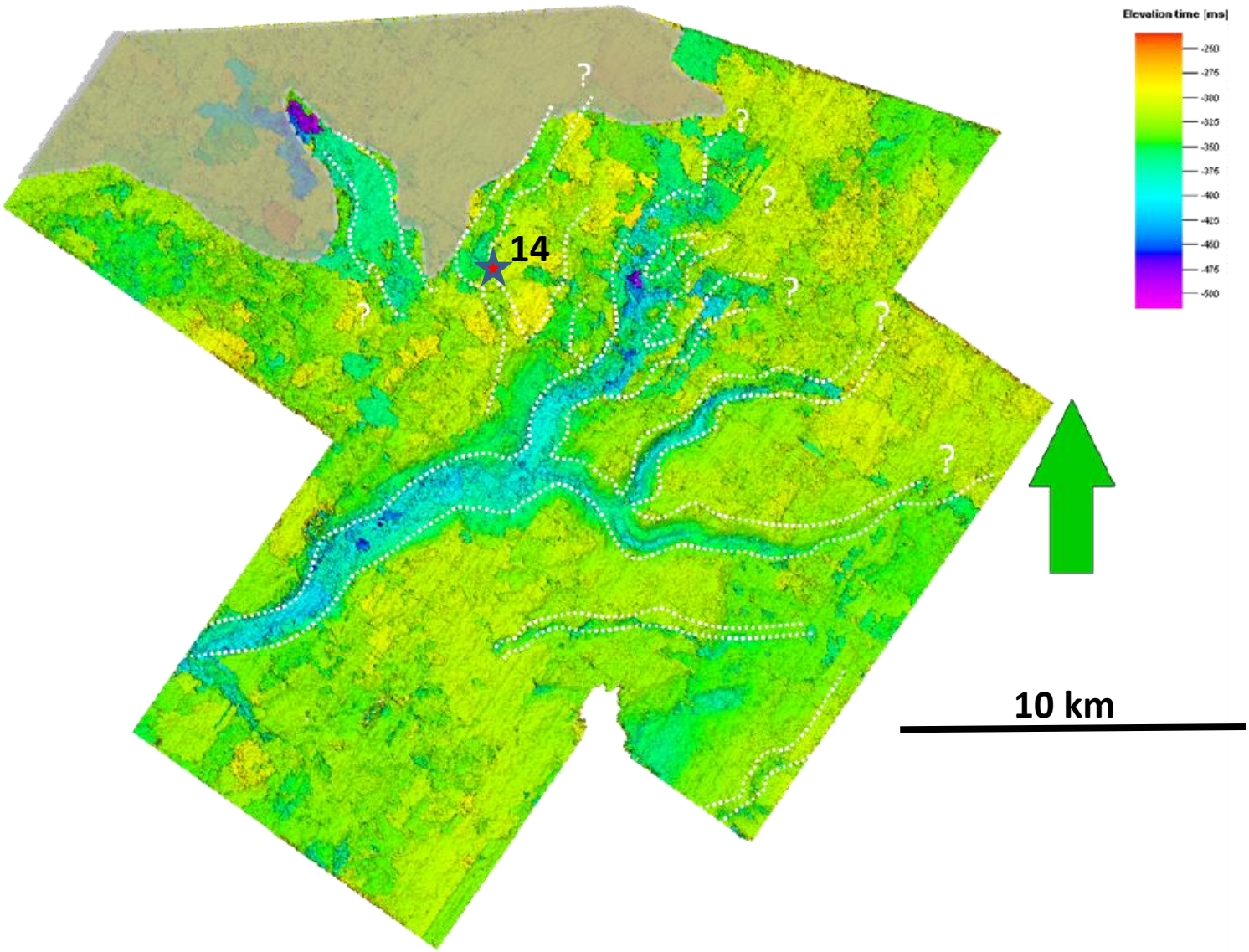


1991 3D survey

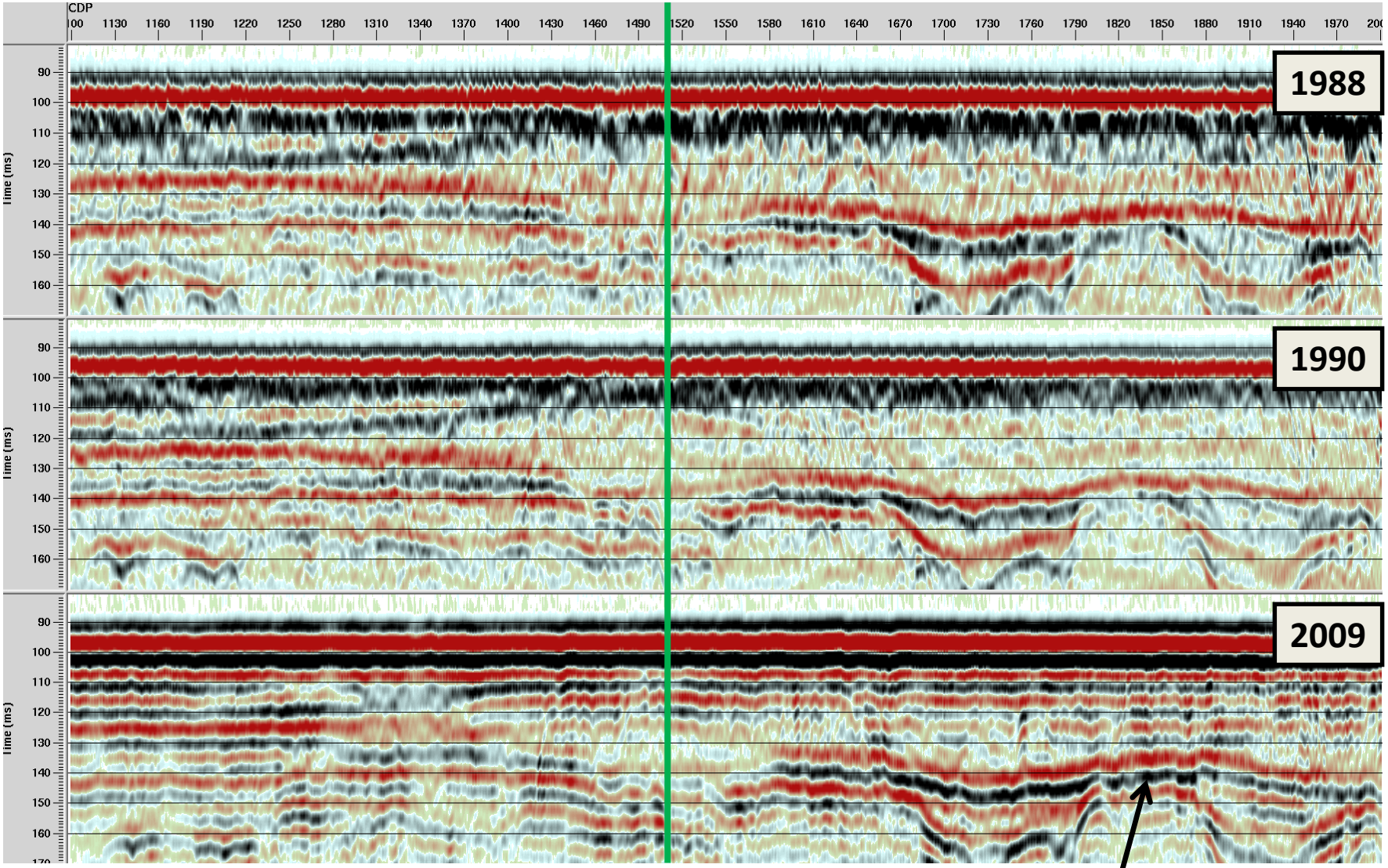
Area = 214 km^2

Interpreted tunnel valleys

250-300 m depth close to 2/4-14 (Kjetil Haavik's MSc)



