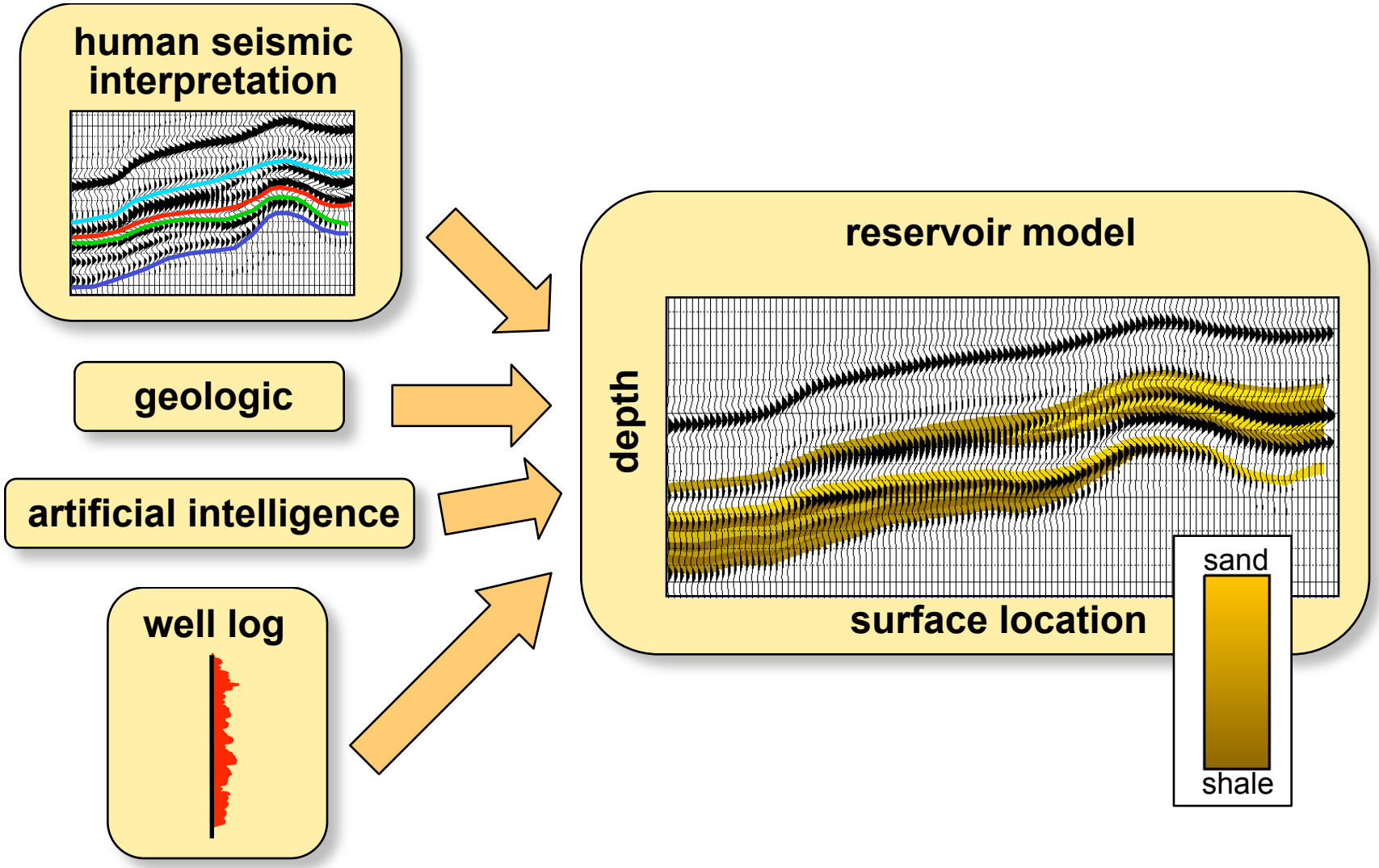
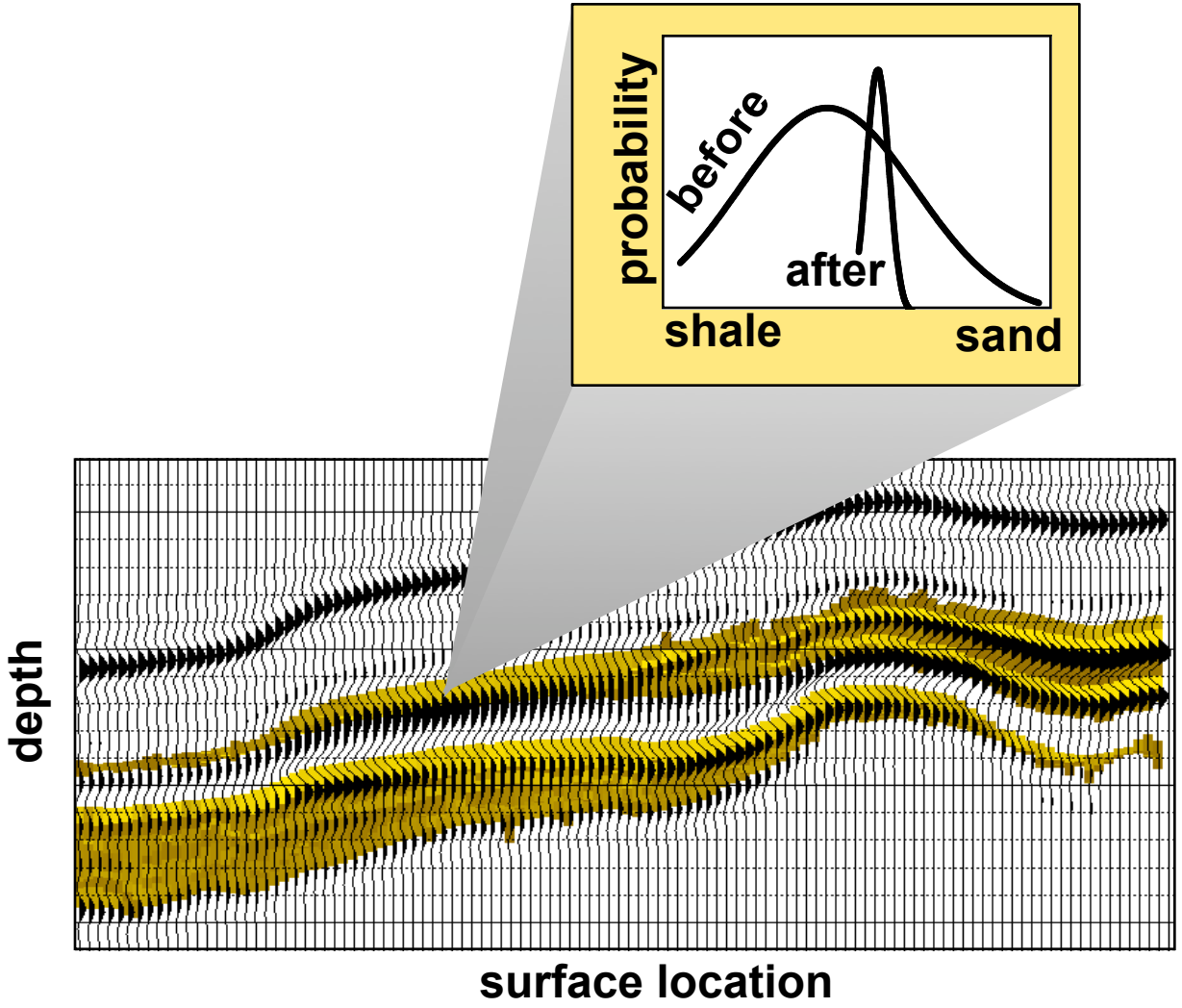
Seismic inversion of reservoir models using DepSim, FLINT and PROMISE

