

Time-lapse changes within Groningen gas field caused by reservoir compaction and distant borehole drilling

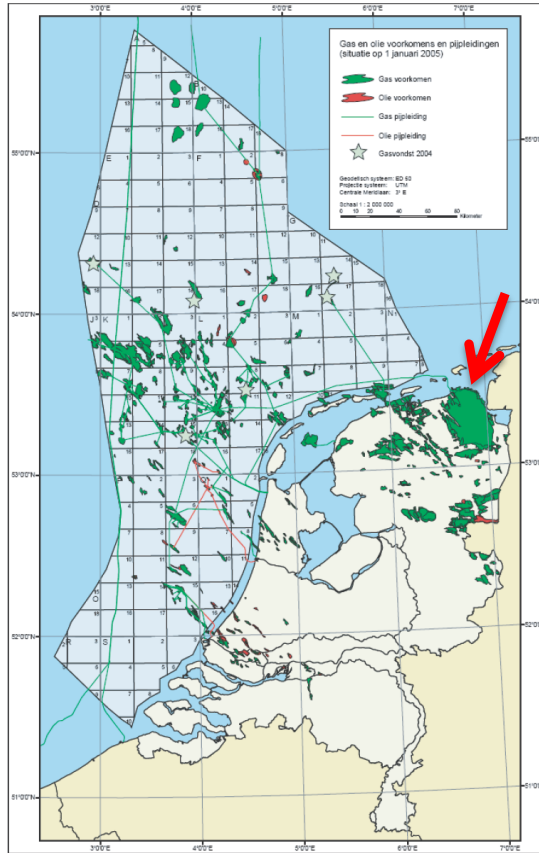
Hanneke Paulssen

Wen Zhou