Line 804: searching for gas effects close to seabed

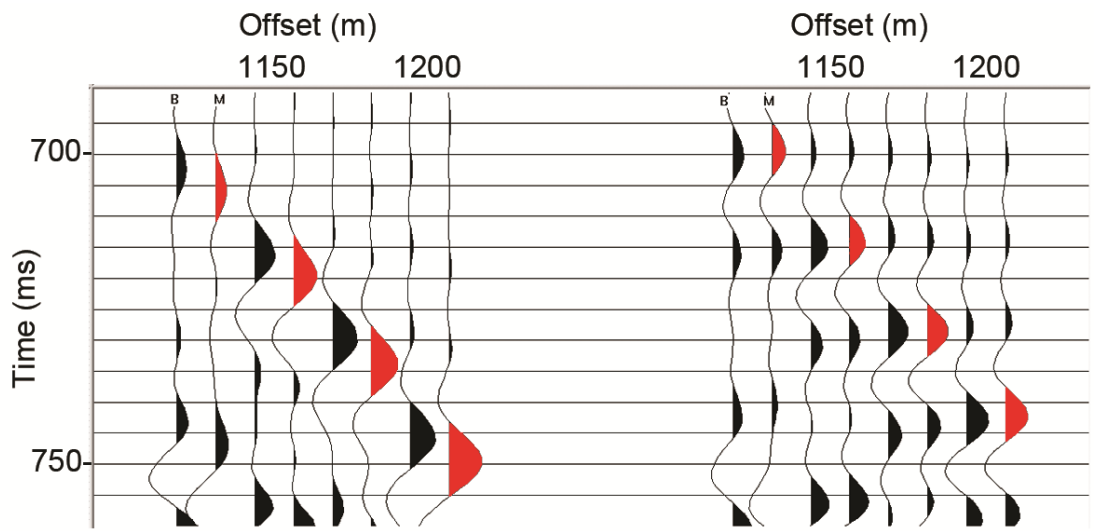


Brighter tunnel valleys in 2009 – due to gas?

