

Redwater Leduc Reef, Alberta: seismic characterization and CO₂ fluid replacement modeling

Taher M. Sodagar

Don C. Lawton

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UNIVERSITY OF
CALGARY



Outline

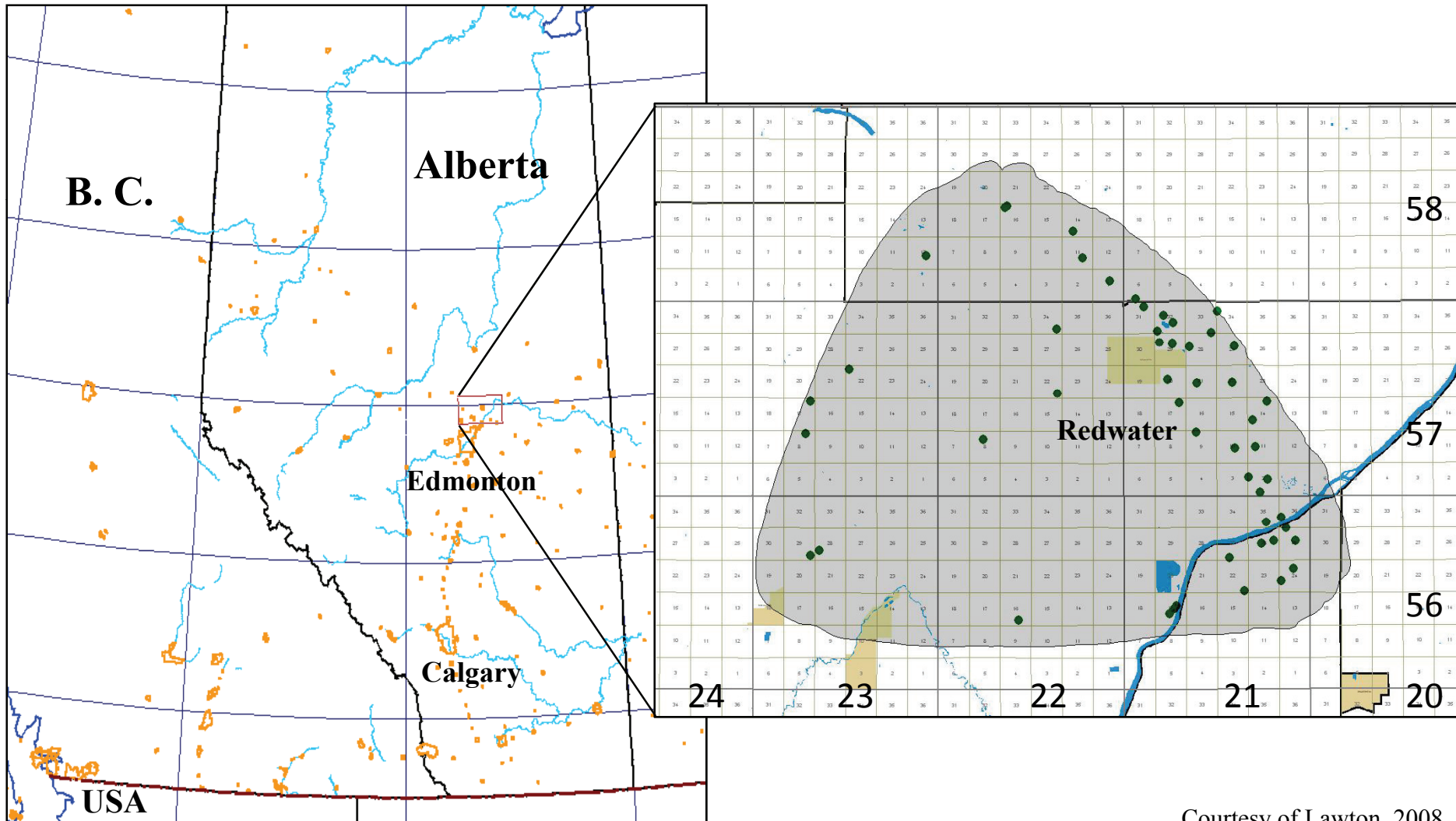
- **Objectives and Methods**
- **Geology and reef overview**
- **Results**
 - Seismic interpretation**
 - Seismic modeling**
- **Conclusions**

Objectives/Methods

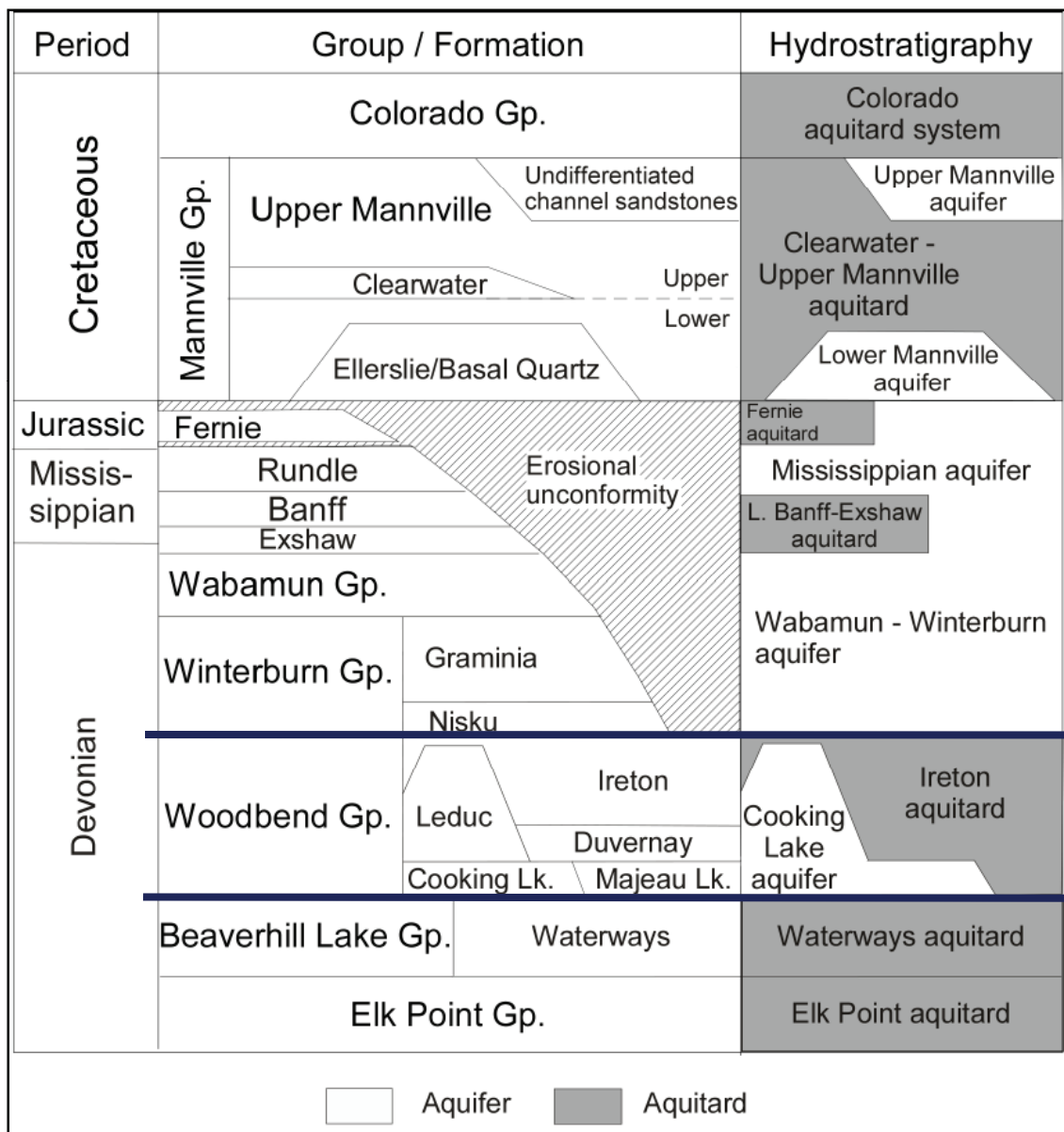
Seismic characterization and evaluation of the Devonian Redwater reef for geological storage of CO₂ and seismic monitoring

- **Evaluate 2D seismic modeling attributes and reflection character**
- **Determine Redwater reef litho-facies**
- **Multi-component ray tracing**
- **Gassmann fluid substitution**
- **Time-lapse seismology for CO₂ monitoring**