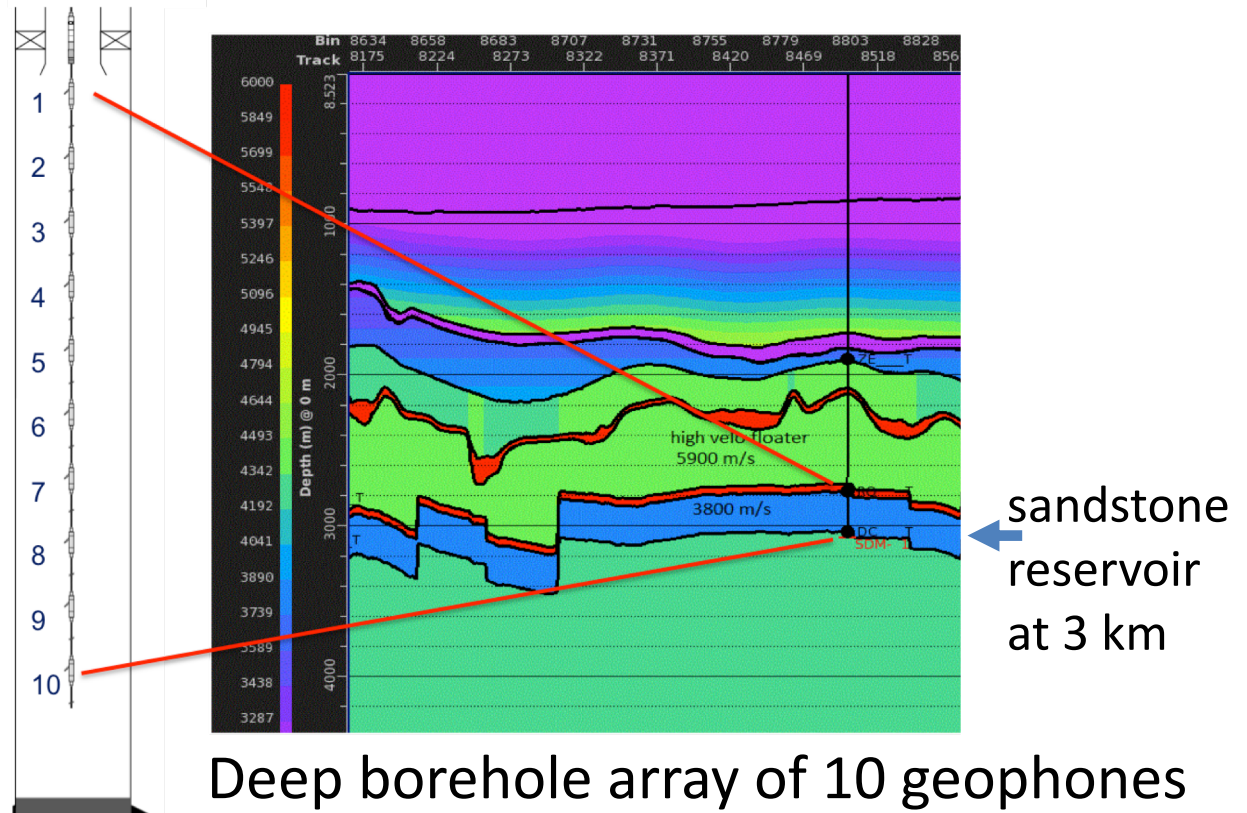
Utrecht University, The Netherlands



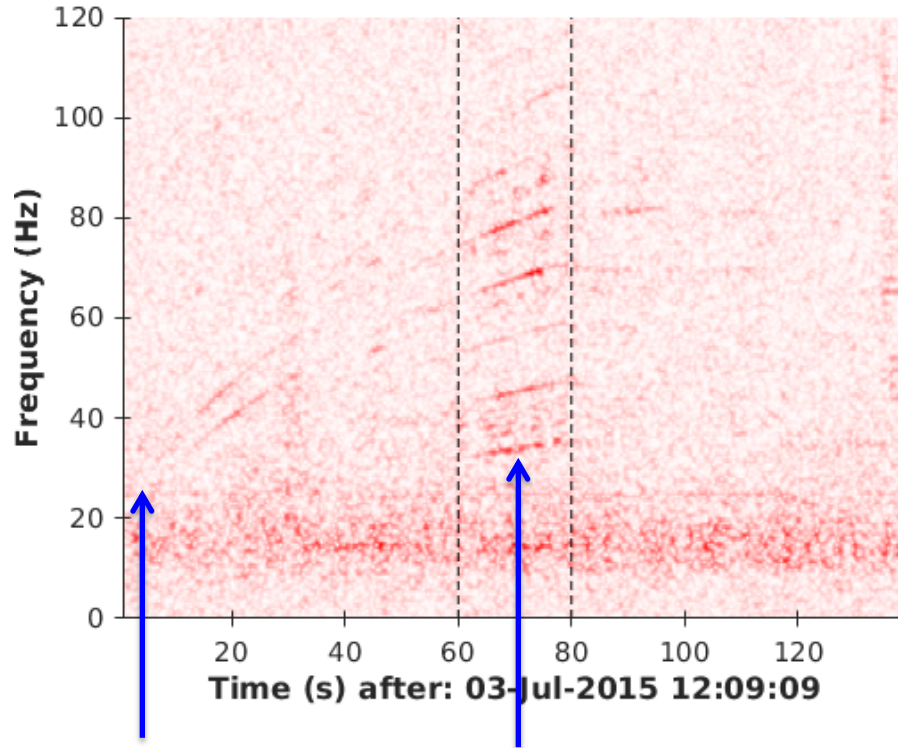
Seismic monitoring at reservoir level



Groningen gas field

