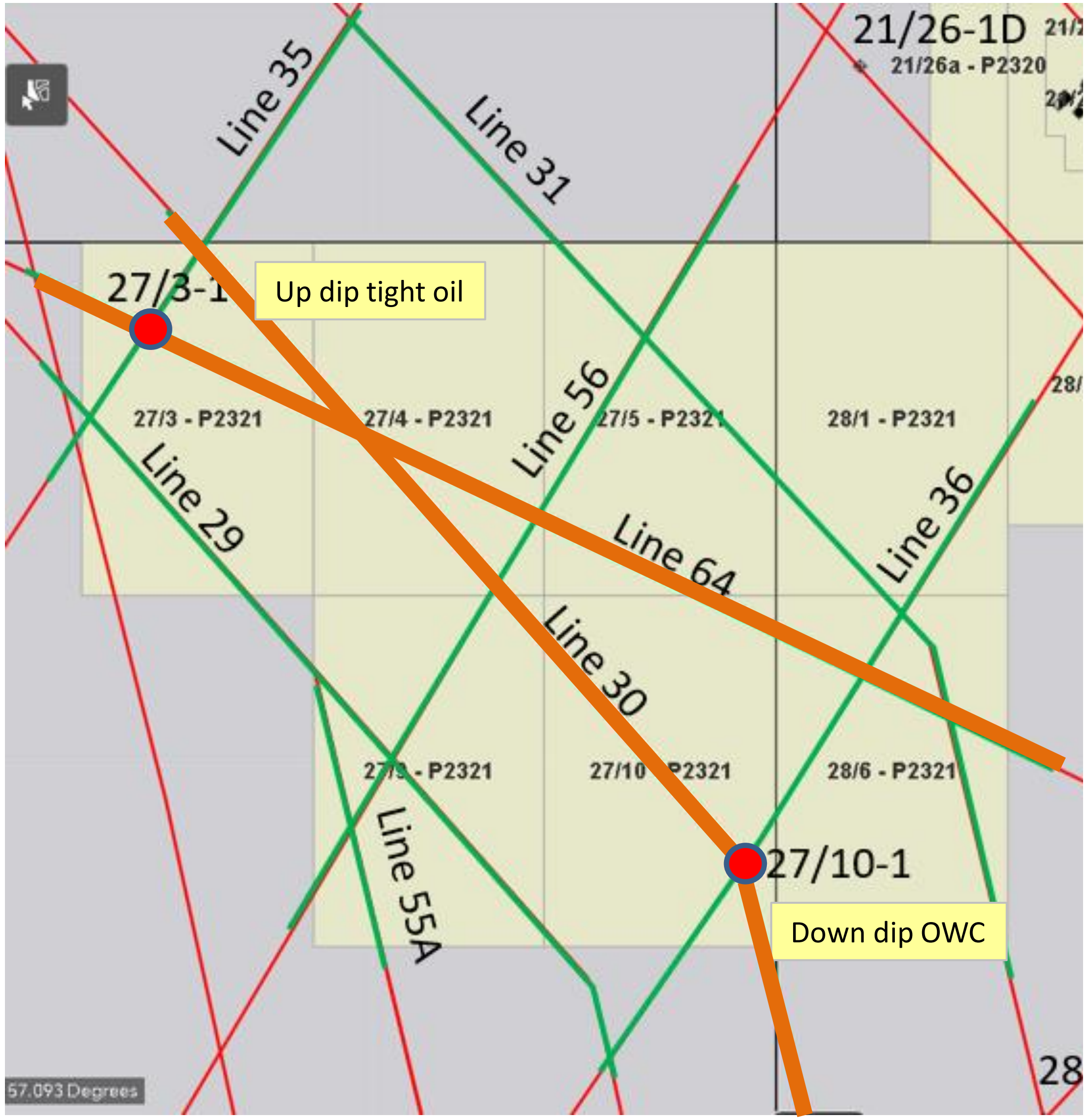
MNSH Devil's Hole Horst
Porosity Change Study - Summary
Well 27/3-1, 27/10-1

Company: Natural Resources North Sea (NSNR)

SIP Project ID: SIP-35

Date: 28th February 2022

Scope



- OWC proven at 27/10-1
- Tight oil proven at 27/3-1
- Aims:
  - to prove brightening between wells is due to increased porosity
  - To determine if brightening due to oil/gas can be separated from brine

Process

- Fluid Replacement Modelling (FRM)
  - Actual porosity is fixed
  - Pores are filled with brine, oil, gas
  - Model changes in Vp, Vs, Rhob, Zp, etc
  - Model corresponding seismic changes via synthetics

- Porosity Change Modelling
  - Porosity is decreased and increased
  - FRM is repeated for each porosity
  - Synthetics are created for each porosity

We have a series of synthetics showing seismic response to changes in porosity and fluid type

Conclusions: Porosity and AVO Z1Z2 Dolomites

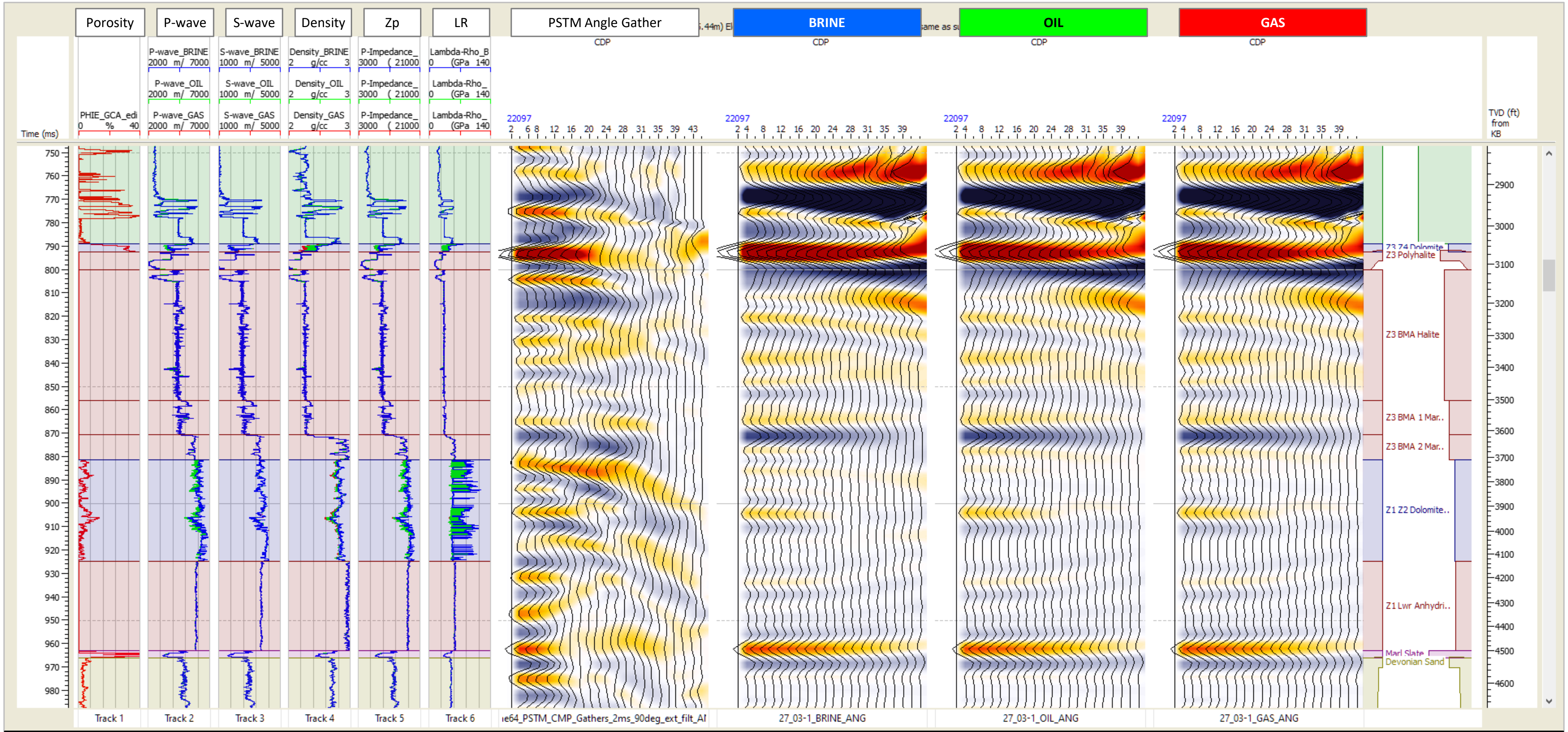
- The Zechstein dolomites will exhibit the same AVO class regardless of fluid fill or porosity