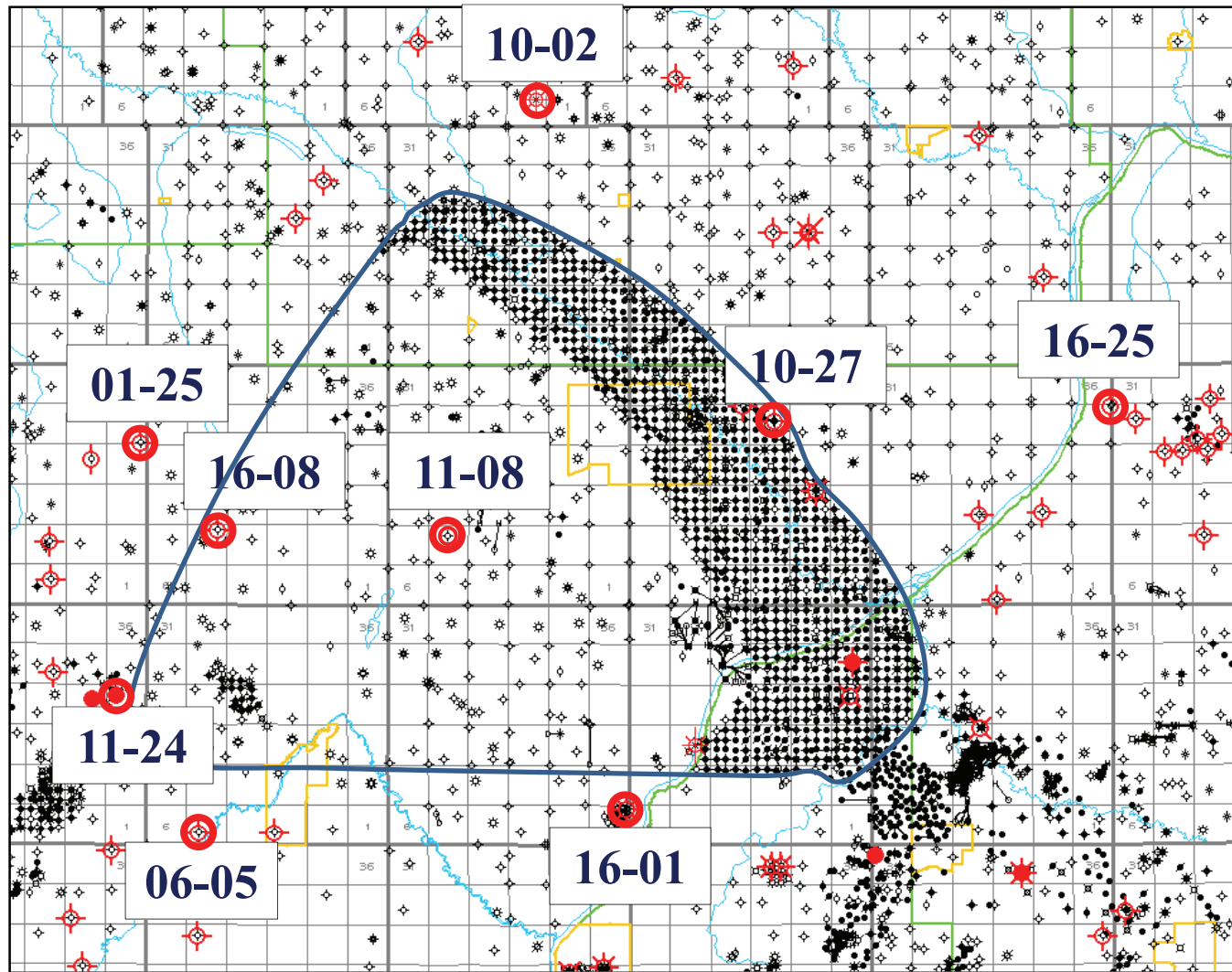
Redwater reef study area



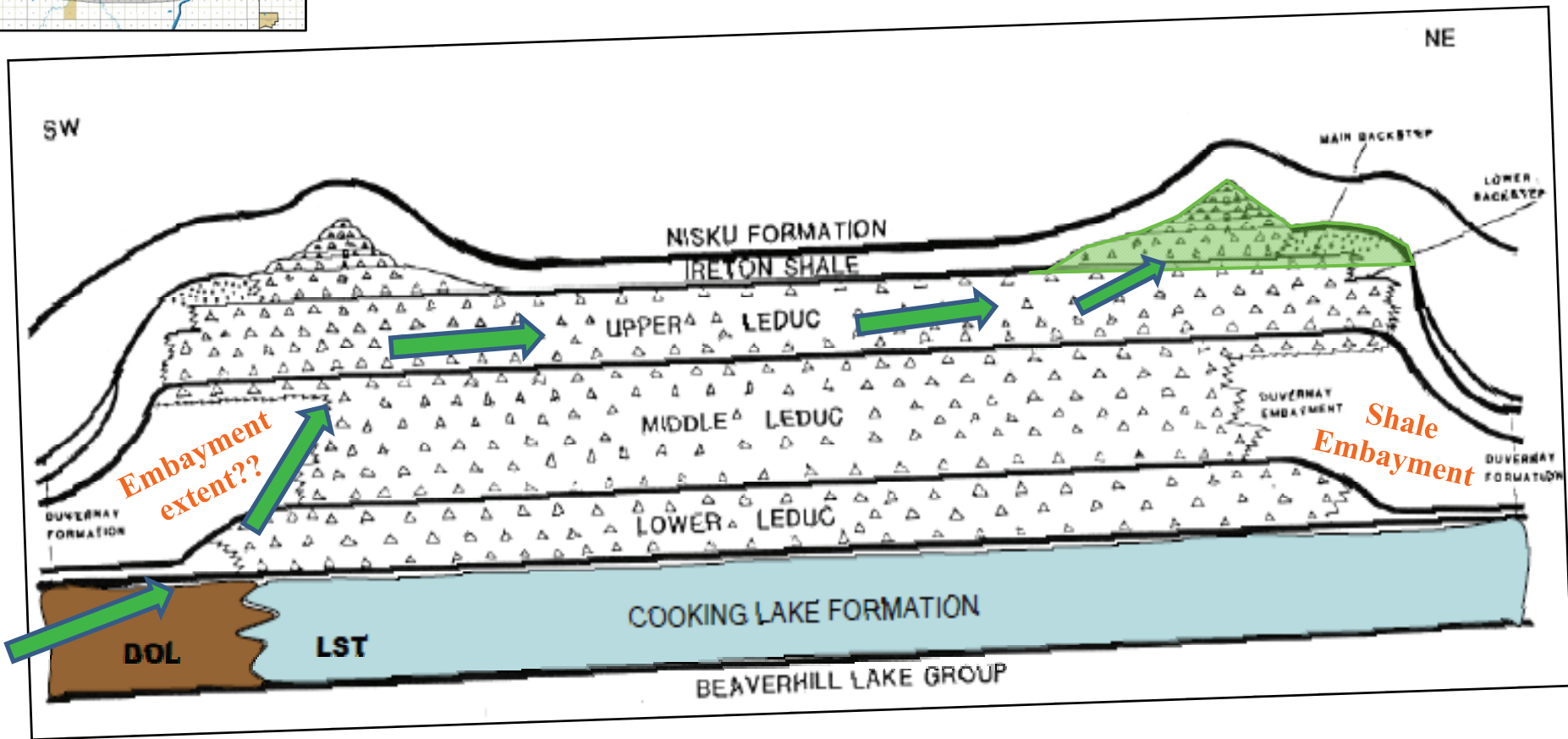
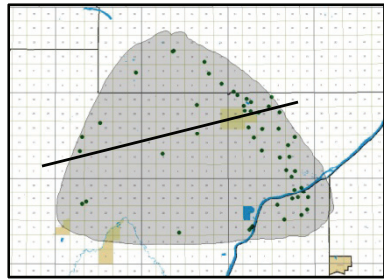
Geological setting



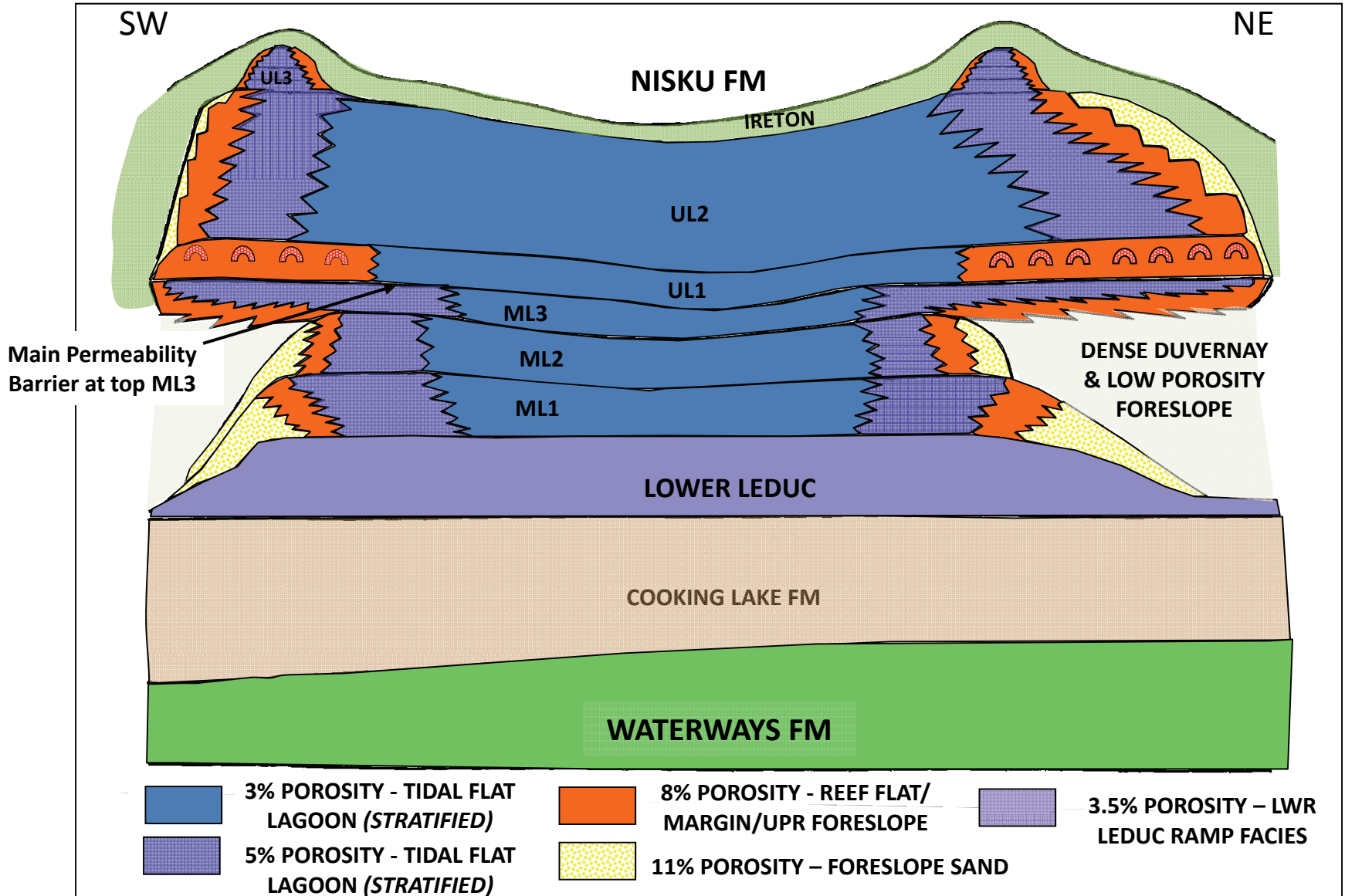
Redwater Wells for Seismic Interpretation