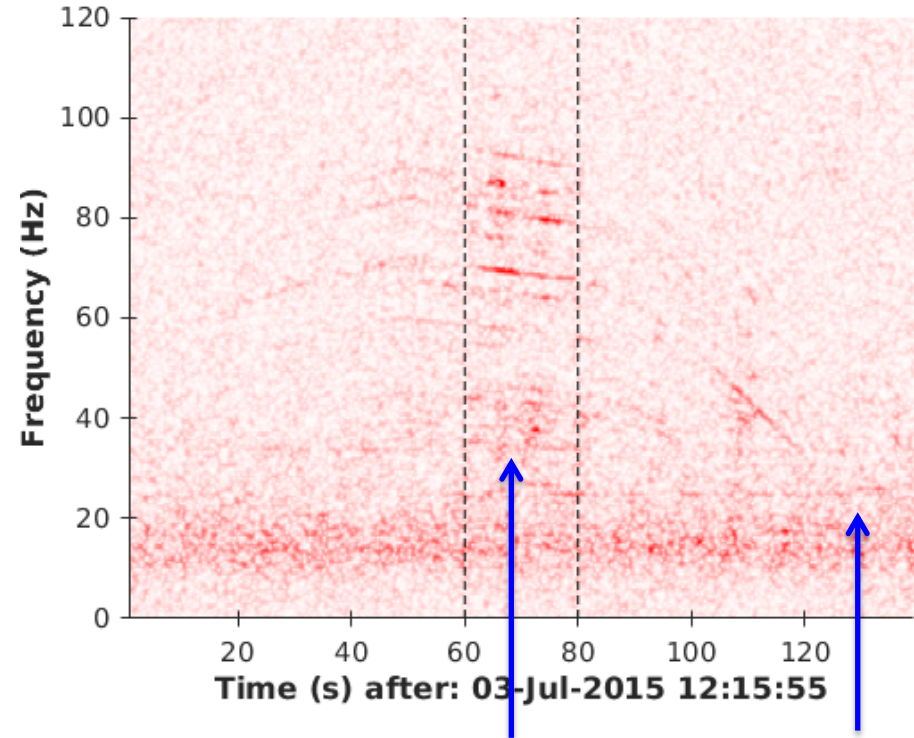


Train signal spectrograms



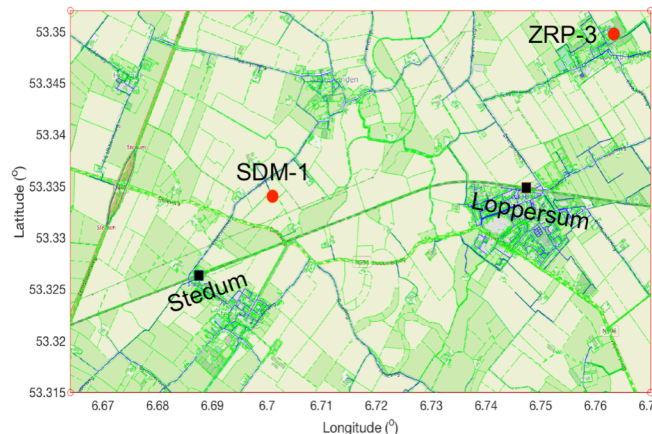
Train leaves
Stedum station

Train passes SDM-1