- Porosity variation results in significant change in bulk density and impedance, and consequently is the primary cause of brightening

- When porosity is the same for all fluid types, increased brightening can be observed on far angles when pore space is filled with hydrocarbons

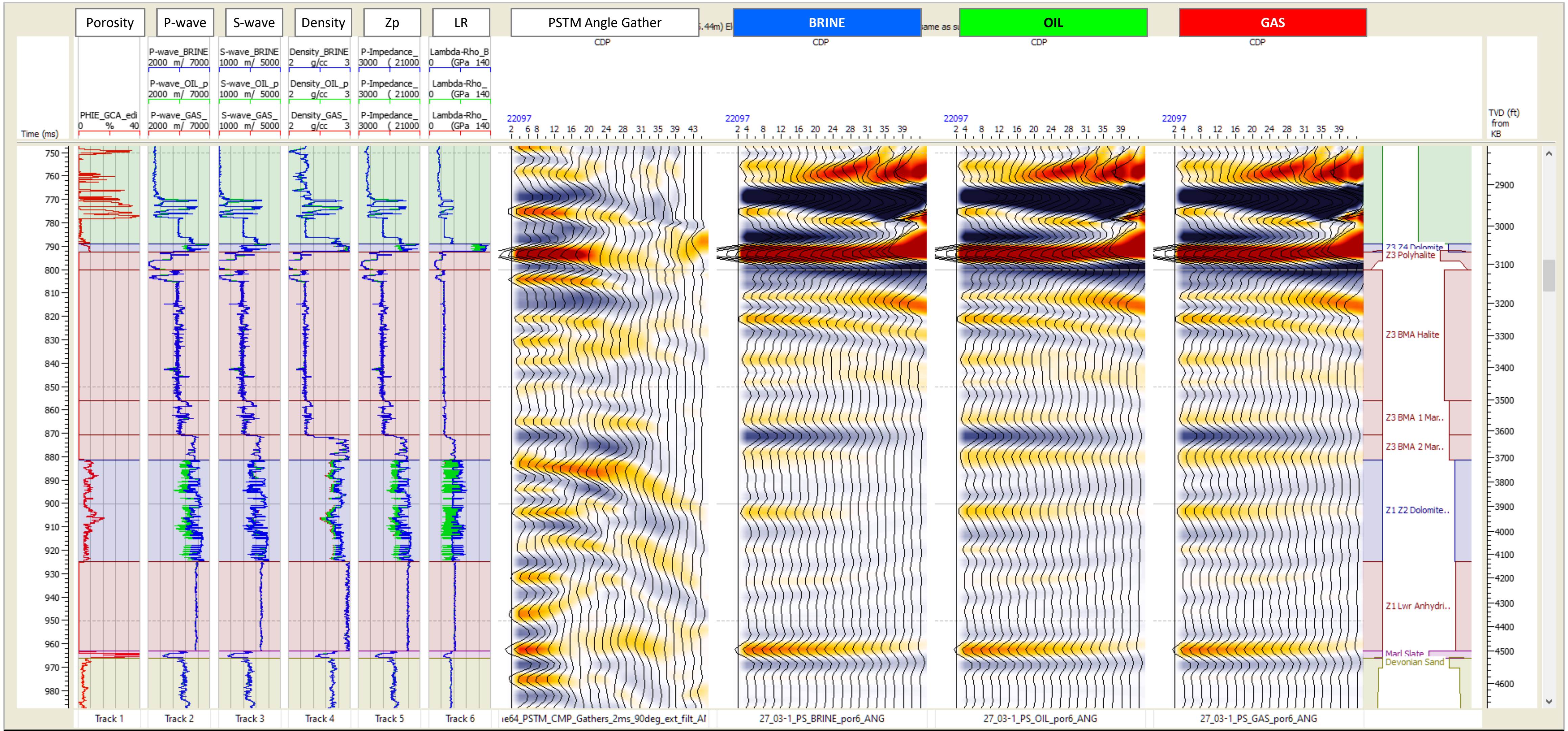
- Therefore, when interpreting seismic stacks, this suggests lateral brightening in the dolomites should indicate zones of higher porosity. For the same porosity, hydrocarbons should be identifiable from brightening on the mid/far stacks

27/03-1: Elastic Wave Angle Synthetics Actual Porosity Z1Z2



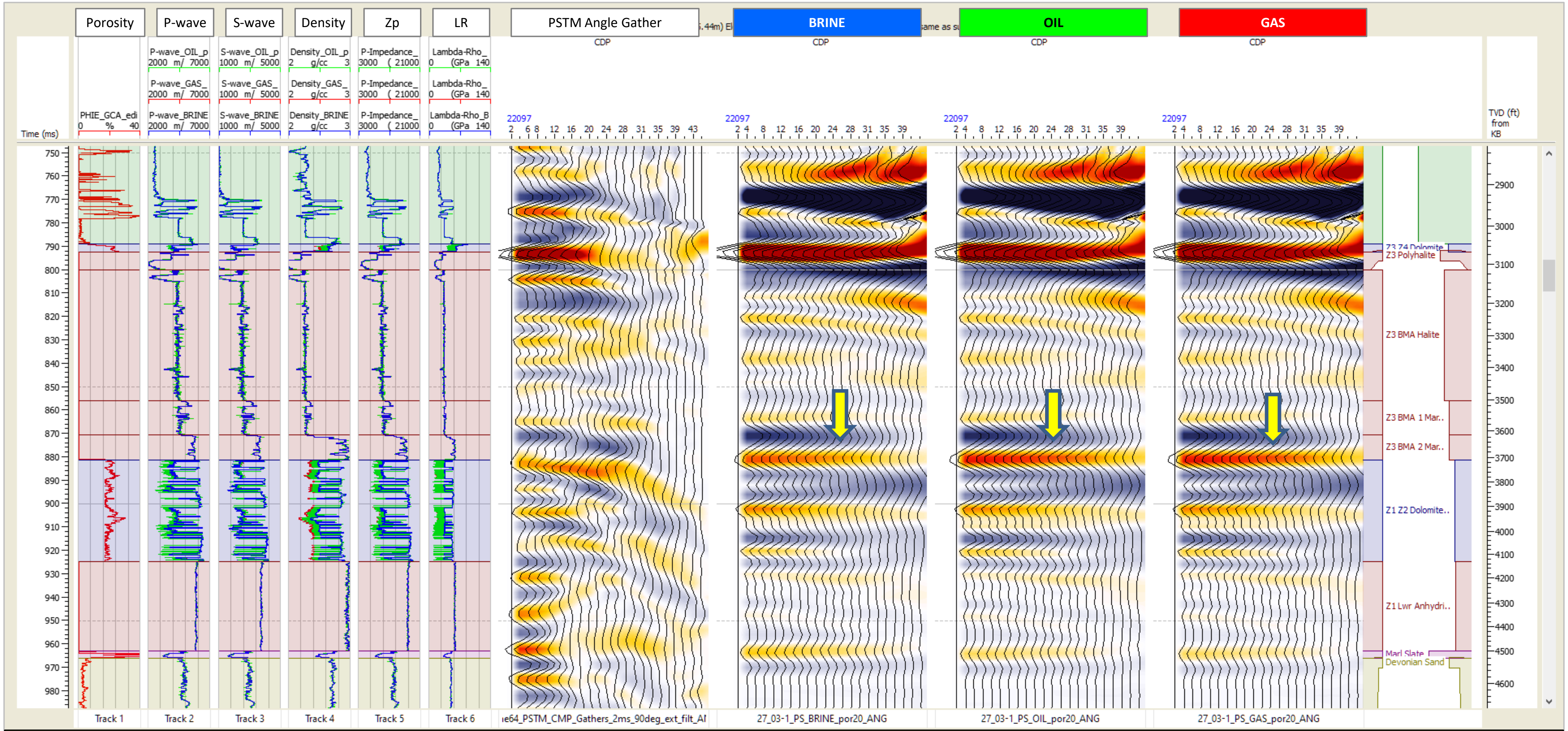
Z1Z2: All fluid types show the same AVO class. Hydrocarbon produces a weak brightening