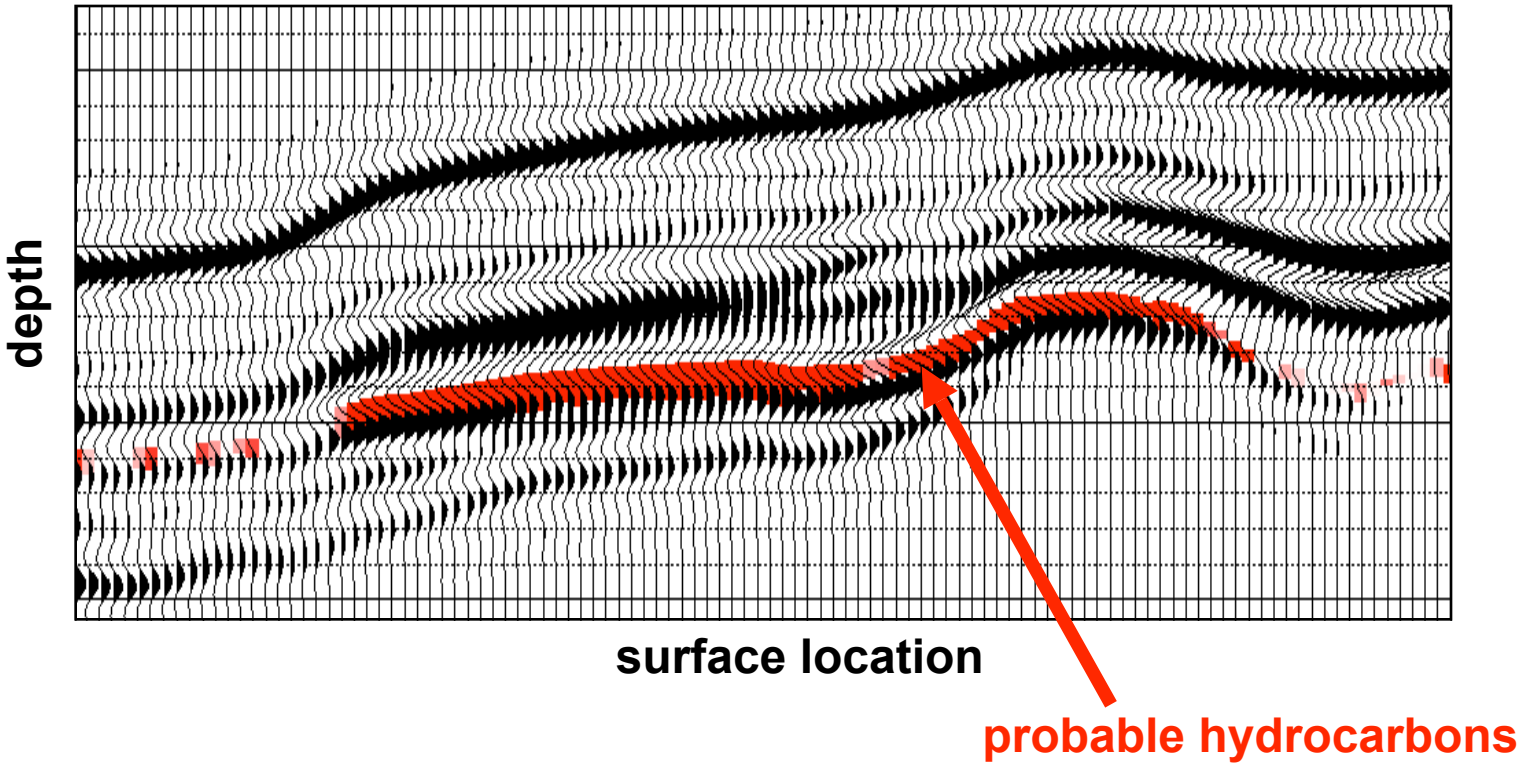
Reservoir modeling combines many types of information