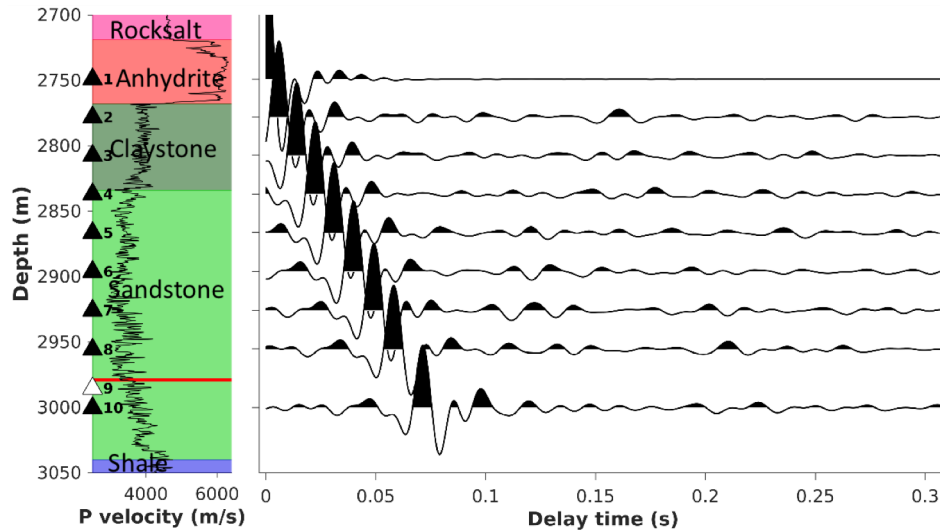


Train passes
SDM-1

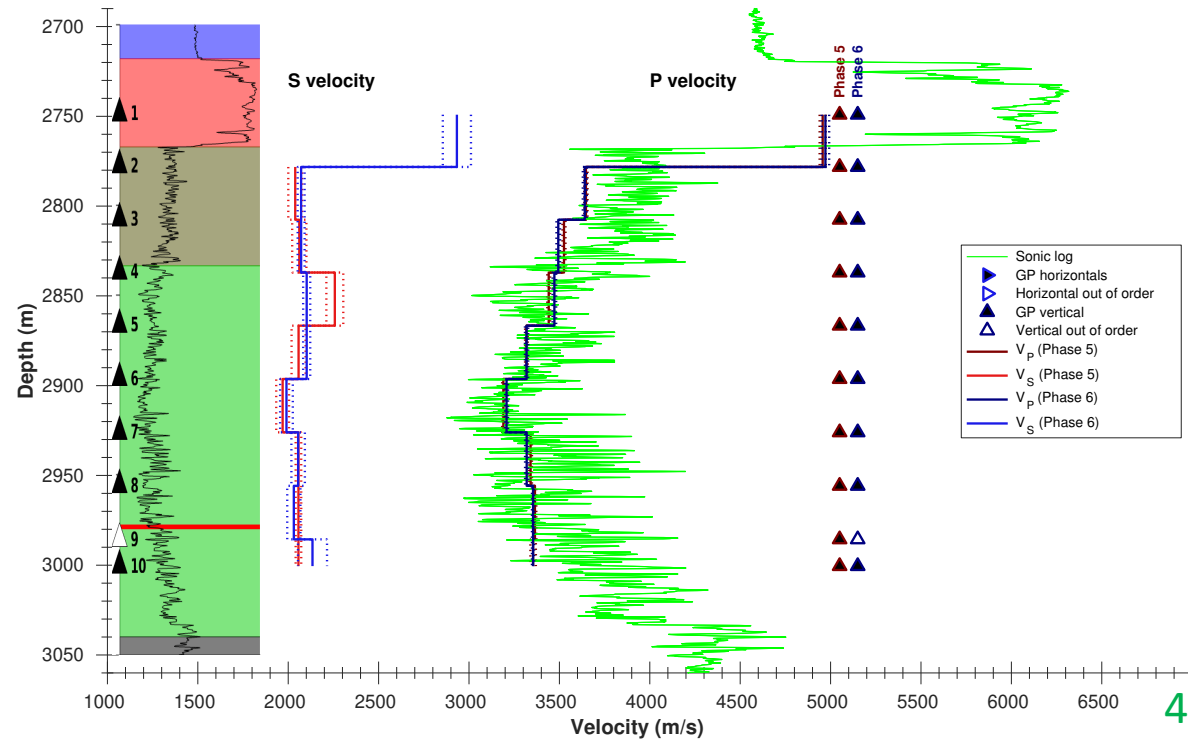
Train arrives at
Stedum station



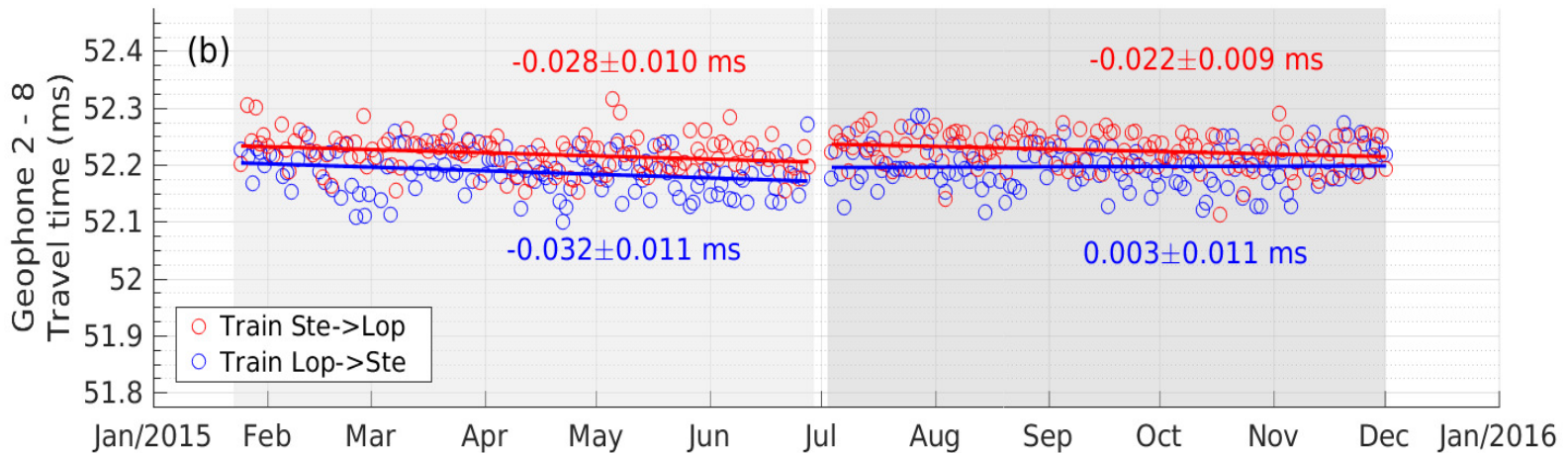