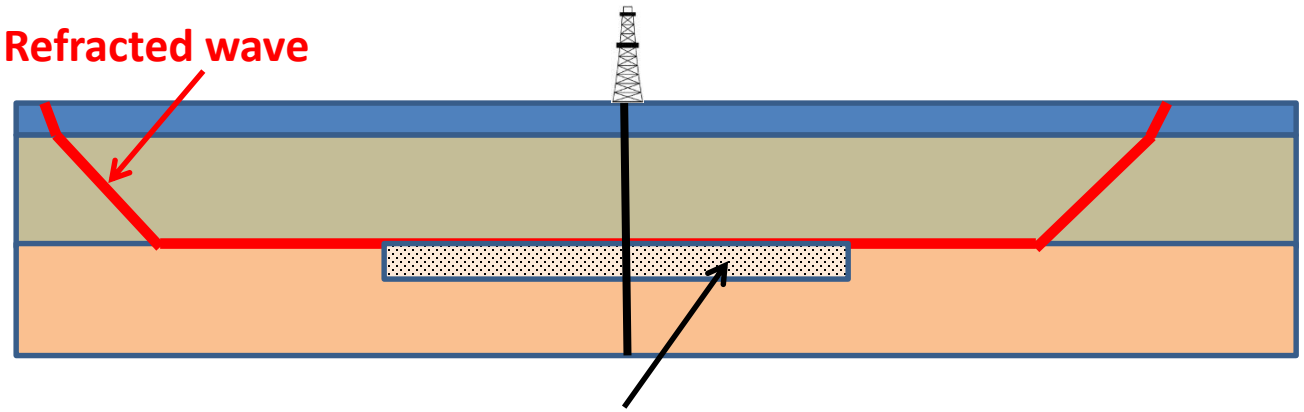
4D refraction timeshift analysis

Ref.: H. Mehdi Zadeh and M. Landrø, Geophysics 2011

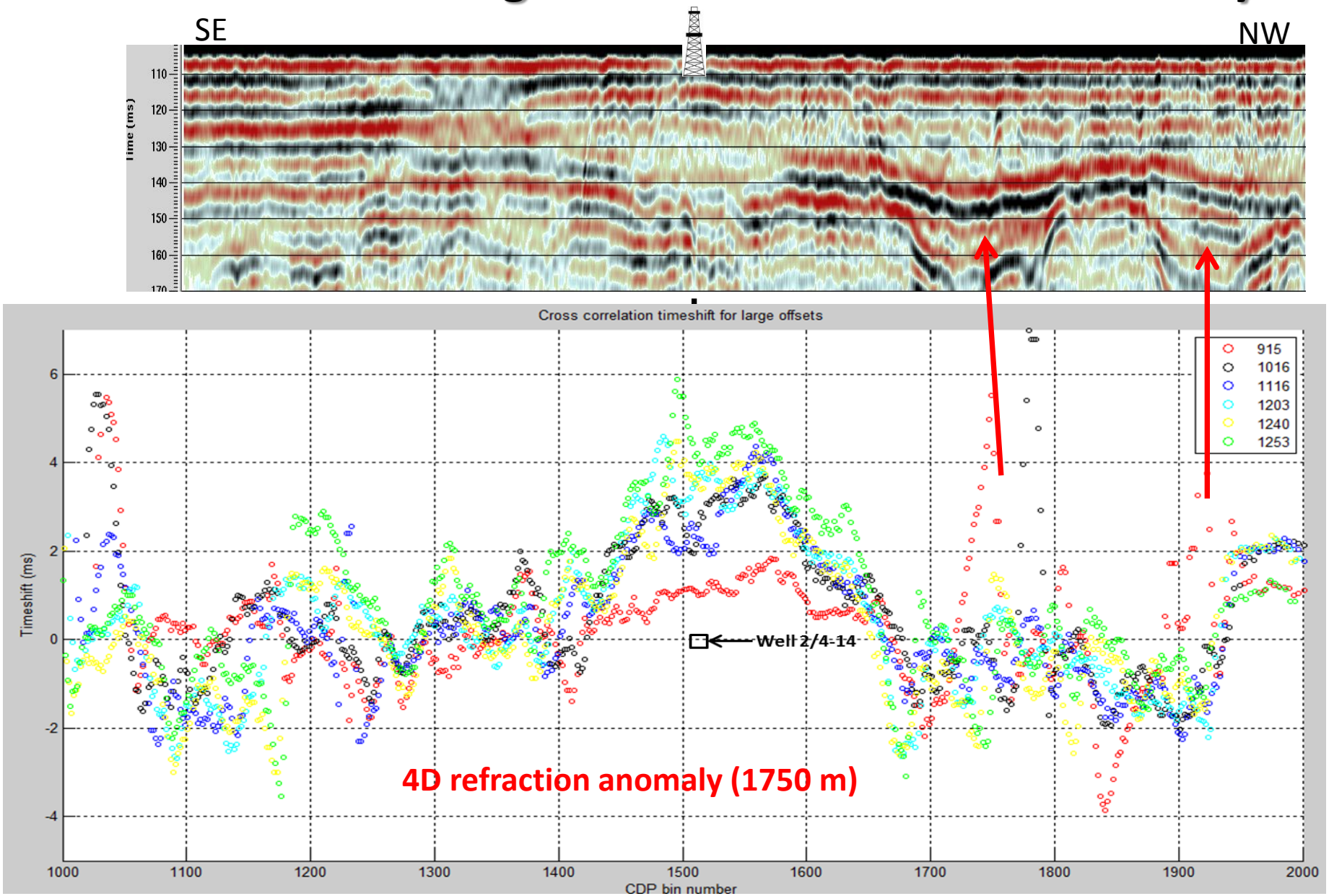
Close to well **Away from well**



Field data



Time shift refraction signal associated with tunnel valleys?



Discussion

- Both naturally occuring gas and gas from the blowout are present in the shallow gas layers
- Shallow sand layers are major recipient of gas leakage from below, and serve as an extra buffer against leakage to the surface.
- The gas in the 492 m sand layer has not moved much between 1991 and 2005
- Ice scours create small traps for shallow gas
- Tunnel valleys might act as storage volumes and transport routes

Acknowledgments

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- ML thanks the Norwegian Research Council for financial support.

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