Probabilistic inversion includes seismic information, improving accuracy of model



Inversion also locates hydrocarbons



Application of reservoir modeling and inversion has financial impact

- **vintage deterministic FLINT technology**
  - this technology has been applied to over 35 hydrocarbon reservoir developments worldwide
  - it has saved drilling over 45 wells
  - it has saved $300 to $500 million USD
- **modern probabilistic PROMISE technology**
  - this technology has been applied to over 8 hydrocarbon reservoir developments worldwide

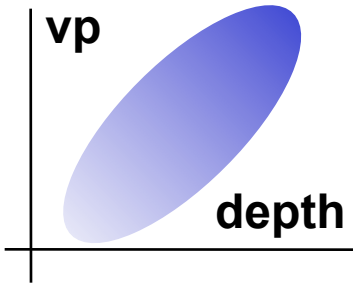
Unique Shell capabilities exist

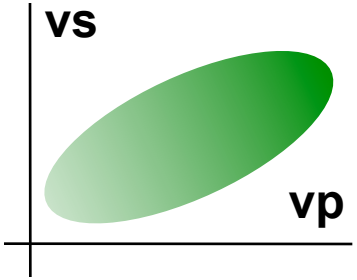
- **multiple stack AVO/4D inversion**
  - one model fits multiple stacks
- **estimates of parameters and uncertainties**
  - petrophysical uncertainties integrated with seismic
  - parameters that matter estimated
    - N/G, saturations, porosity, etc.
- **probabilistic inversion done on business relevant time scale**
  - DepSim model built, petrophysics analyzed, and PROMISE inversion done in 8 calendar days (FRAM, North Sea Forties)
- **tight integration of seismic inversion (FLINT and PROMISE) with reservoir modeling (DepSim) and seismic interpretation (123DI)**

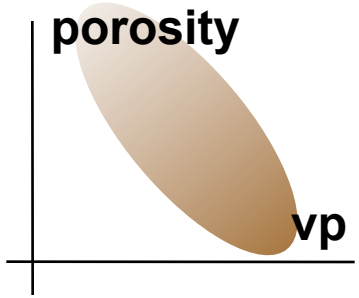
Probabilistic Inversion Case Study (Ram/Powell Gulf of Mexico turbidite)