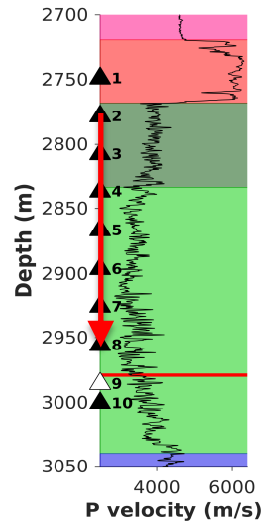
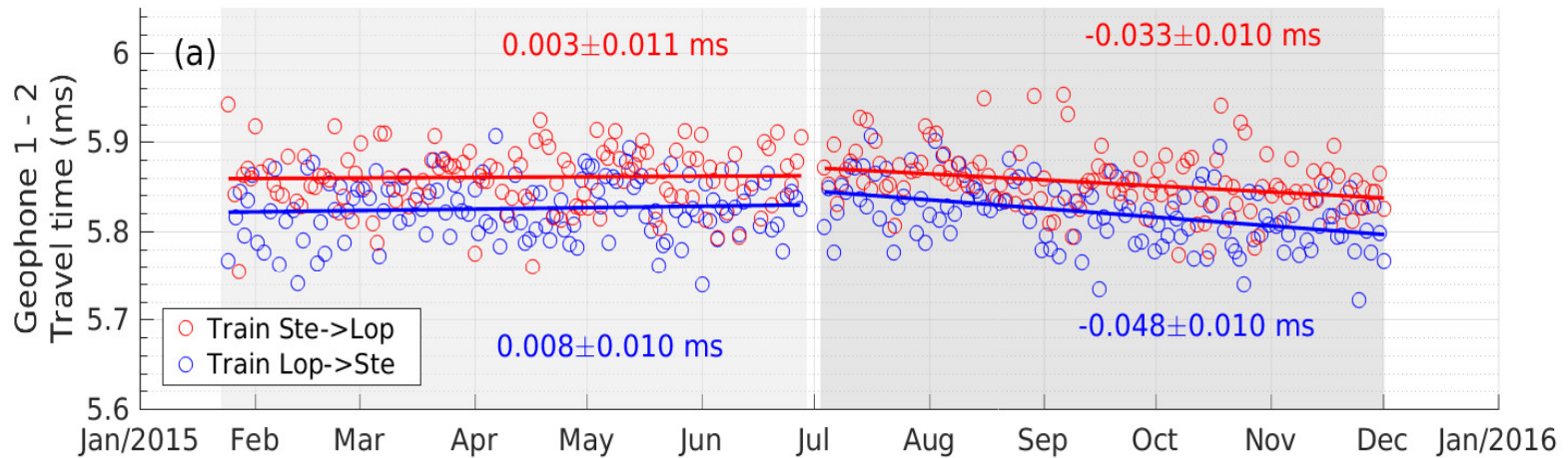
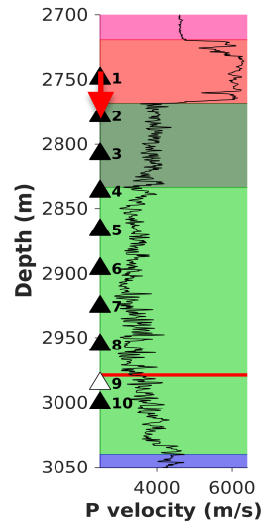
Velocity structure from train signal deconvolution