27/03-1: Elastic Wave Angle Synthetics 6% Average Porosity Z1Z2



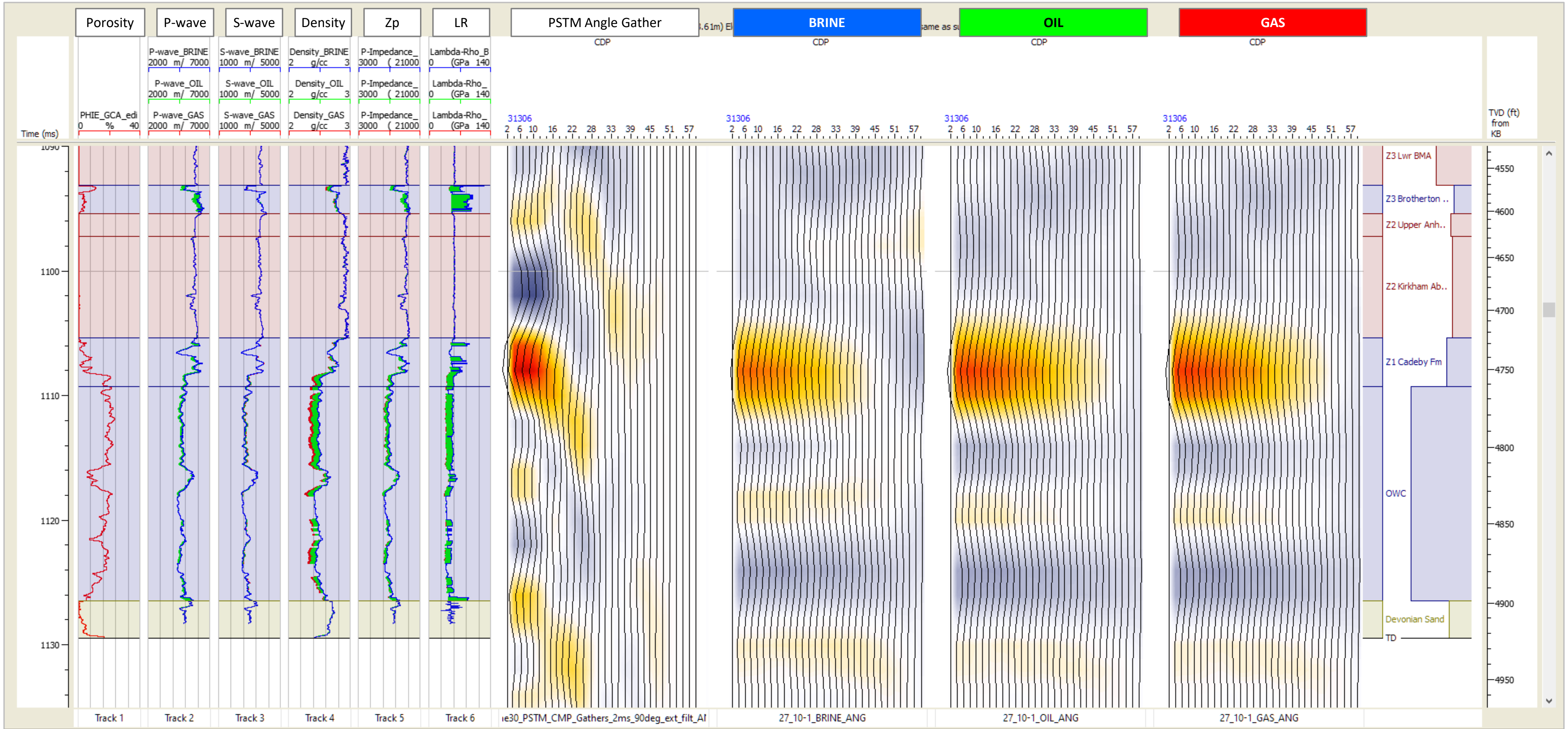
Z1Z2: All fluid types show the same AVO class. A small increase in porosity to 6% produces a stronger brightening when hydrocarbon is present compared to the brine response