Reef subdivisions and HC migration

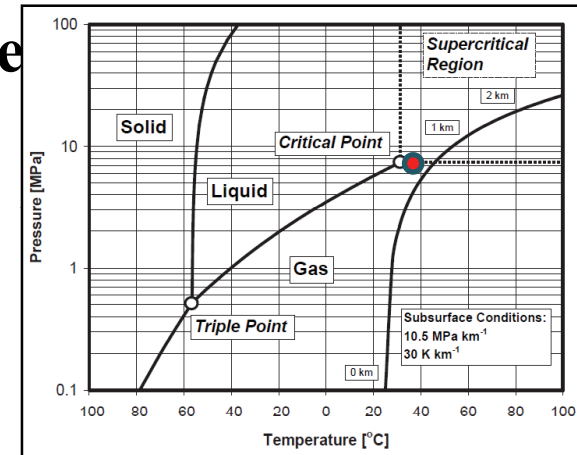


Reef porosity and facies distribution



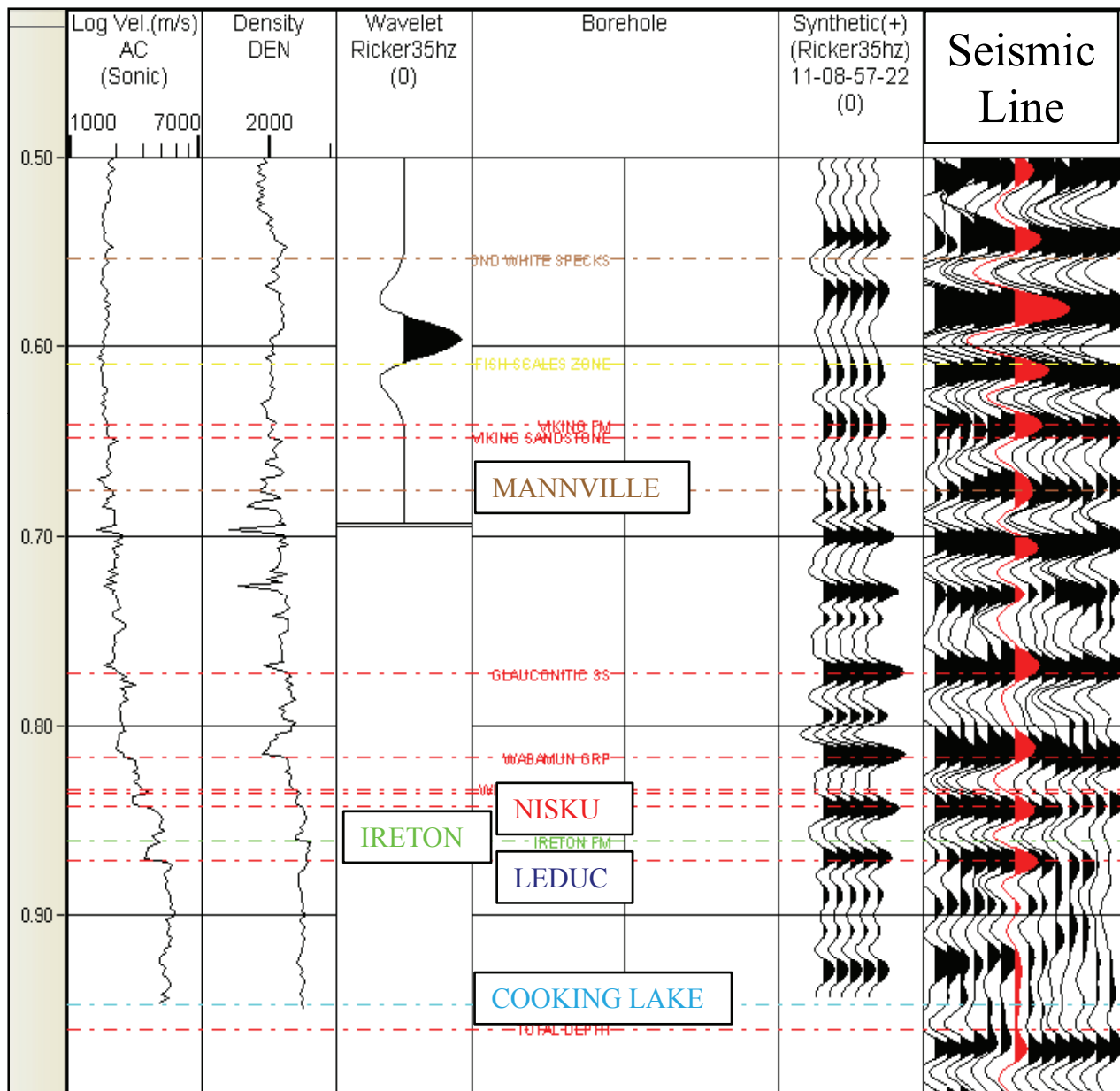
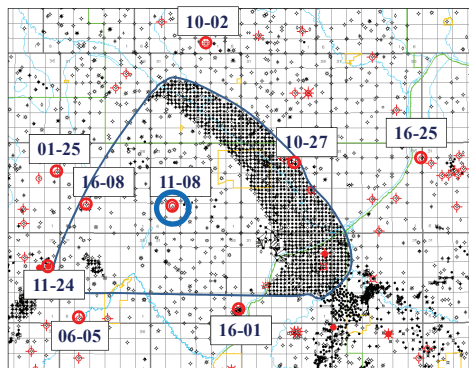
Leduc Formation properties

- **Porosity: 1-17% (Avg. 7%)**
 - Intercrystalline, moldic, and fracture
- **Permeability:**
 - Horizontal: 0.01-4000 md
 - Vertical: 0.02-670 md

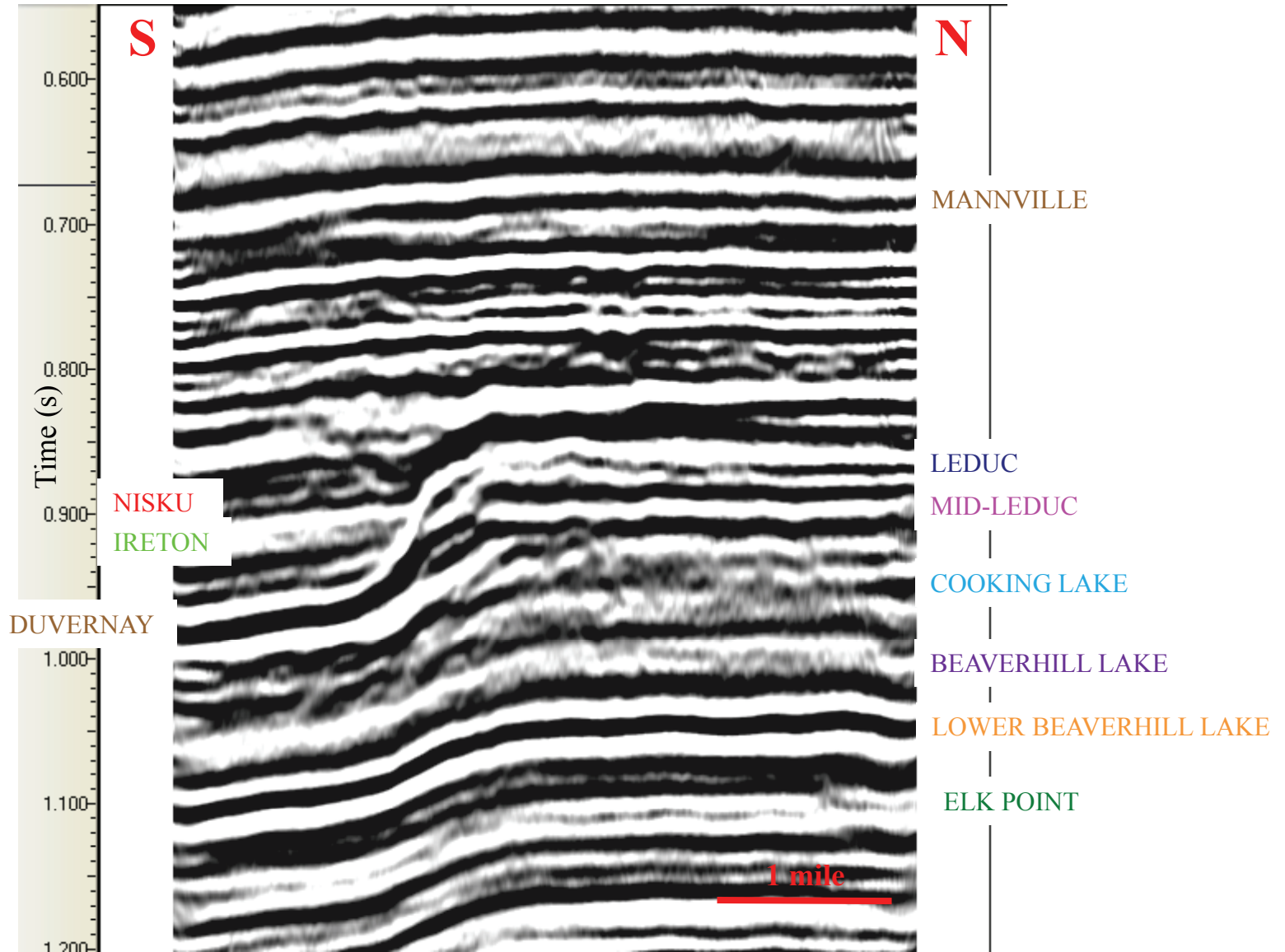


- **Pressure 7.4 MPa and Temperature 34°C**
- **Formation water NaCl, salinity 107 mg/l**
- **Leduc depth: 994 - 1120 m**

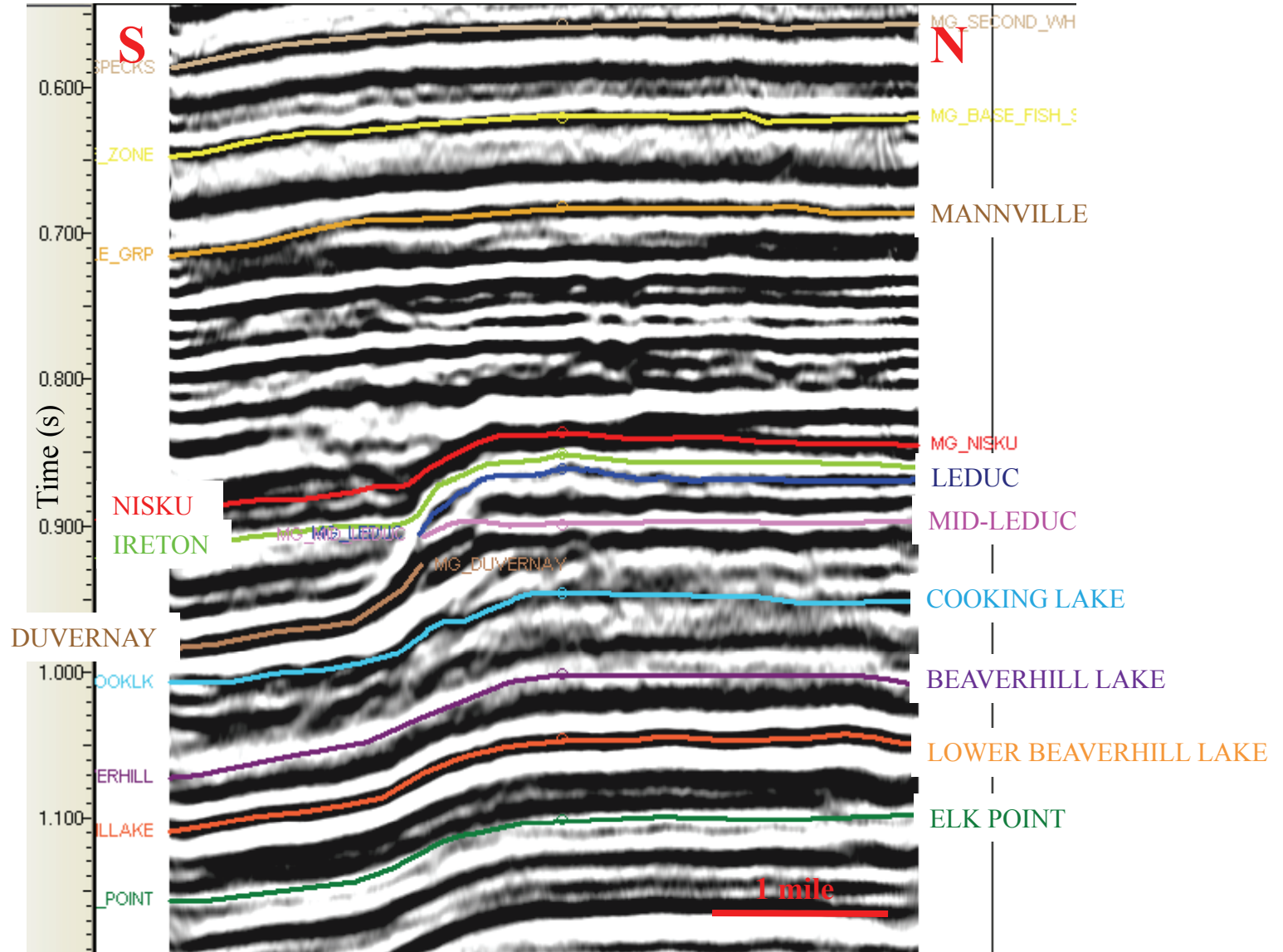
Well 11-08 synthetic tie to seismic data