Inter-geophone travel times
(direct arrivals)



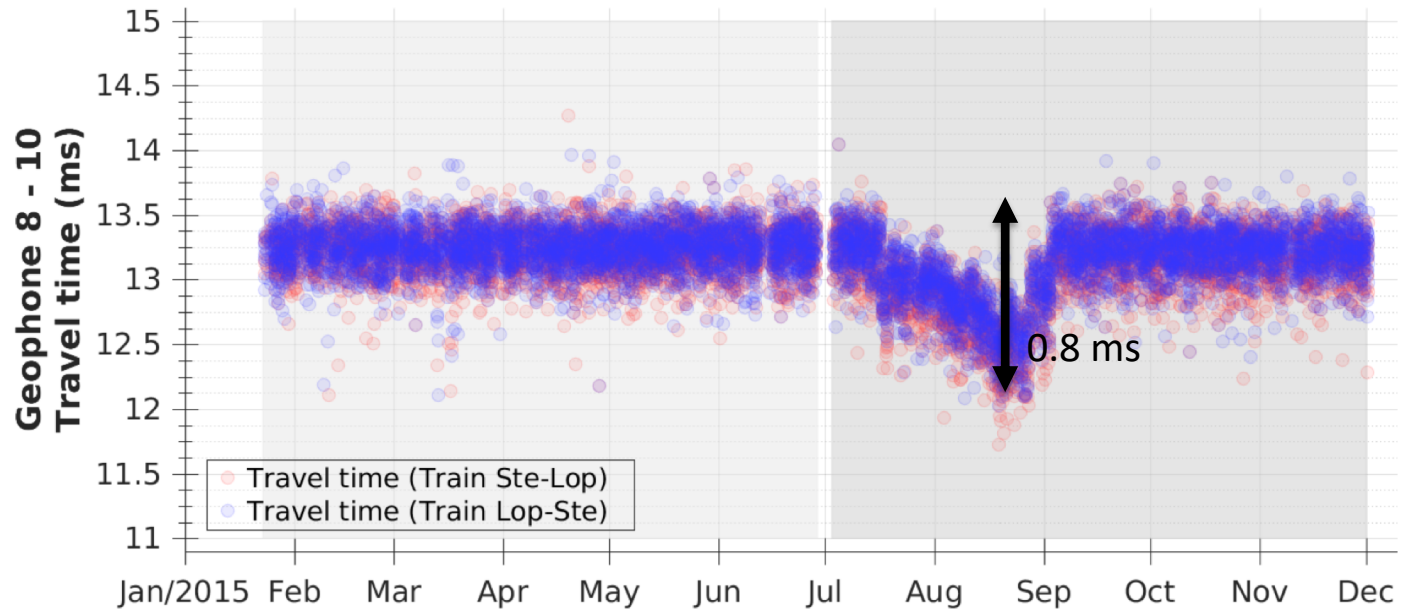
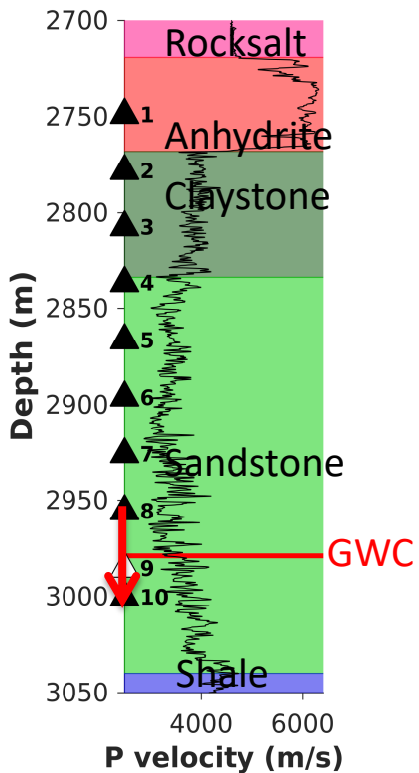
Travel time reduction by compaction is small