27/03-1: Elastic Wave Angle Synthetics 20% Average Porosity Z1Z2



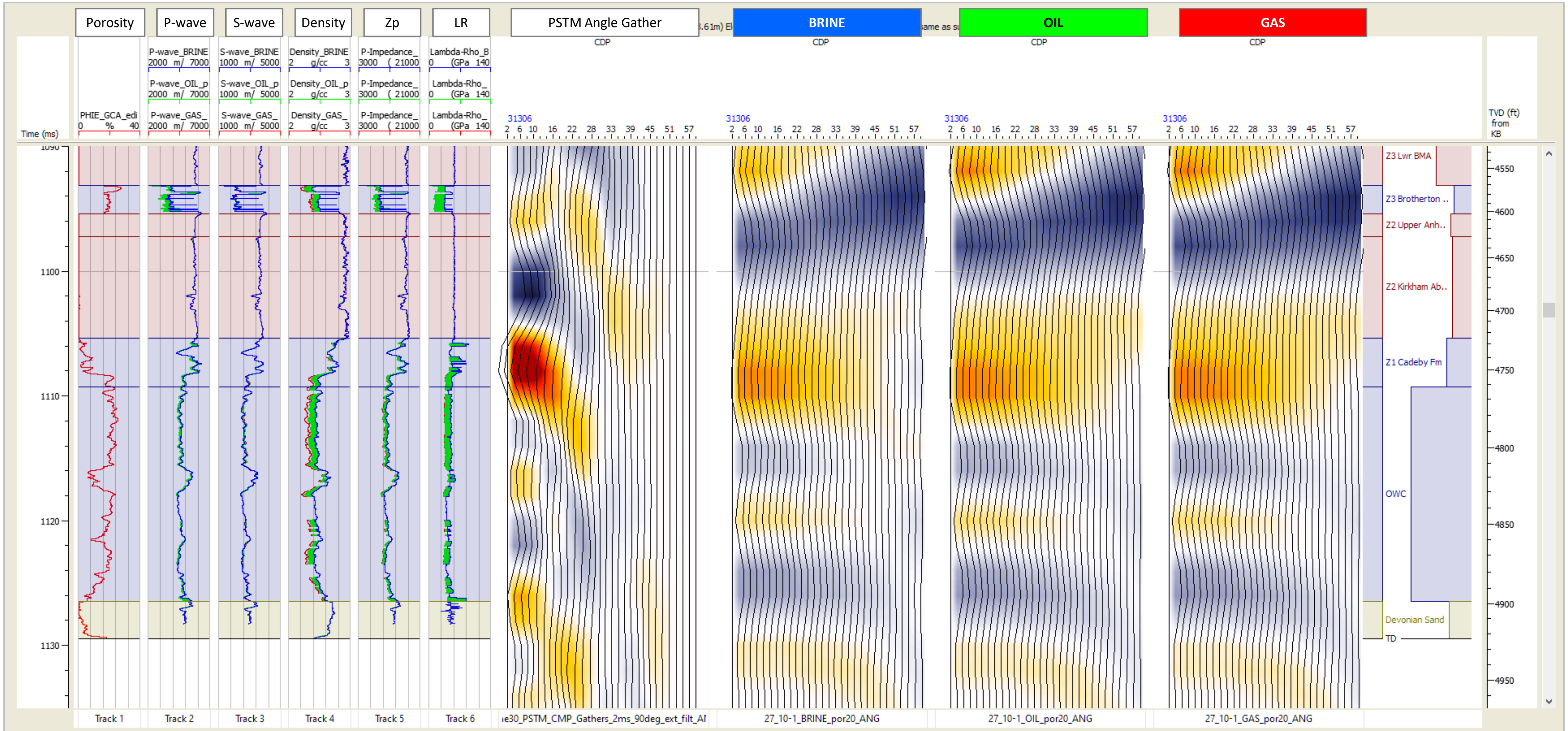
Z1Z2: High porosity results in a strong impedance contrast for all fluid types. Hydrocarbons produce in a noticeable brightening compared to brine. Oil may be distinguishable as brightening over the 20-30deg angle range (far stack) especially at the top of the interval

27/10-1: Elastic Wave Angle Synthetics Actual Porosity Z1, Z3



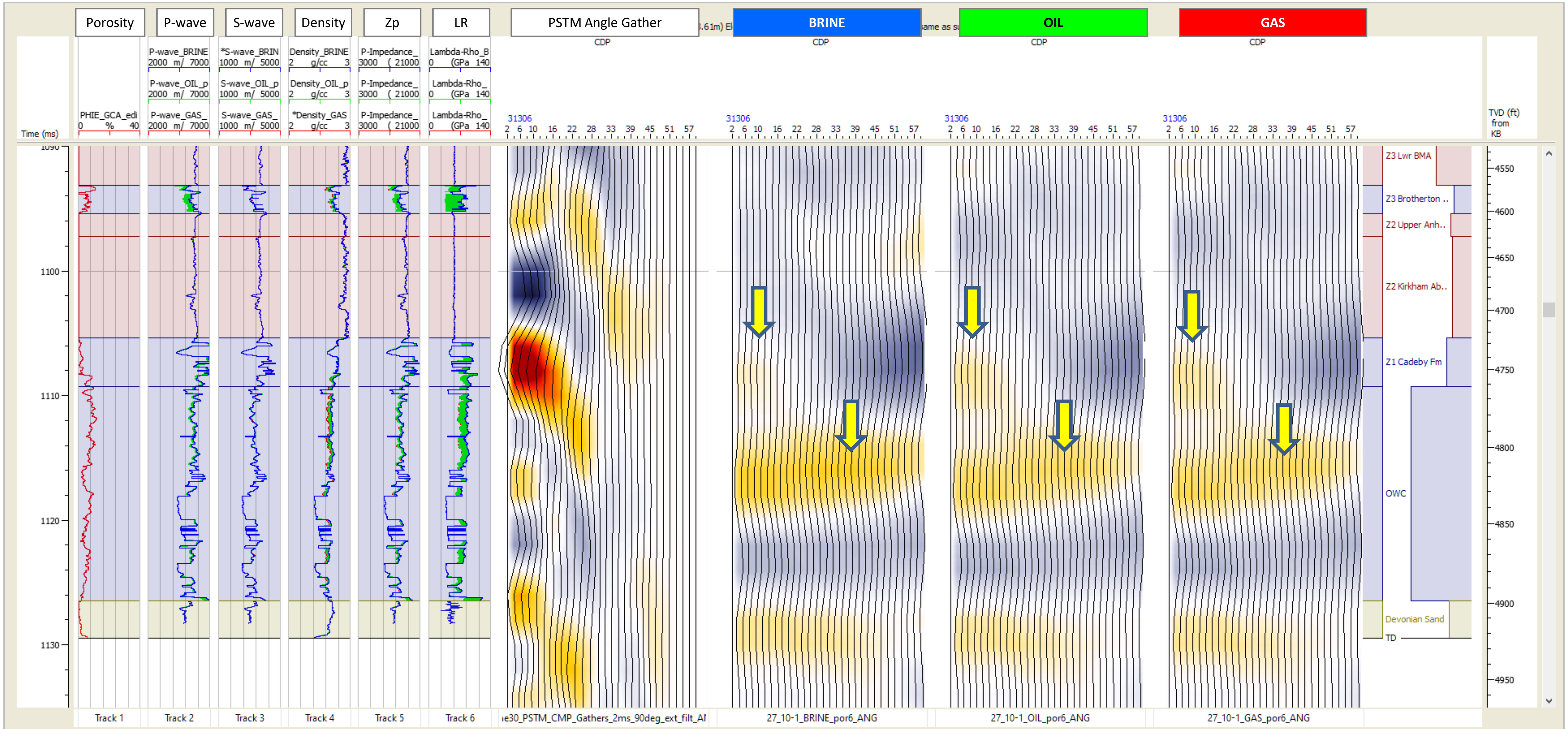
All fluid types show the same class IV AVO. Hydrocarbon produces a moderate brightening compared to brine at Z1.
Z3 Brotherton does not produce any discernible AVO class.

27/10-1: Elastic Wave Angle Synthetics 20% Average Porosity Z1, Z3



At high porosity (20%) we observe the same AVO as for the actual porosity case. All fluids show the same class with brightening occurring when hydrocarbon is included. Oil may be distinguishable as brightening over the 20-30deg angle range (far stack) at the top of the interval