GOM petrophysical end member trends used in prior probability

wet sand

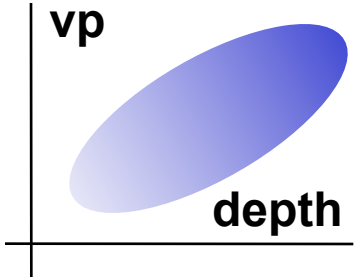


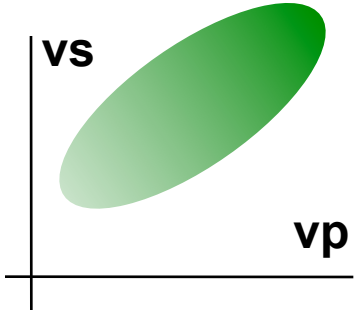


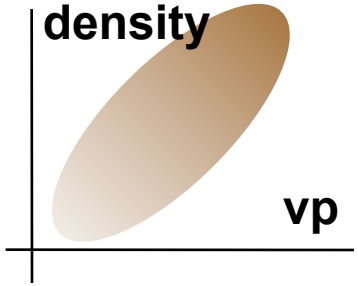


mix with net/gross ± σ

mud-stone

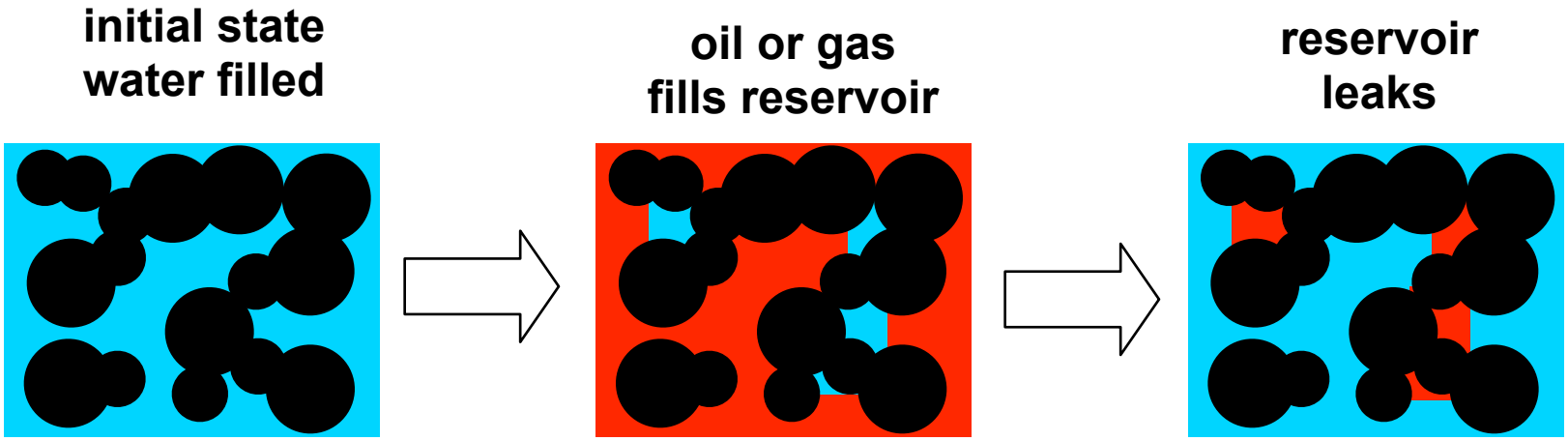






note: separate trend for each layer

Discrete cases of fluid fill are used

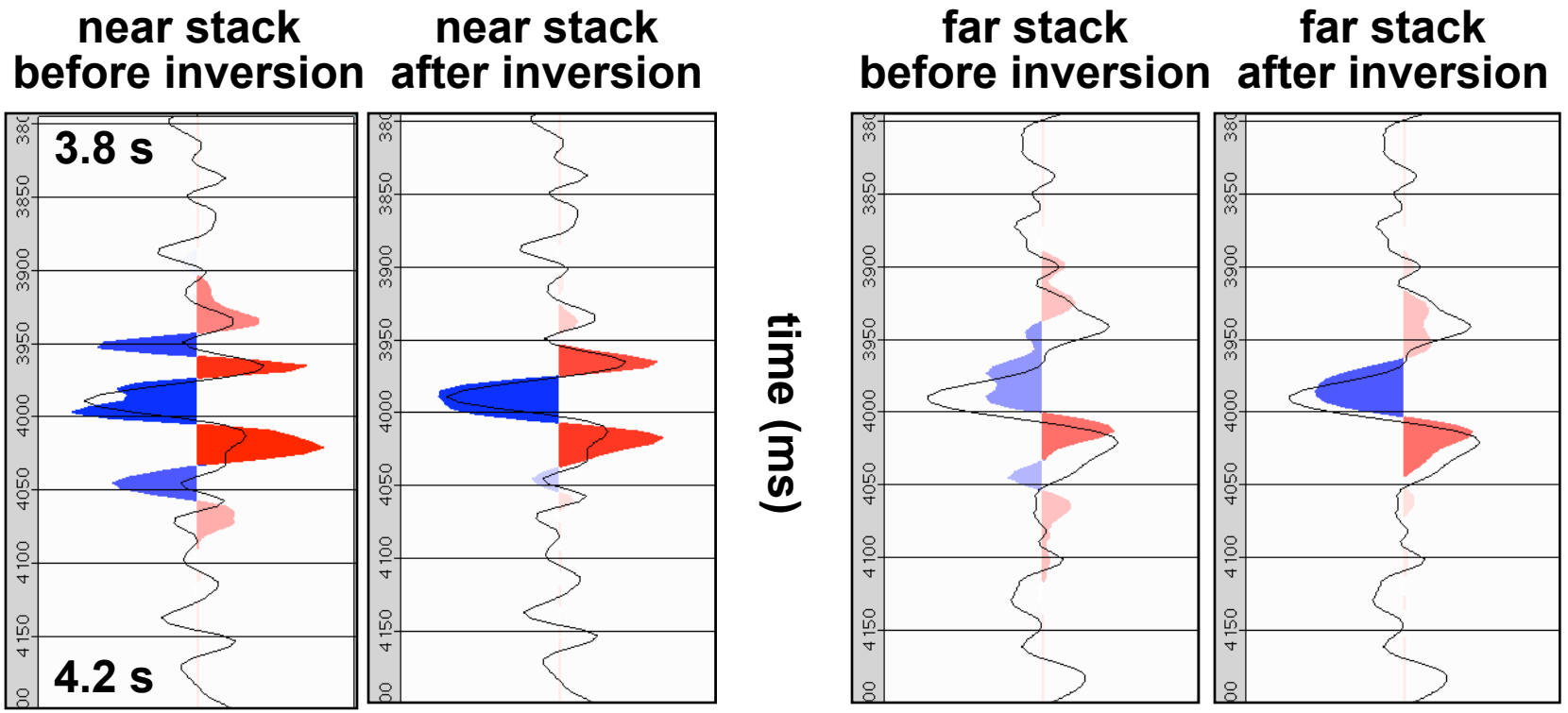


- **prior probability of each fluid fill case**
  - neural network fluid prediction
  - regional information (trap probability, leak probability, etc.)
- **posterior probability of each fluid fill case**
  - adds seismic AVO information