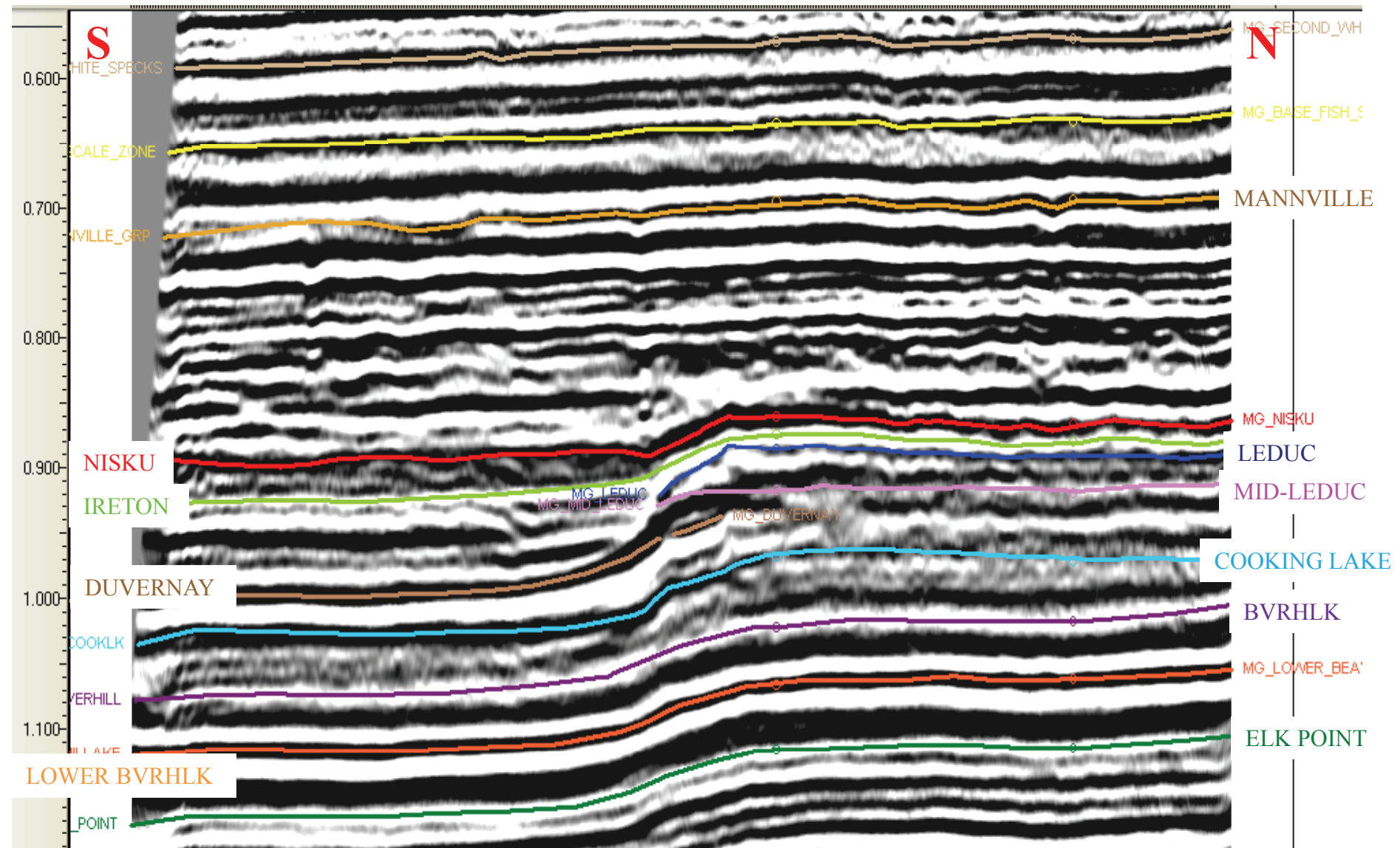
Reef margin seismic line



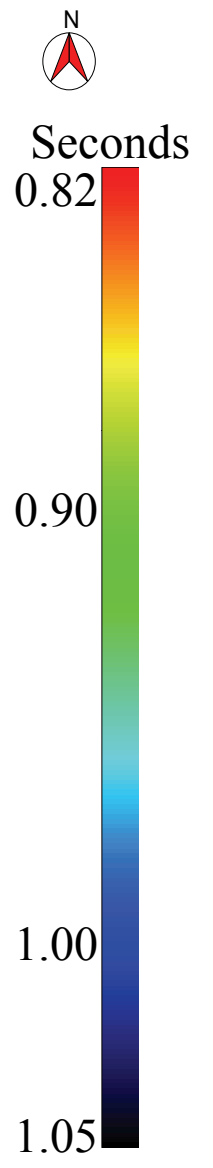
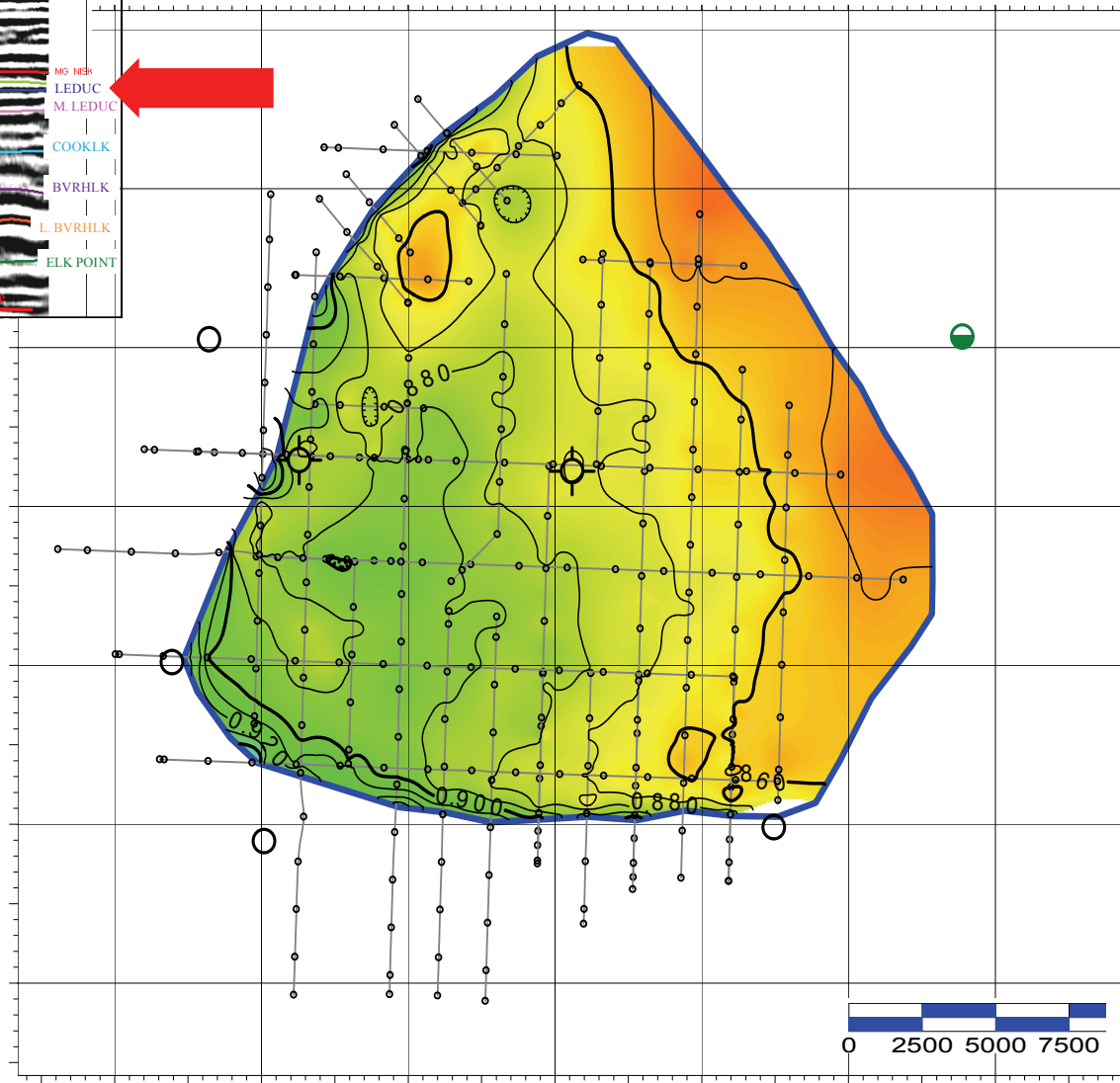
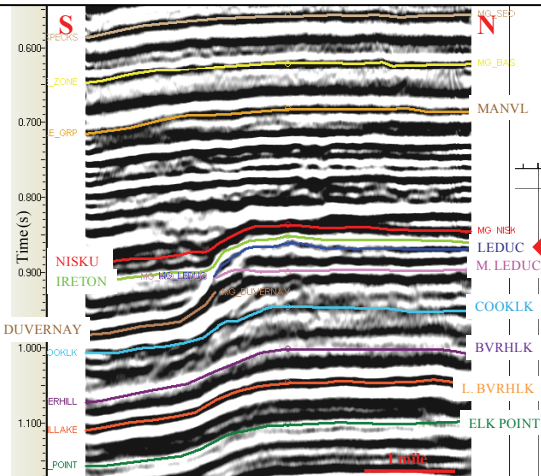
Reef margin seismic line