27/10-1: Elastic Wave Angle Synthetics 6% Average Porosity Z1,Z3

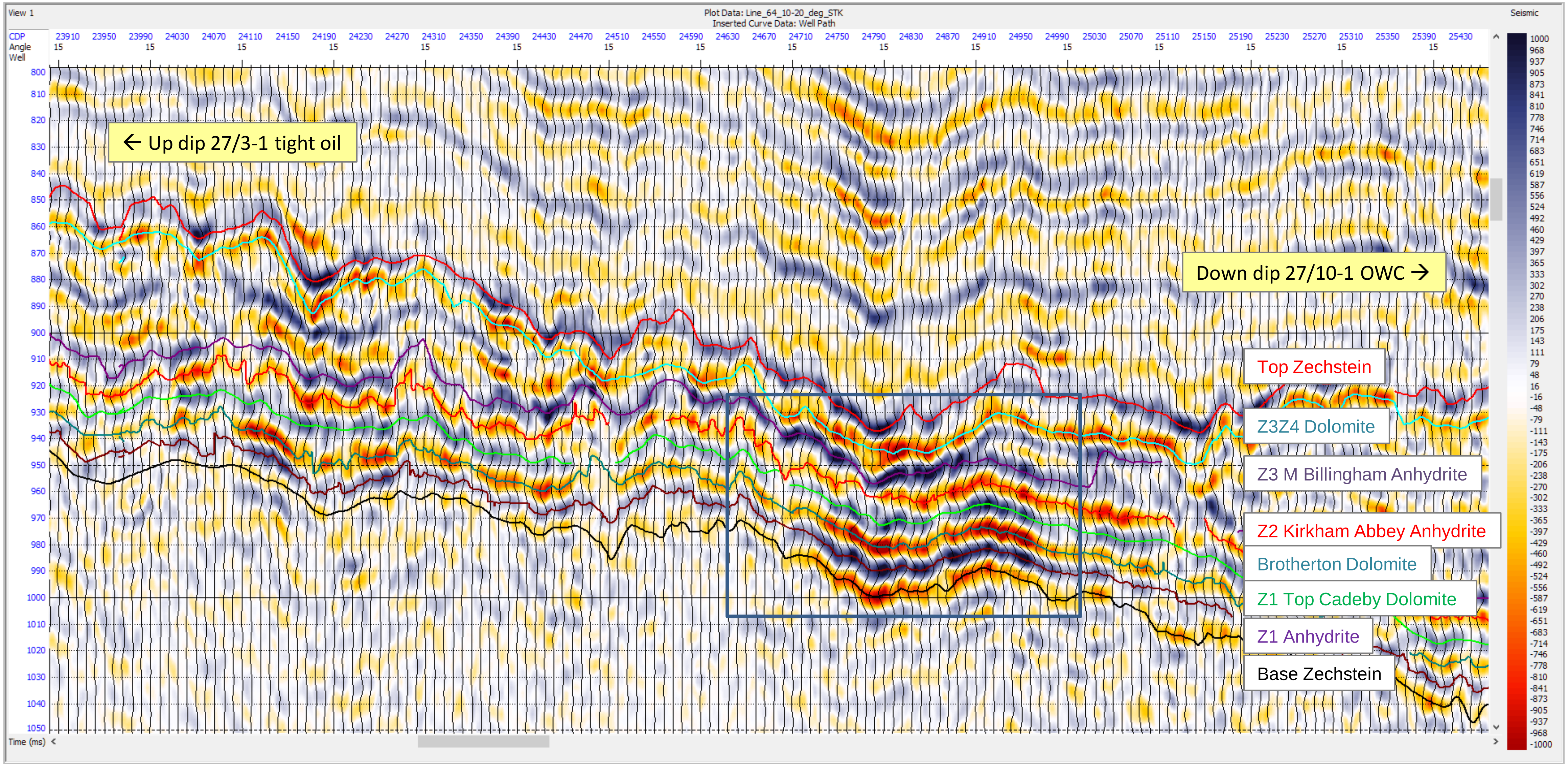


At low porosity, Z1 density and impedance is similar to the anhydrite. The bright trough at Top Cadeby is almost extinguished. Hydrocarbon fill results in weak brightening. The base of the main oil zone results in dimming compared to brine. Z3 does not provide a distinct AVO character.

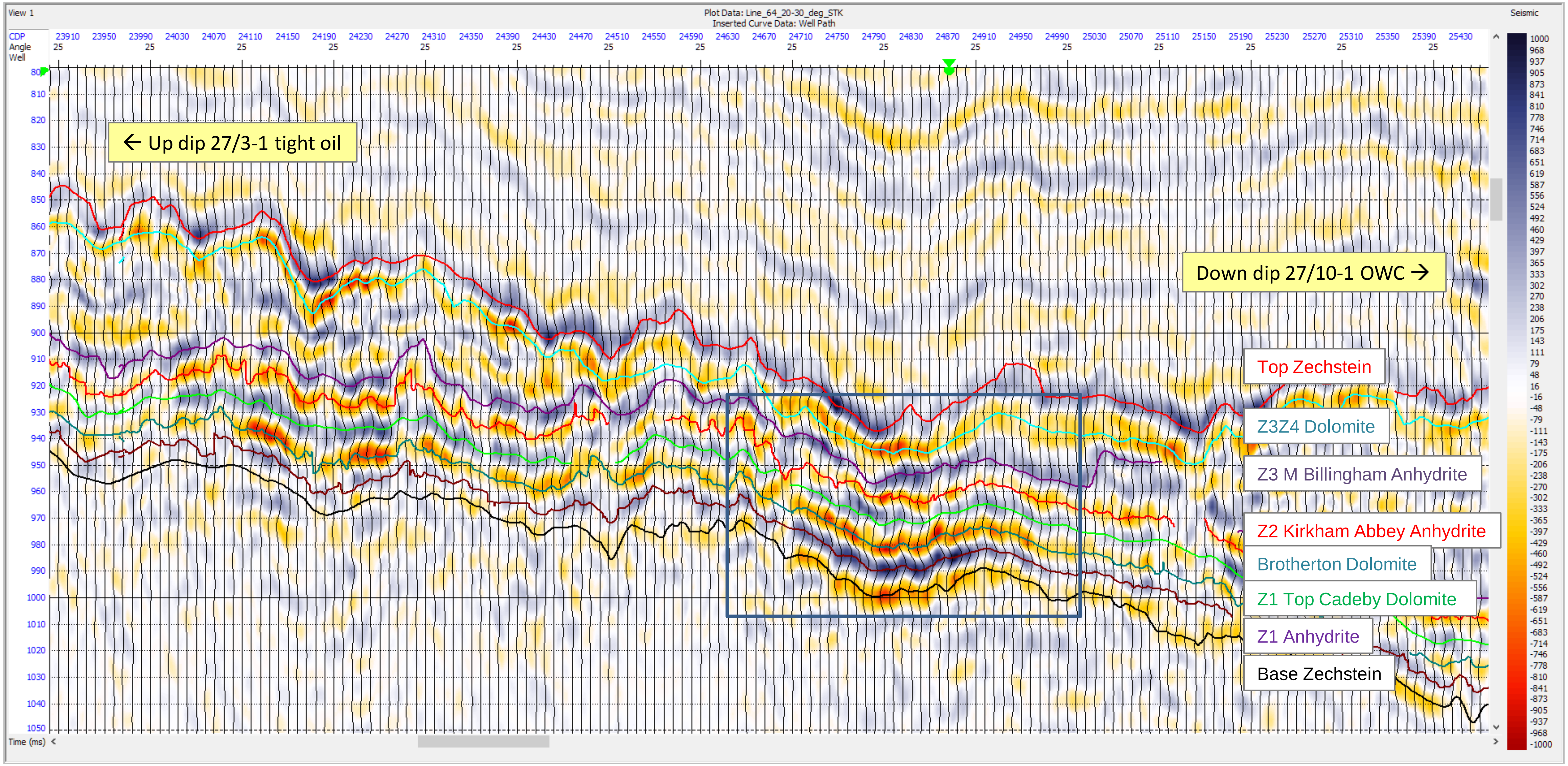
MNSH Devil’s Hole Horst, Porosity Change Study