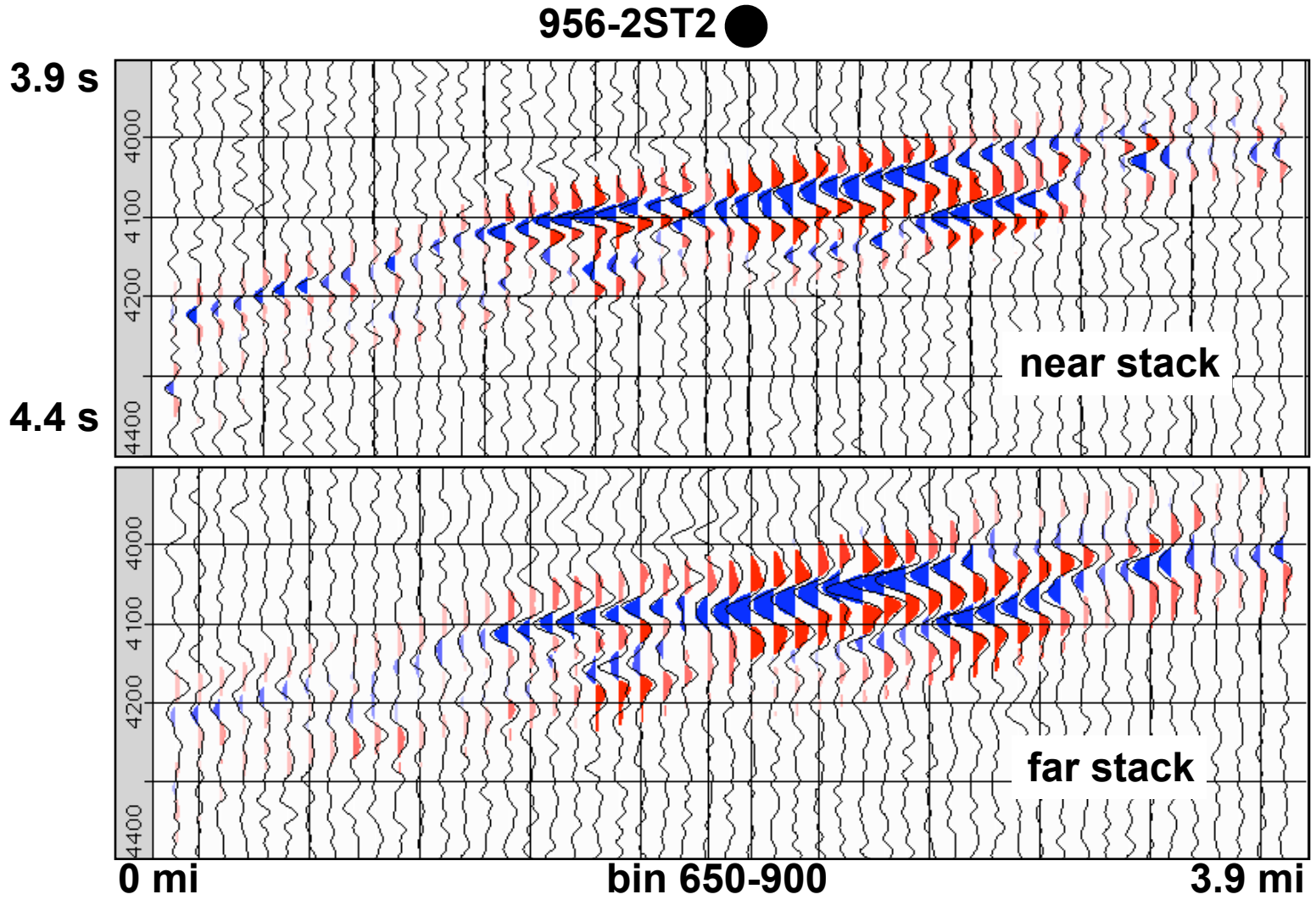
General information about Ram/Powell

- **stratigraphically trapped unconfined turbidites in Eastern Gulf of Mexico**
  - J-sand is an amalgamated channel sheet sand complex
  - L-sand is channel levee
  - M-sand is channel levee to amalgamated channel
  - N-sand is massive channels
- **in 2500 to 4000 ft of water**
- **250 MMBBL equivalent**