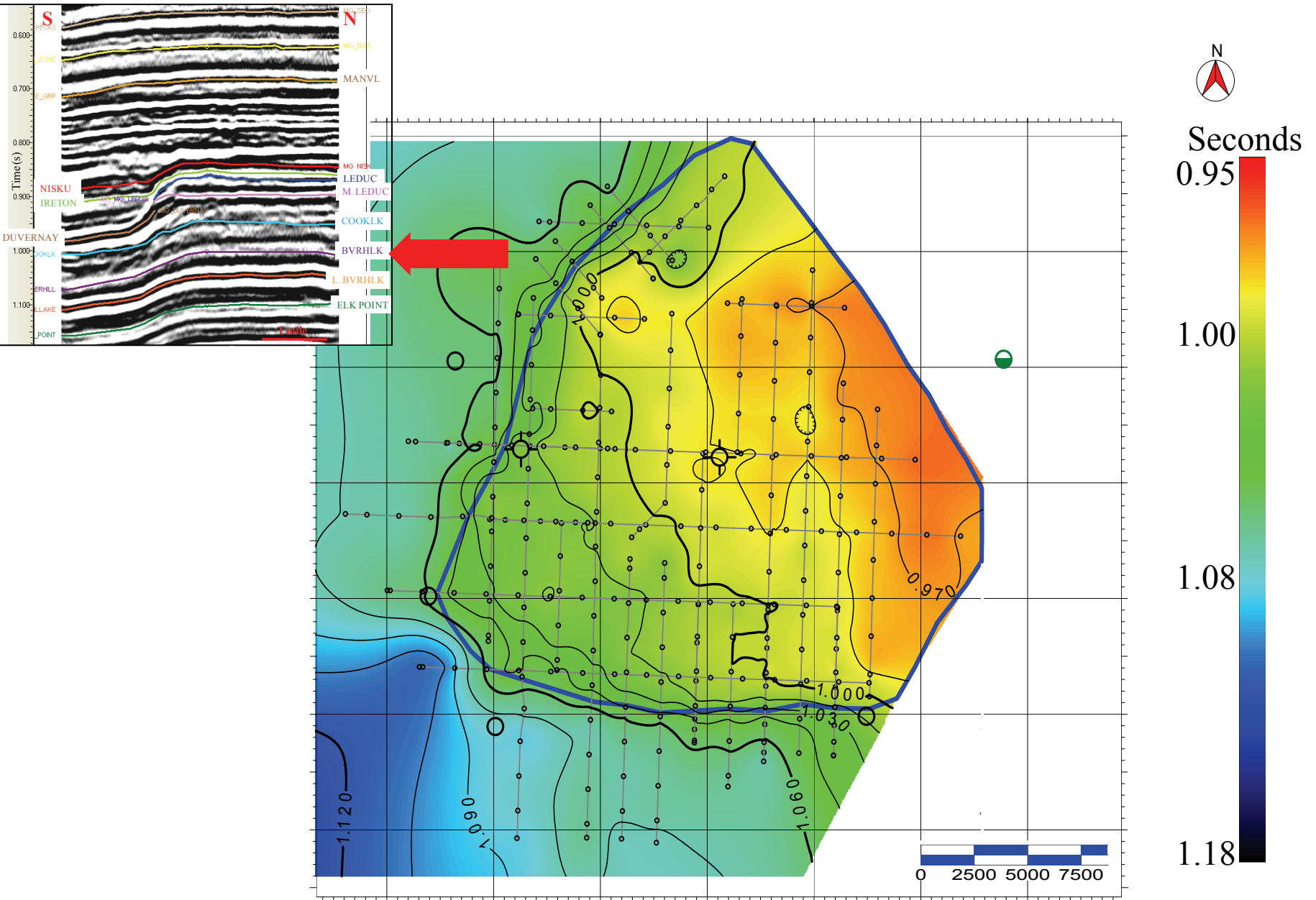
Reef margin and with embayment



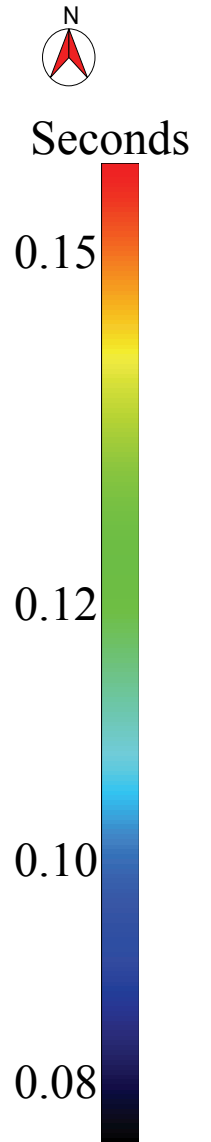
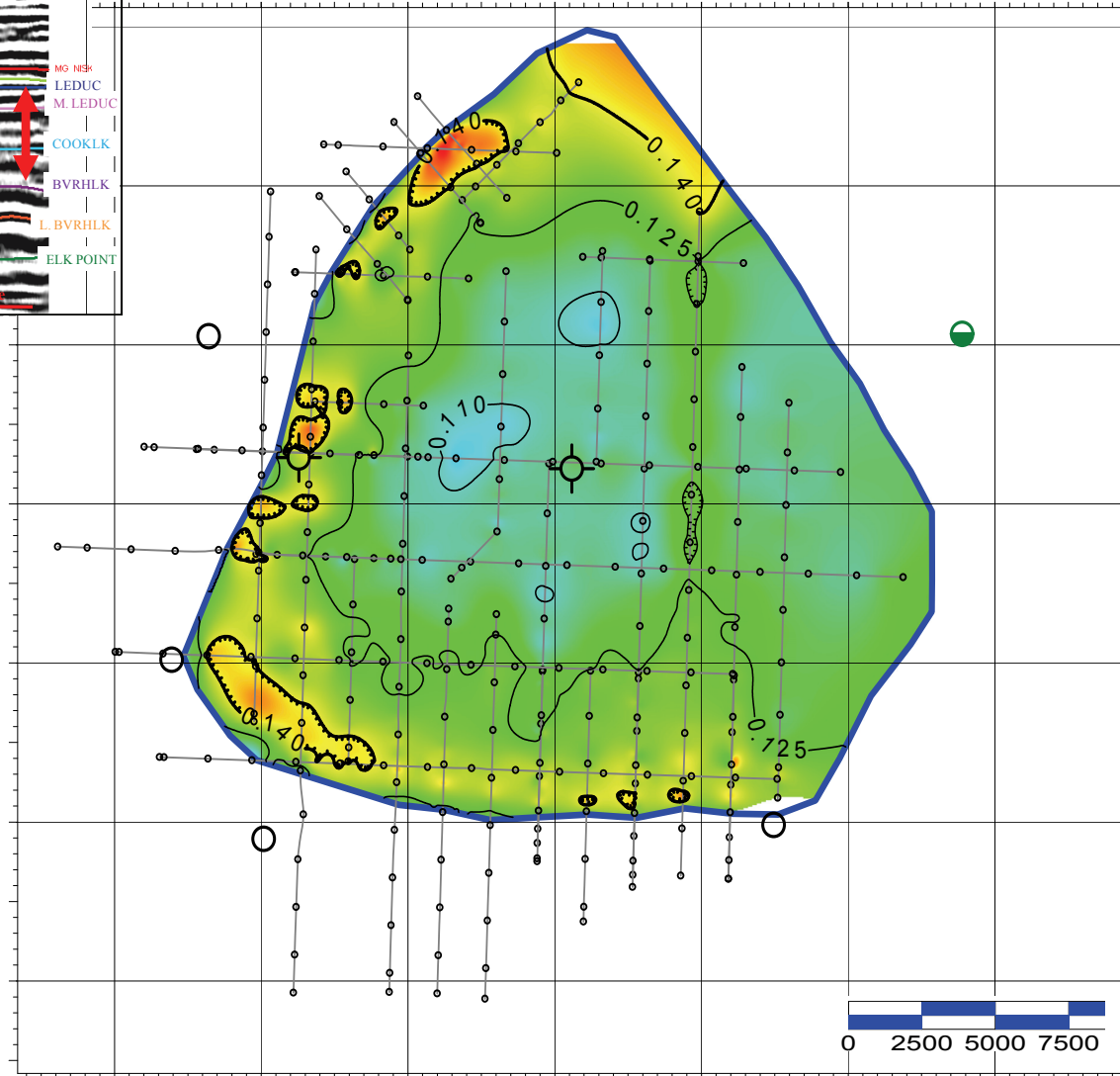
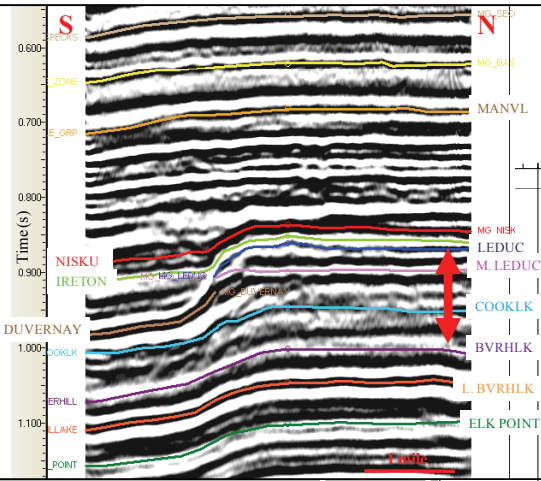
Leduc time structure map