COMPARISON TO SEISMIC

Line 64 (27/03-1): 10-20deg Stack

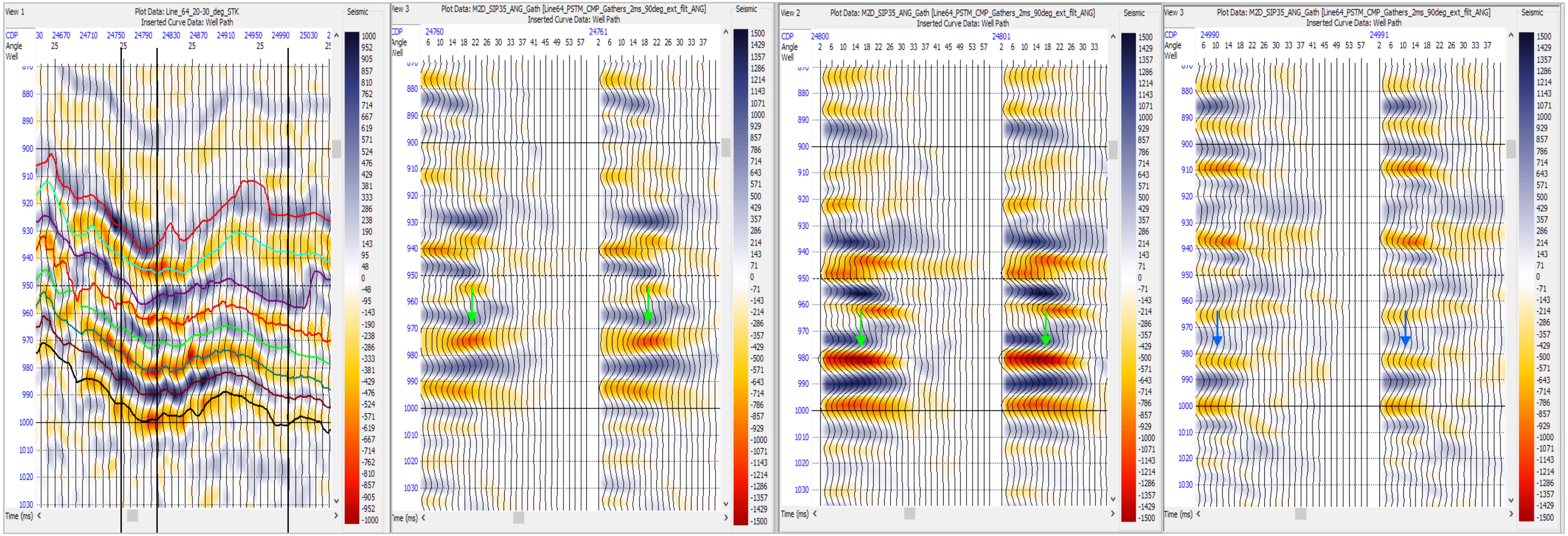


Line 64 (27/03-1): 20-30deg Stack



Line 64: Z1Z2

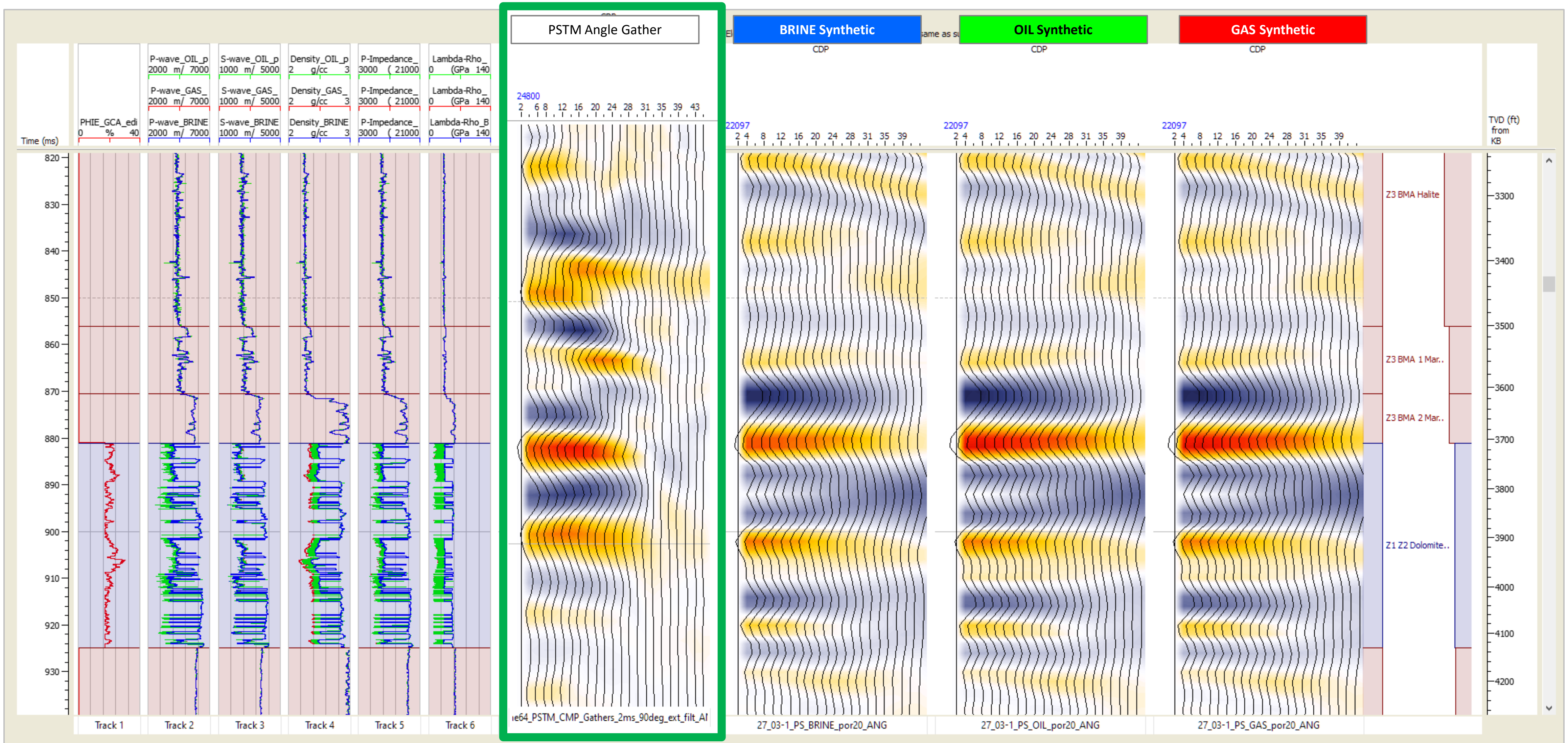
20-30deg Angle Stack | CDP 24760 | CDP 24800 | CDP 24990



Bright zones on the 20-30 degree angle stack and brightening on mid-angles.