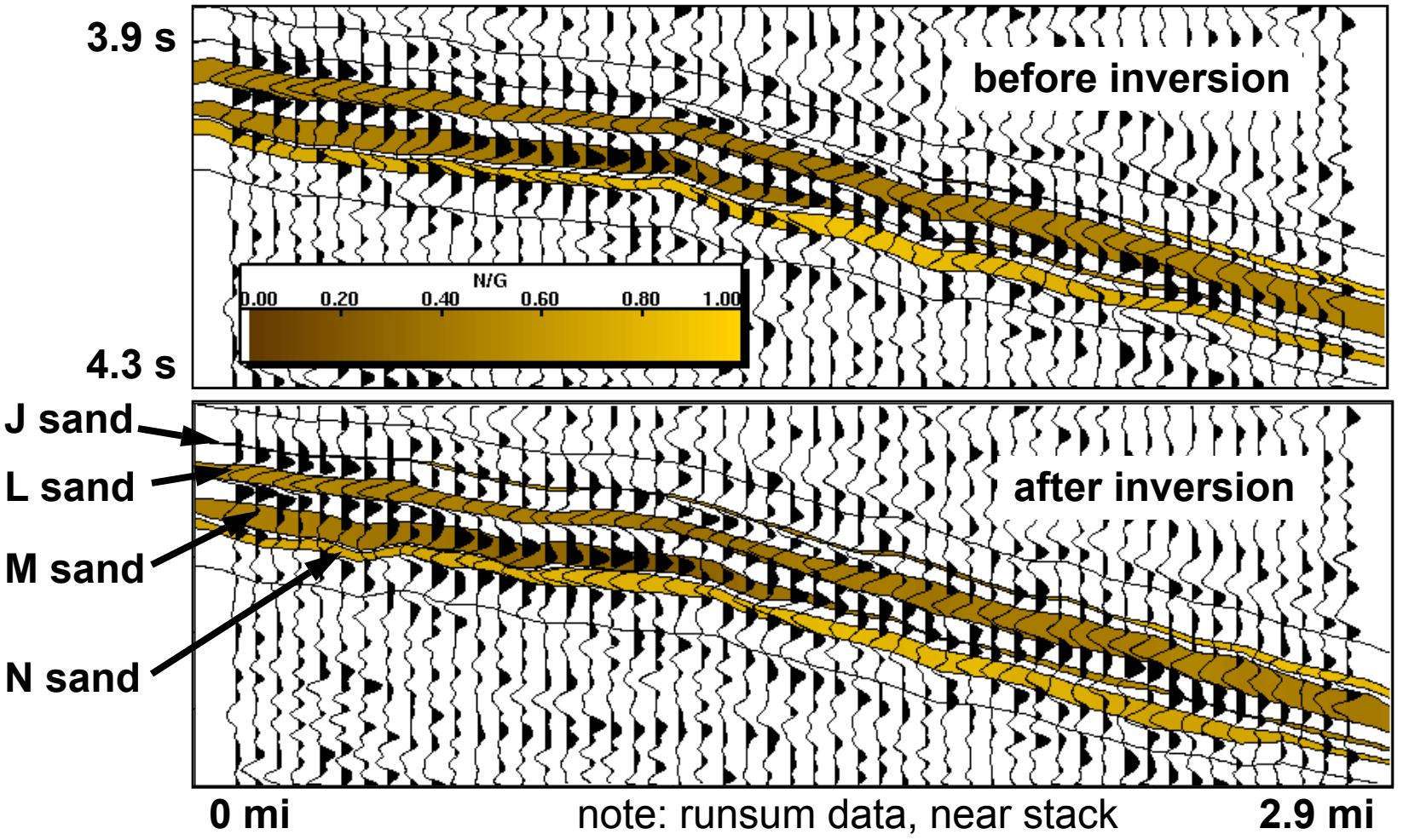
PROMISE inversion at a well (912-2)