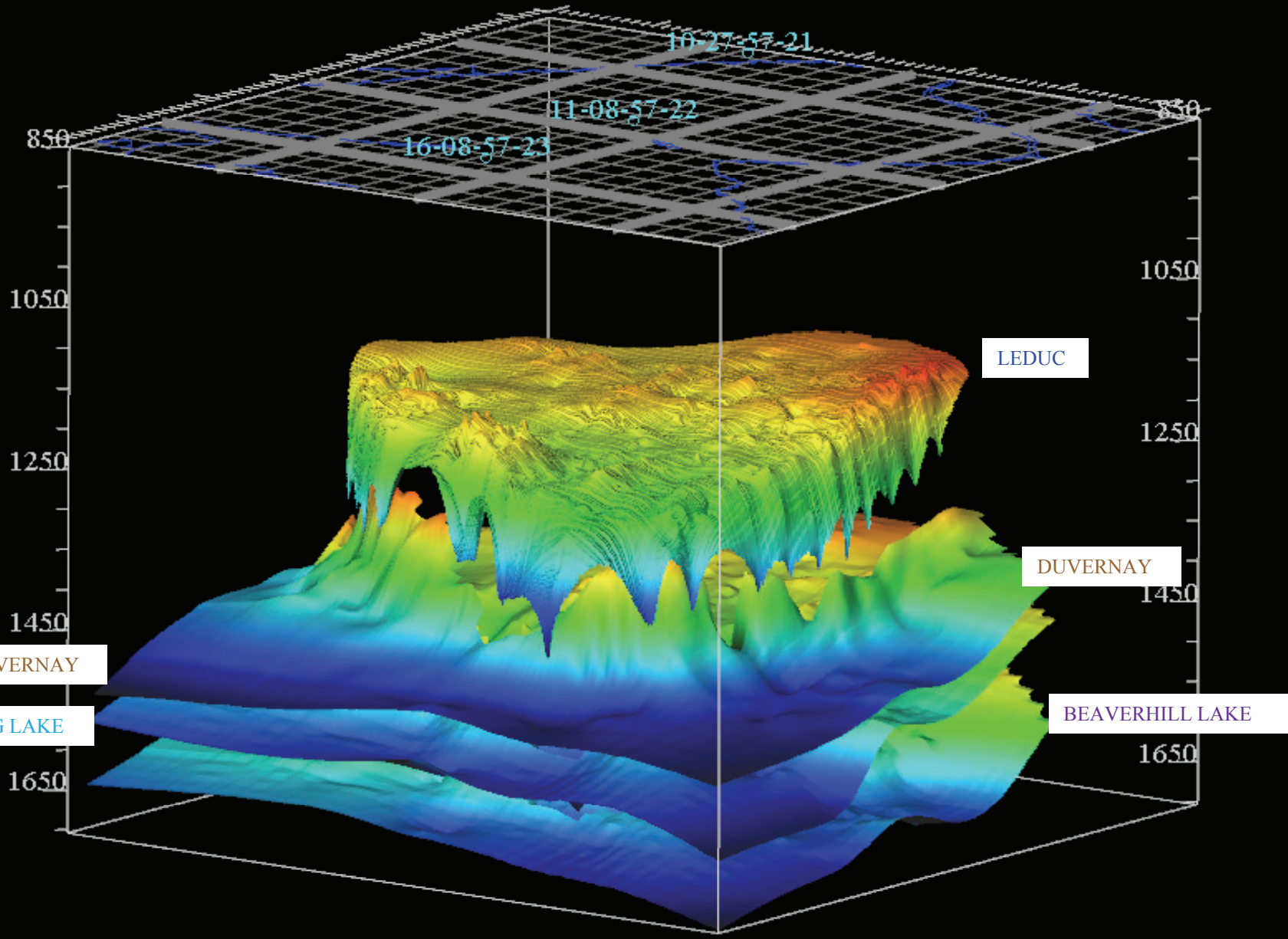
Beaverhill Lake time structure map



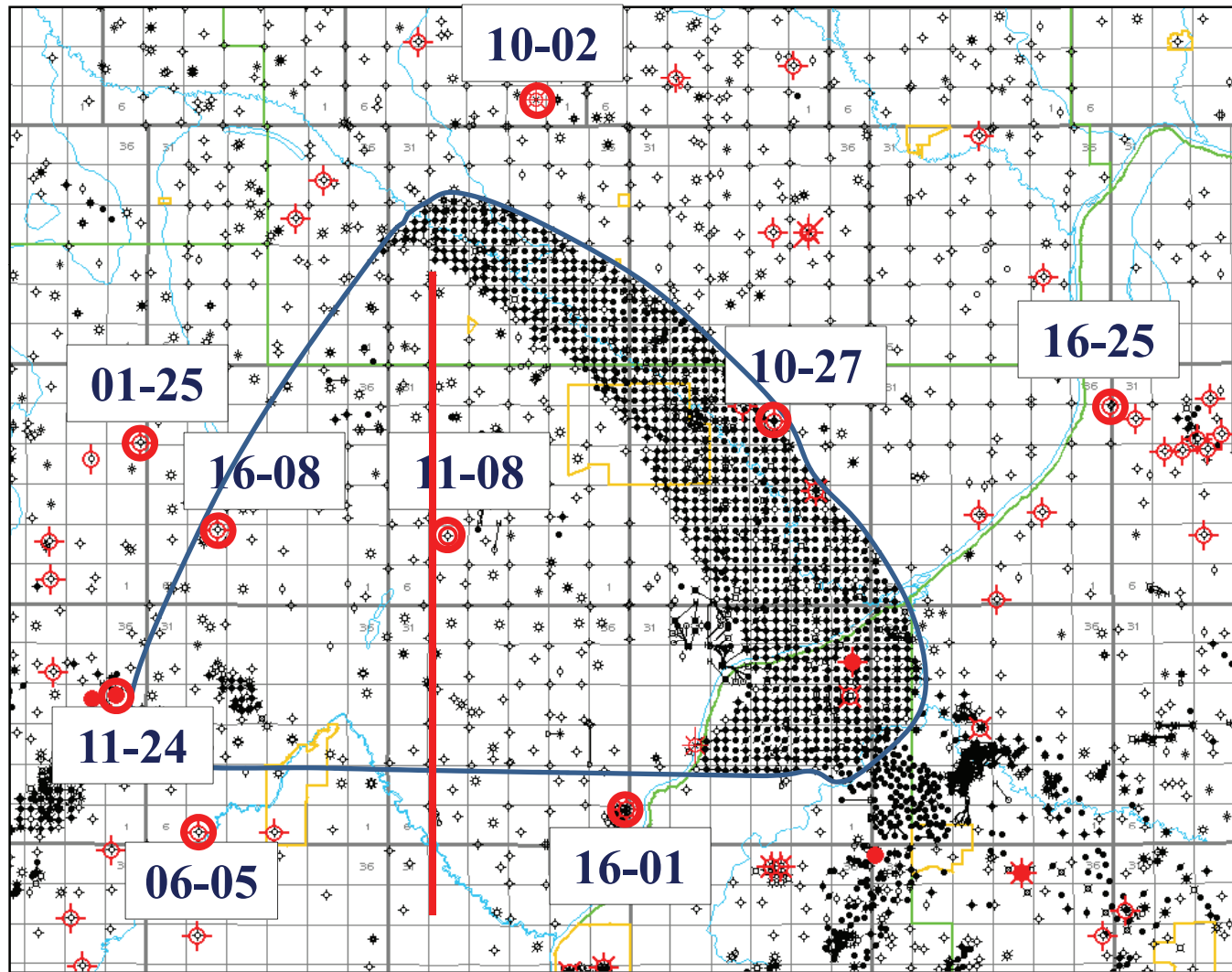
Leduc - Beaverhill Lake isochron map



Redwater reef 3D view in depth

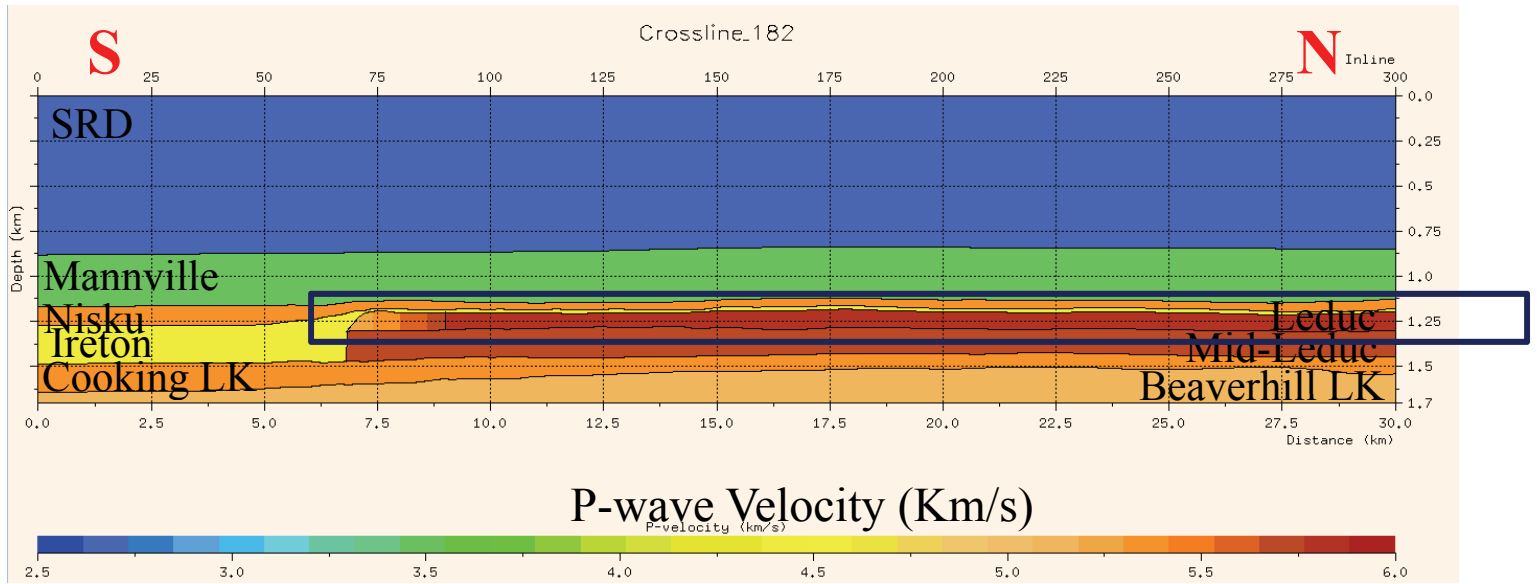


Redwater wells for seismic interpretation

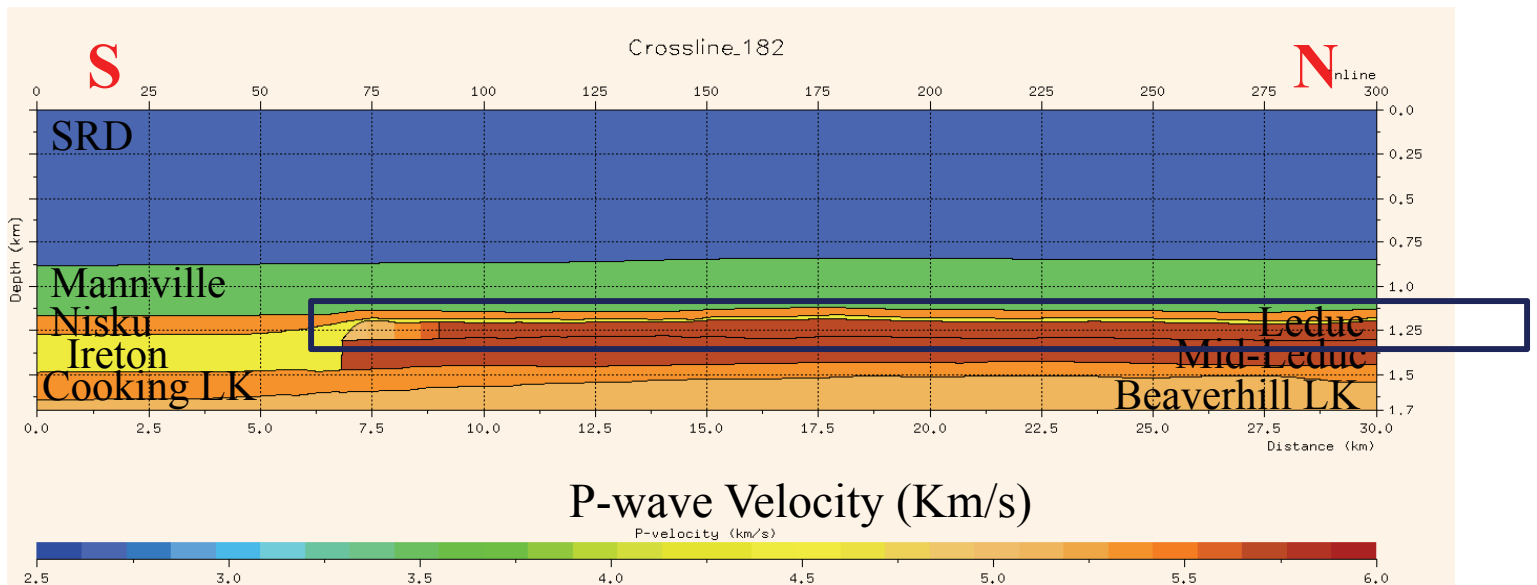


2D geological model (P-wave velocity)