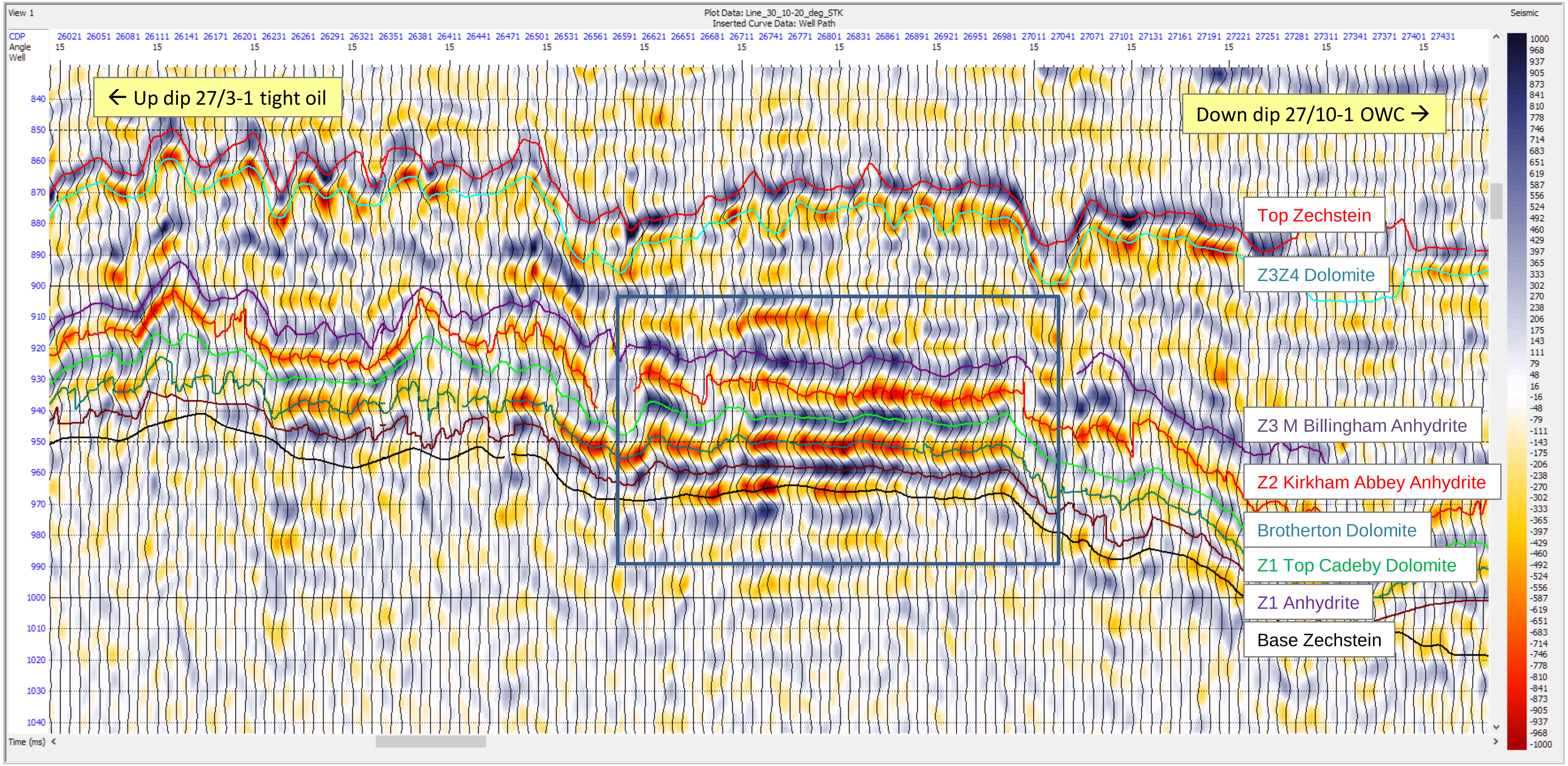
Synthetics from the porosity change study indicate that the bright zone equates to higher porosity. Adjacent dim zones indicate low porosity (blue arrows) but may still be oil bearing as seen at 27/03-1. Note how selected gathers within the high porosity zone exhibit brightening on the mid-angles of the angle gathers (green arrows, Class III AVO?). Where porosity is similar laterally, brightening on the far stack (left) could also indicate hydrocarbons. Low porosity is interpreted to occur due to faulting.

Line 64 CDP24800 from Prospect Displayed at 27/03-1 Well Location (20% Average Porosity)

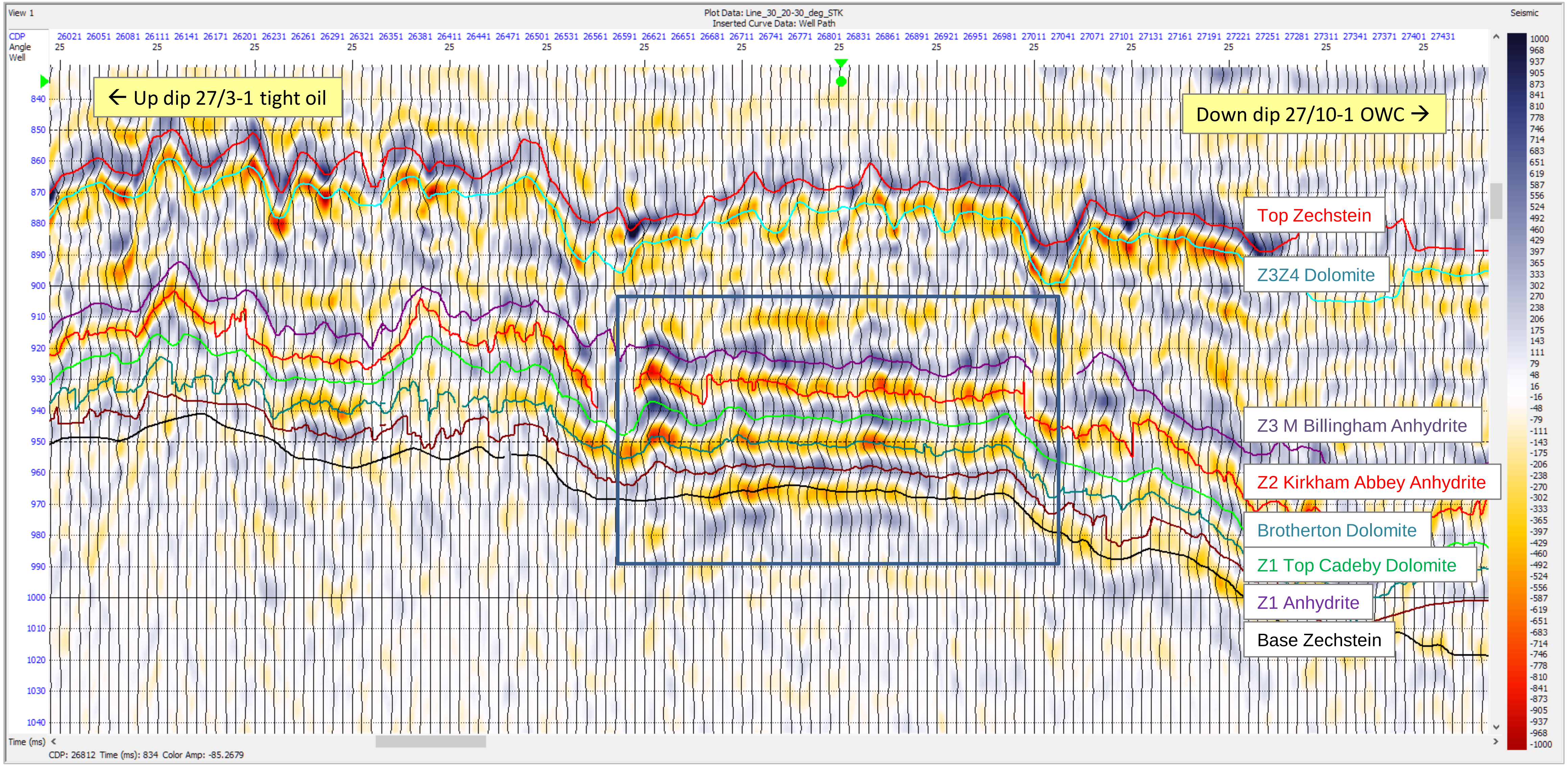


CDP24800 from the prospect (green) is displayed alongside the brine, oil, and gas synthetics created from well logs at 27/03-1 when modelled for high porosity. This seismic response at the prospect is similar to the Z1Z2 Dolomite when porosity is raised.