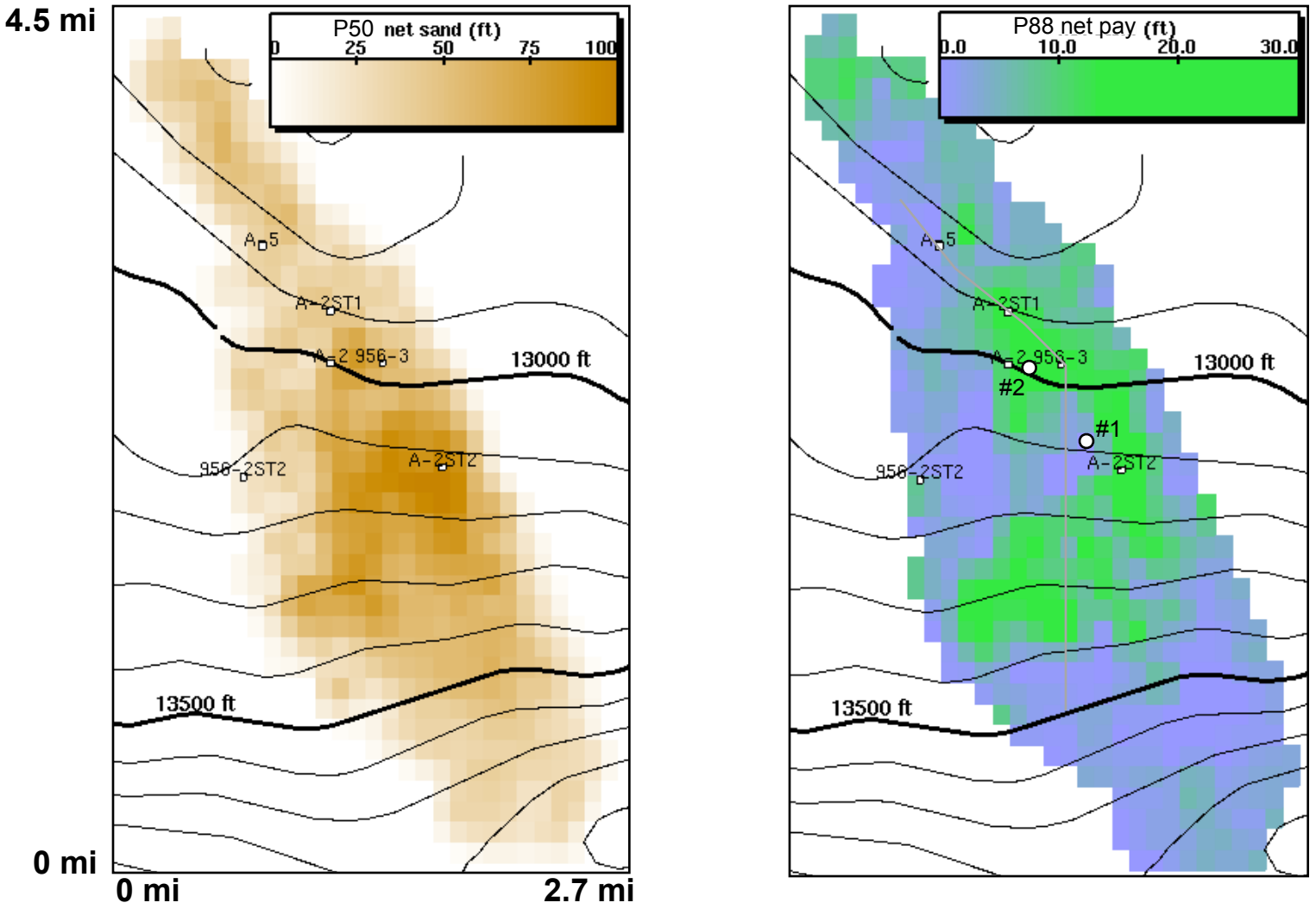
Synthetic data after inversion (red-blue) compared to seismic runsum data (trk 8575)