Baseline

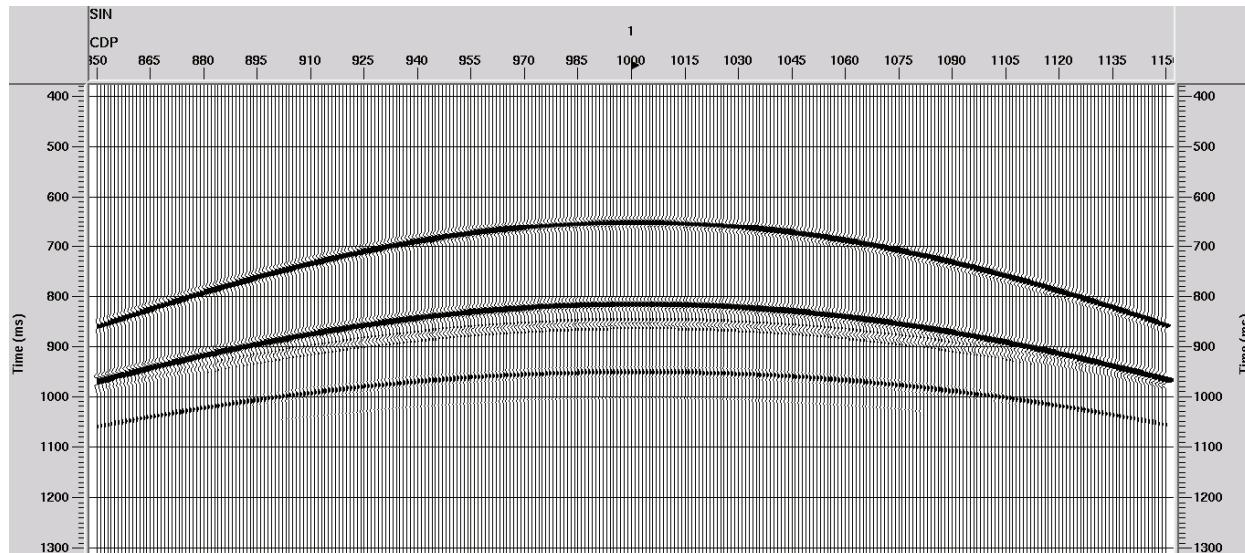


Monitor

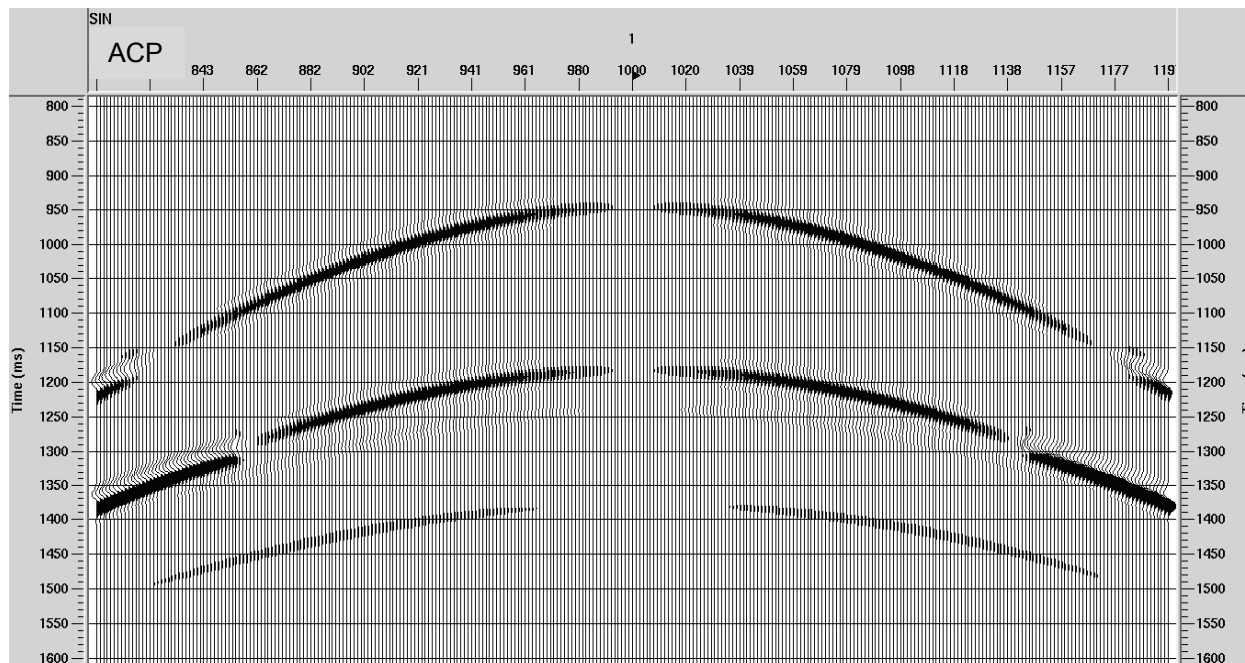


Numerical common shot gathers

PP
40 Hz
Ricker

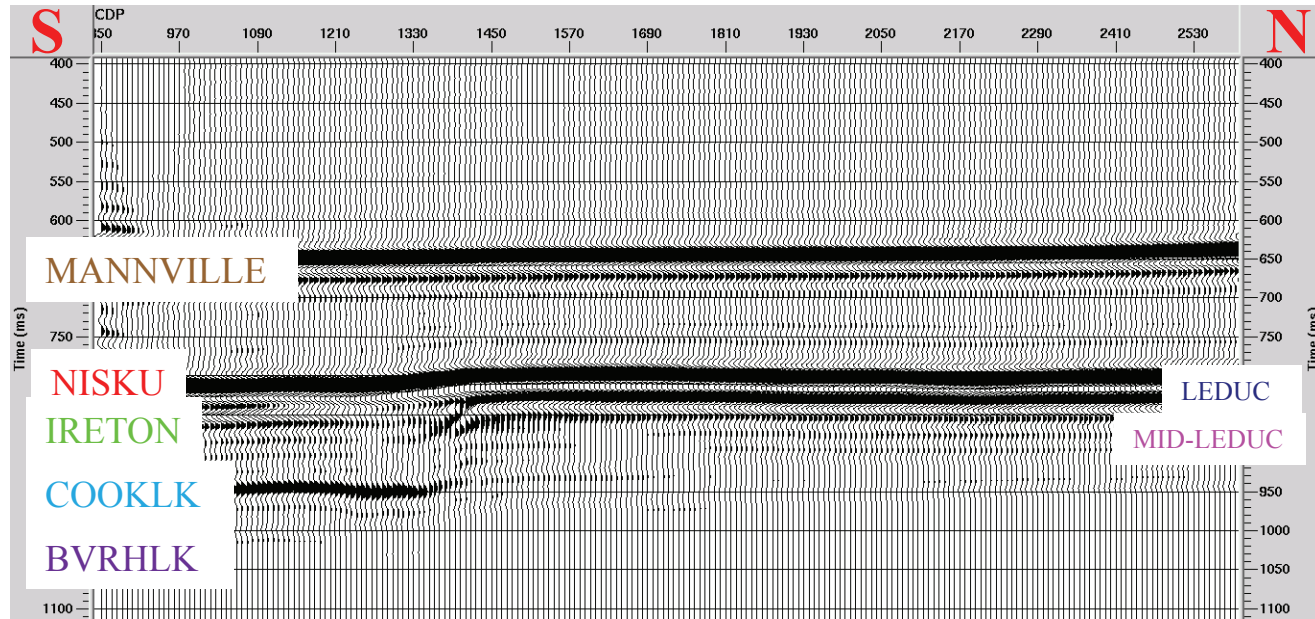


PS
20 Hz
Ricker

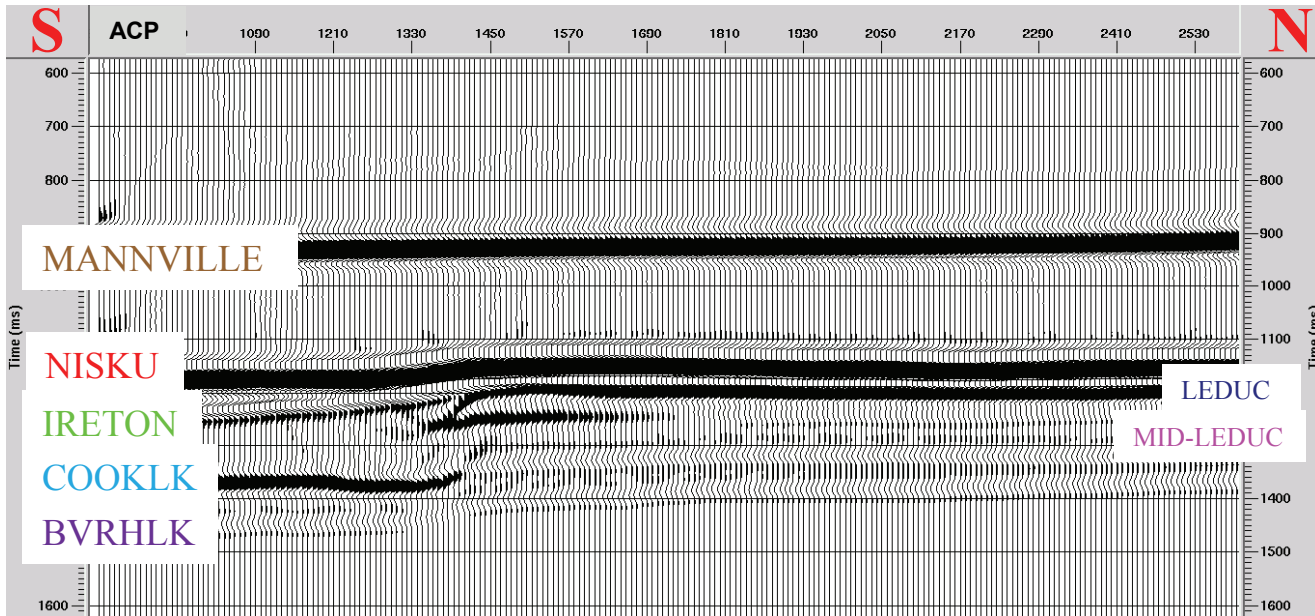


Pre-stack time migrated seismic section

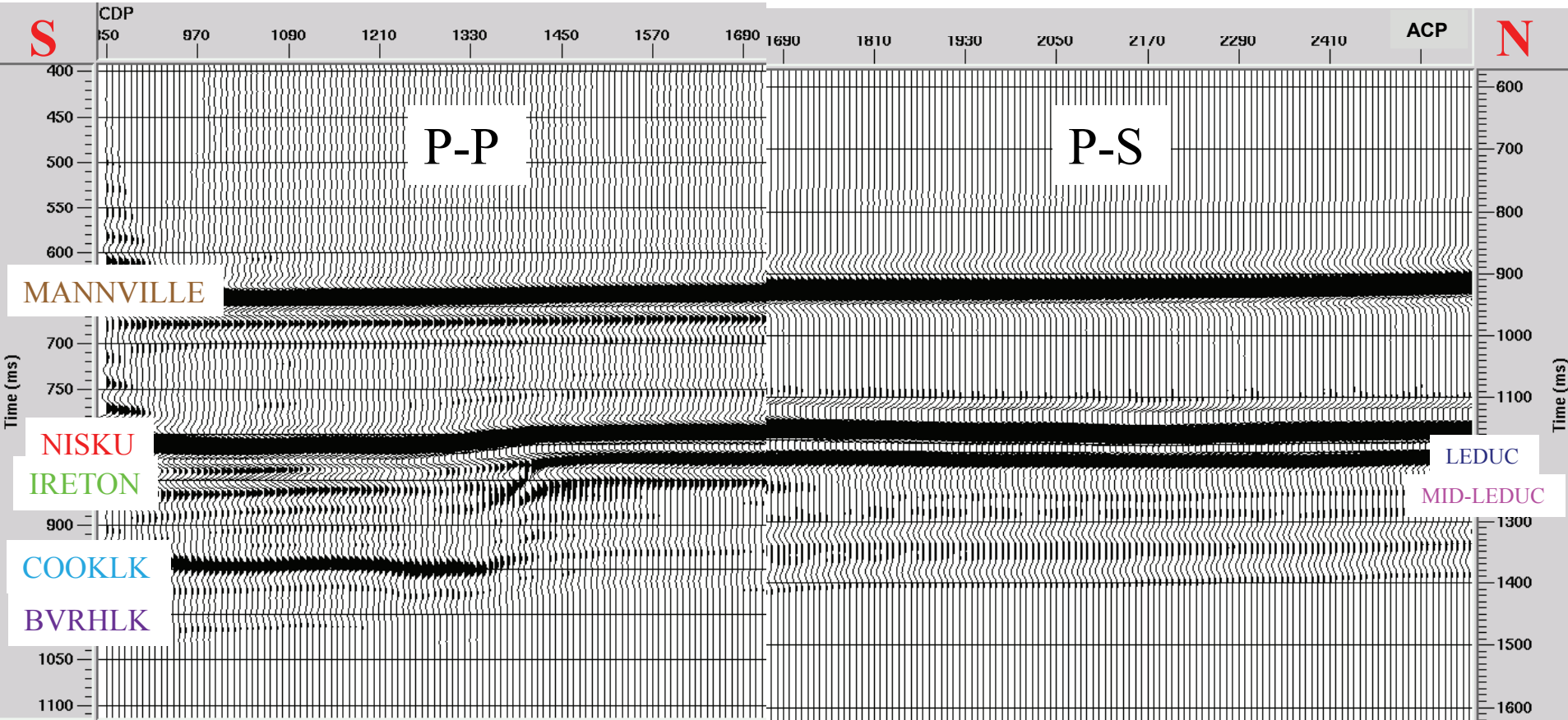