Line 30 (27/10-1): 10-20deg Stack

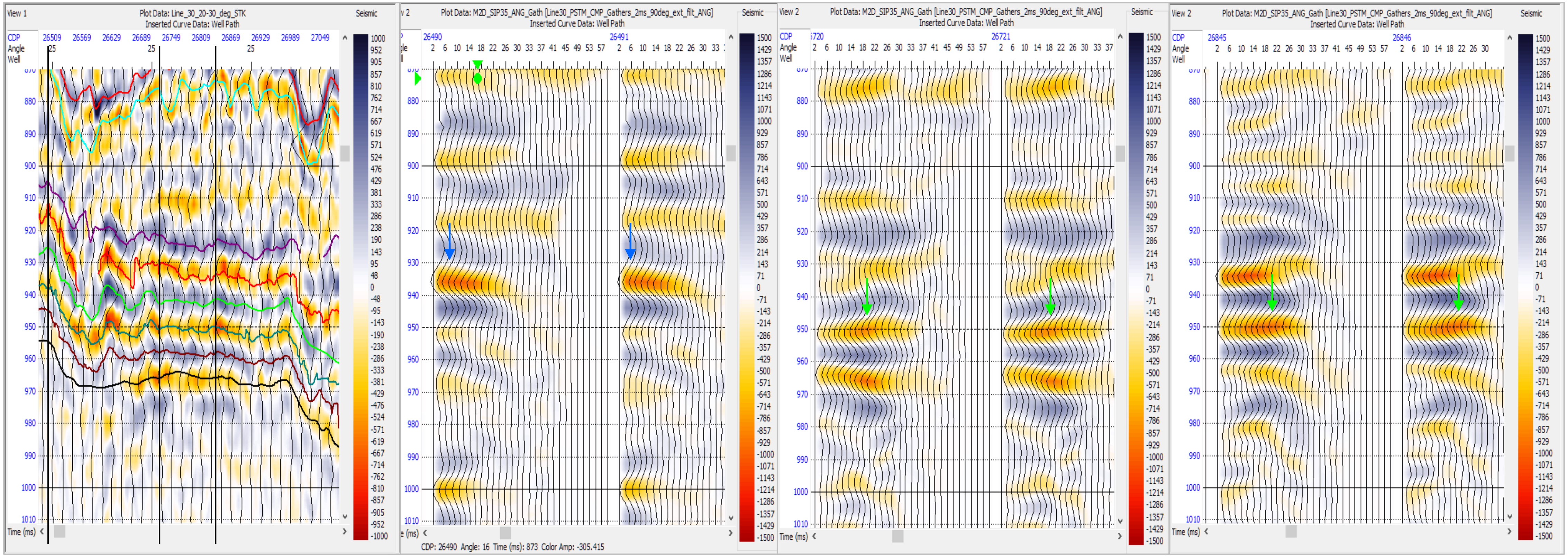


Line 30 (27/10-1): 20-30deg Stack



Line 30: Z1Z2

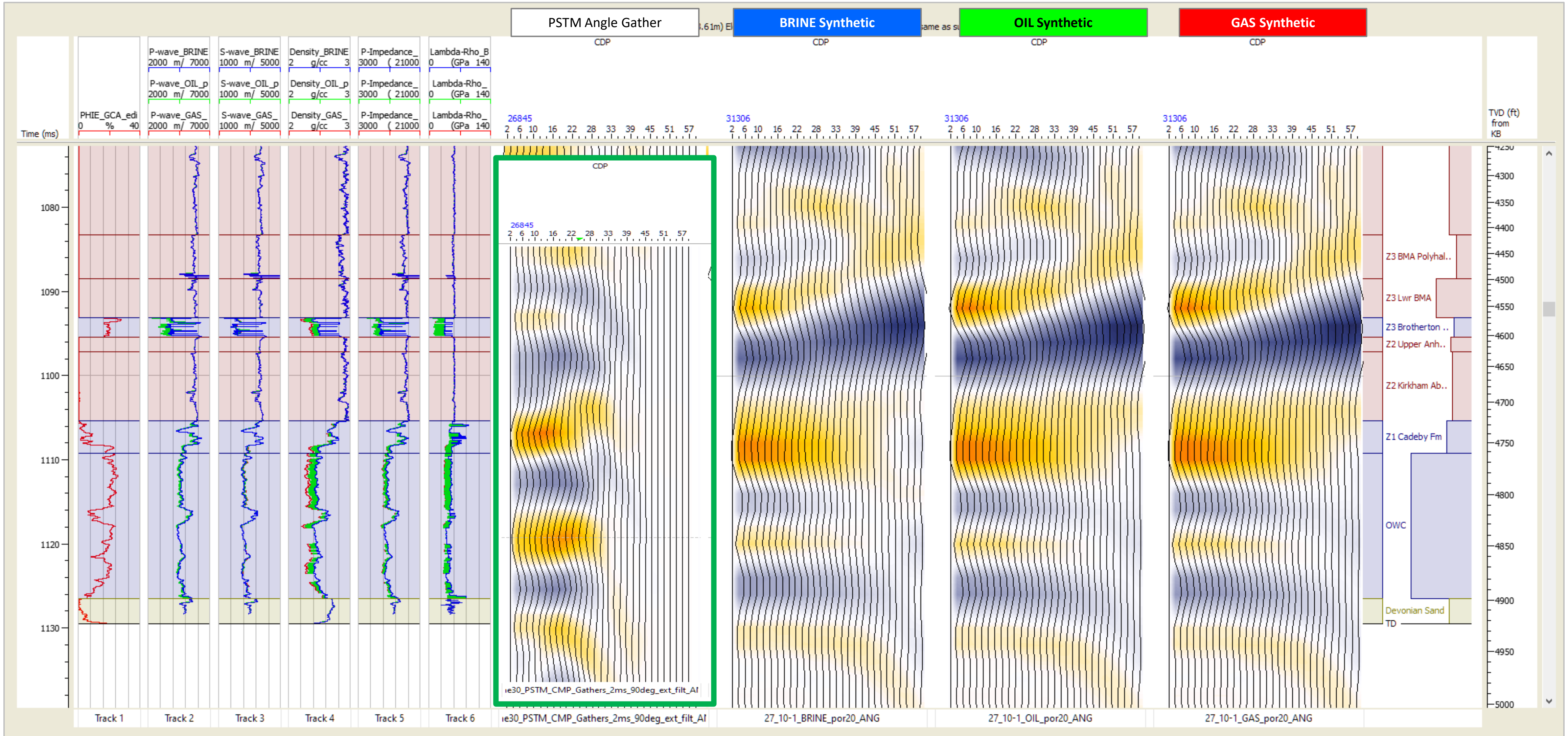
20-30deg Angle Stack	CDP 26490	CDP 26720	CDP 26845



Bright zones on the 20-30 degree angle stack and brightening on mid/far-angles.

Line 30 also exhibits zones of brightening on the stacks which modelling suggests are high porosity zones compared to dimmer low porosity zones. In the prospective zone, brightening also occurs on the far stack (left) which could indicate hydrocarbons where porosity is laterally similar. Once again we see how gathers exhibit brightening on the mid and far angle of the gathers (green arrows, Class III AVO?). Low porosity interpreted to occur due to faulting and fault zones.

Line 30 CDP26845 from Prospect Displayed at 27/10-1 Well Location (20% Average Porosity)



CDP26720 from the prospect (green) is displayed alongside the brine, oil, and gas synthetics created from well logs at 27/10-1 when modelled for high porosity. This seismic response at the prospect is similar to the Z1 Cadeby when porosity is raised.