Travel time reduction less than $40 \pm 10 \mu\text{s}$ per 5-month period

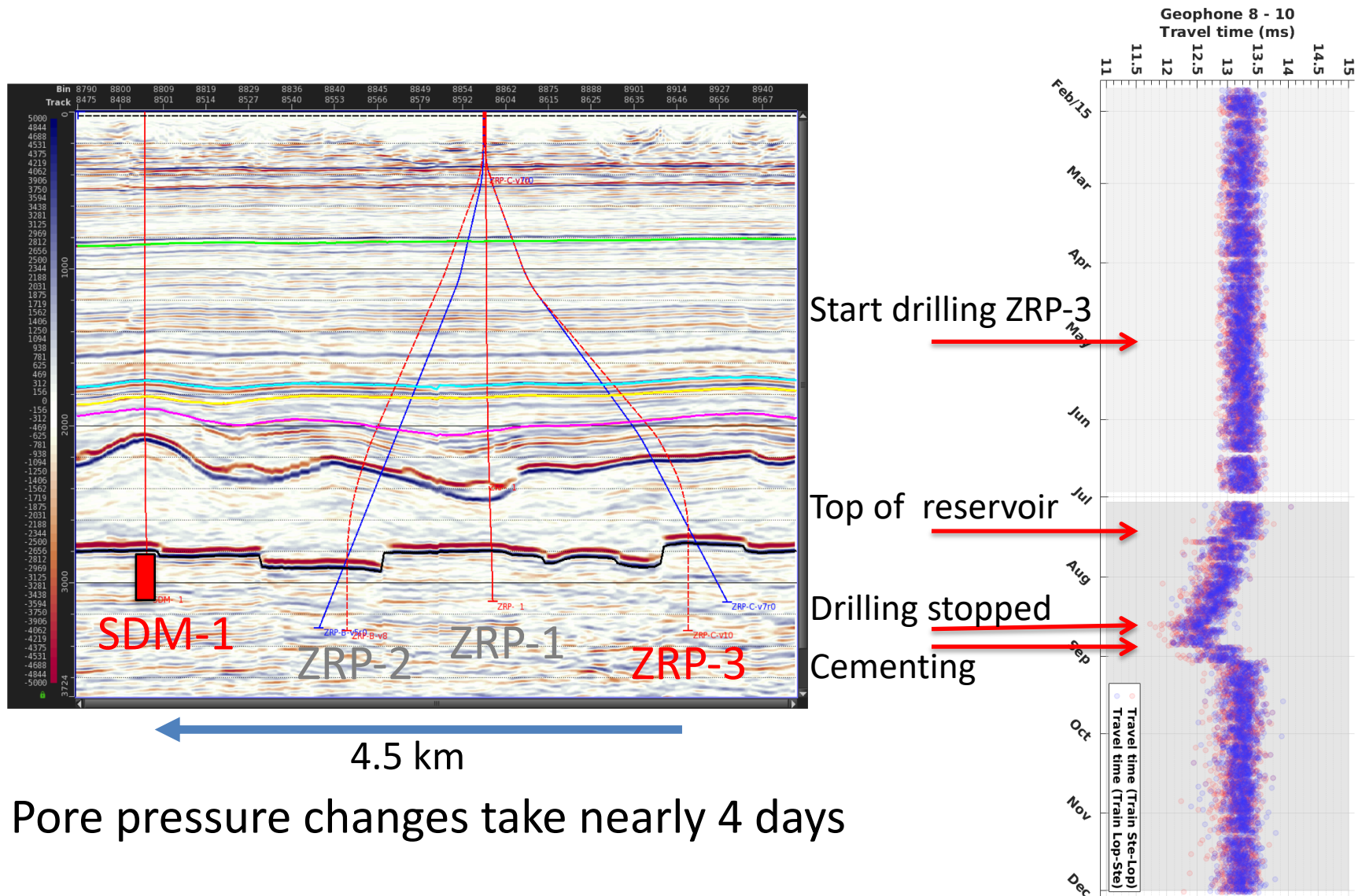
Much smaller than values from literature!

Travel time reduction by elevation gas-water contact



Mid July – August: up to 0.8 ms travel time decrease

Gas-water contact elevated caused by pore pressure changes due to drilling at 4.5 km(!) distance.



Pore pressure changes take nearly 4 days