PROMISE inversion updates P50 model

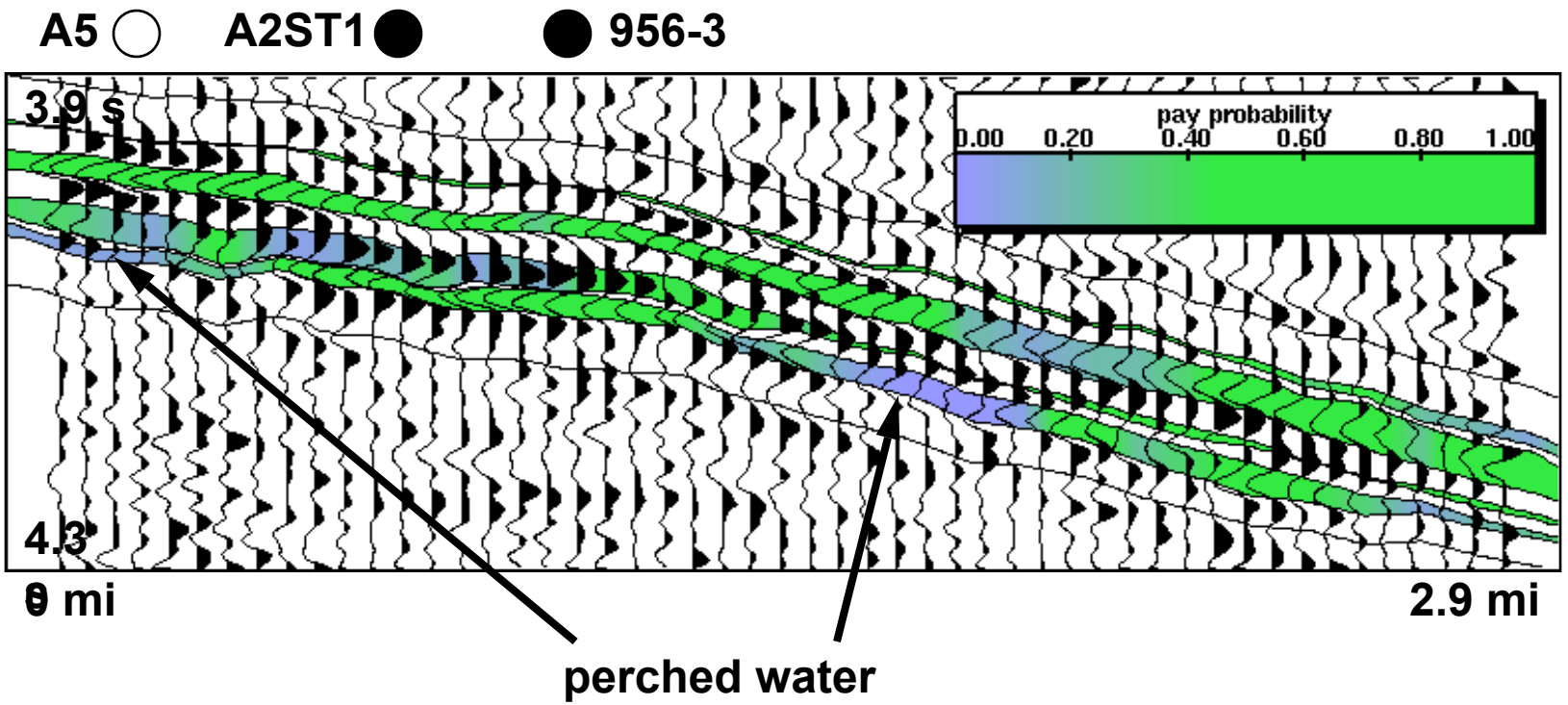


Inversion results of N sand shows perched water levels



net pay = thickness * N/G * porosity * pay probability

Cross section showing perched water level in N-sand



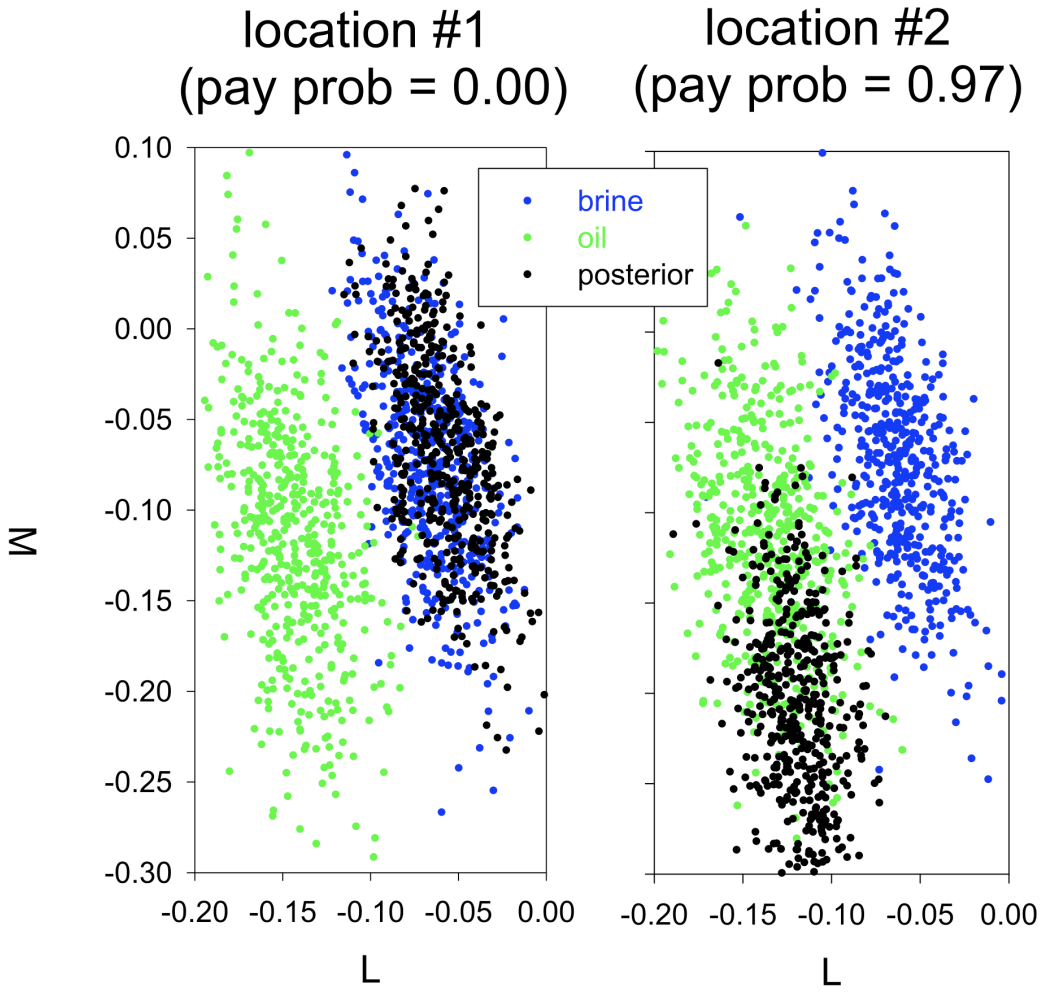
note: runsum data

Inversion is consistent with well information

- **A5 wet**
- **A2 OWC**
- **A2ST1, 956-3, A2ST2, 956ST2 oil**
- **956-3 and A2ST2 in pressure communication**
- **mass balance gives 30 MMBBL connected to A2ST2**

pore volume (MMBBL)	probabilistic inversion estimate
P12	26
P50	36
P88	48

View of the inversion results in L-M space



Multiple stack inversion adds value at location #2 (oil in N sand)

fluid prediction	with AVO	without AVO
oil	65%	41%
gas	32%	38%
residual gas	3%	3%
brine	0%	18%