PP



PS

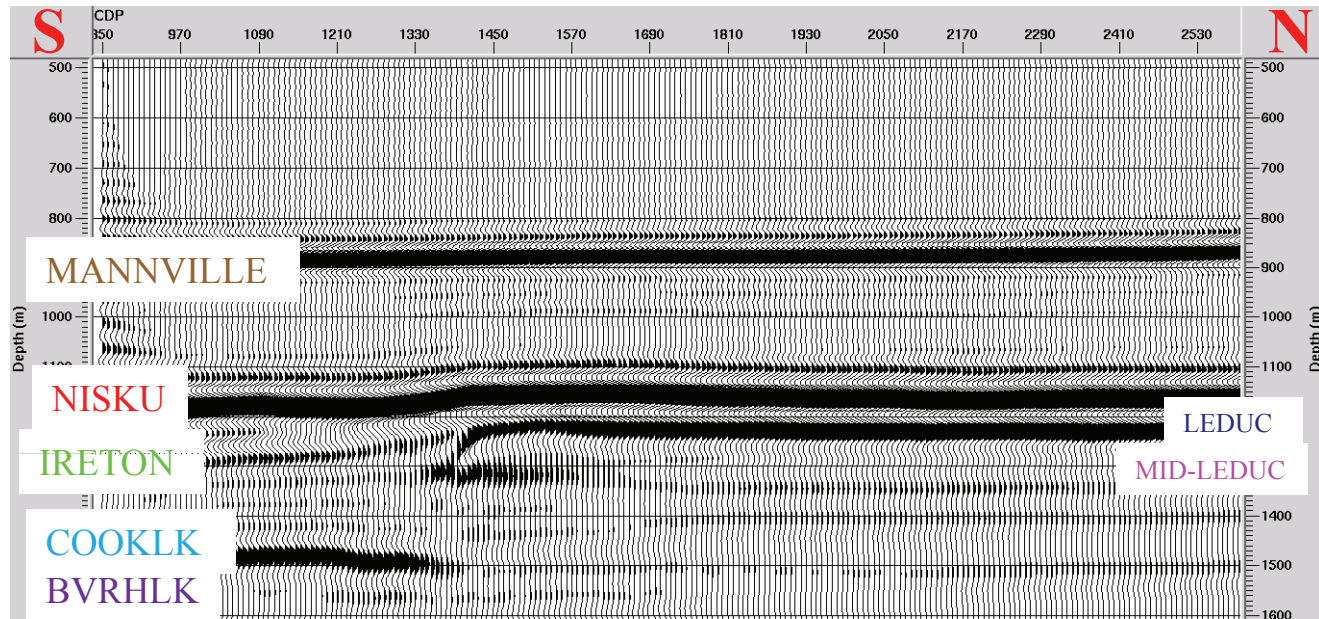


PSTM stack P-P & P-S registration

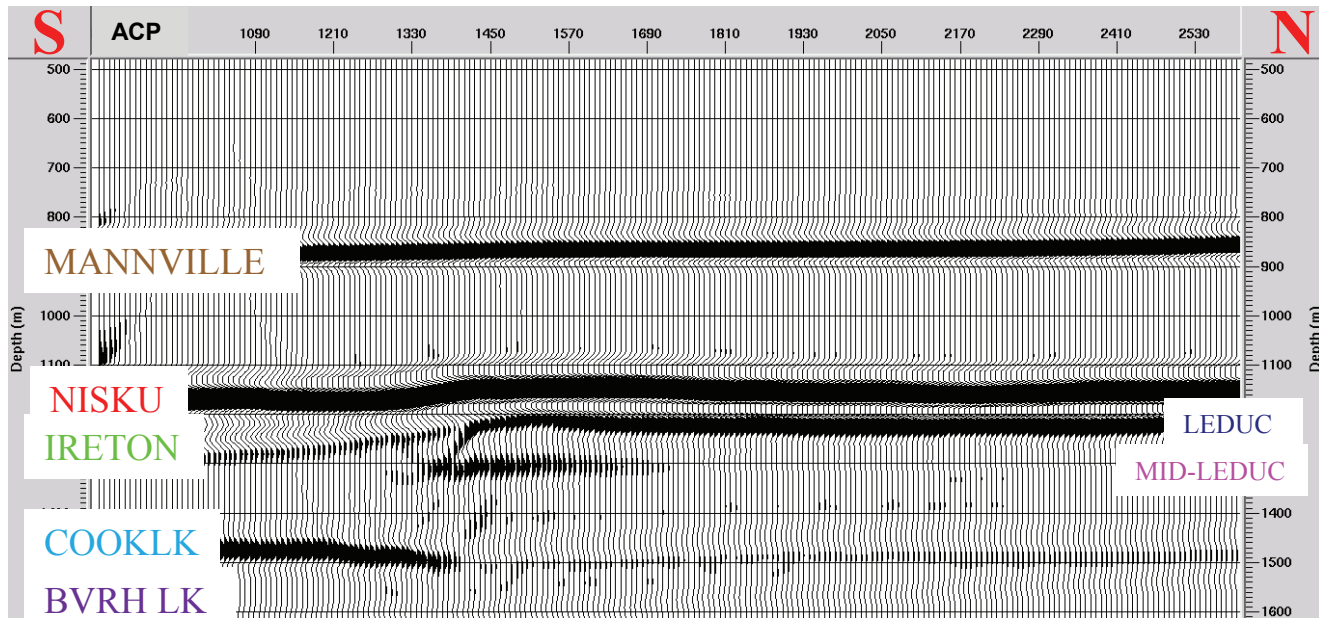


Pre-stack depth migrated seismic section

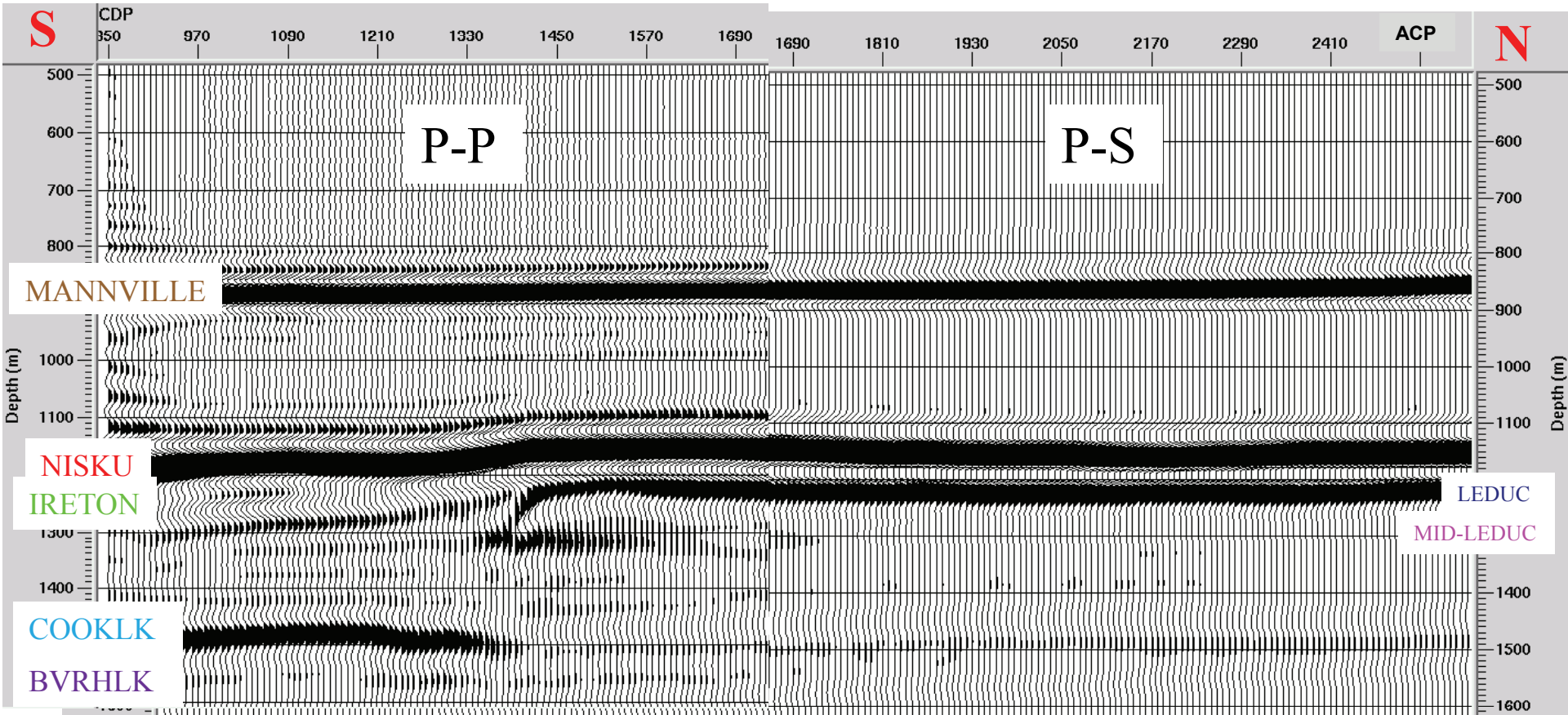
PP



PS

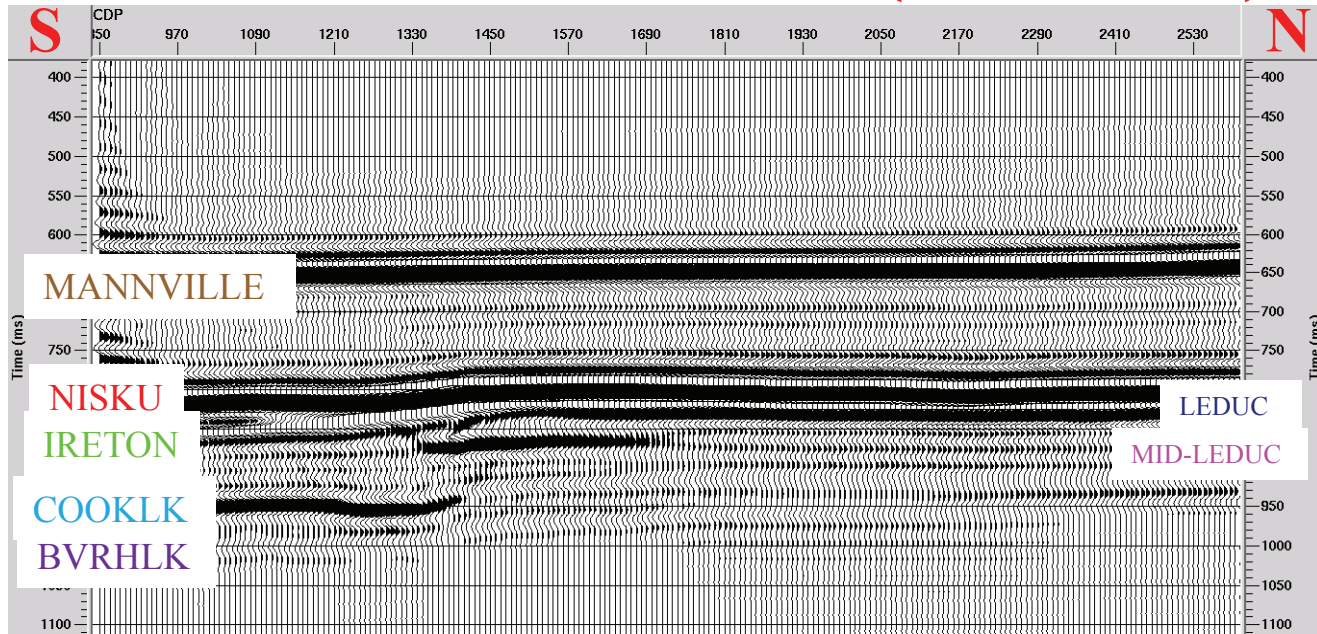


PSDM stack P-P & P-S comparison

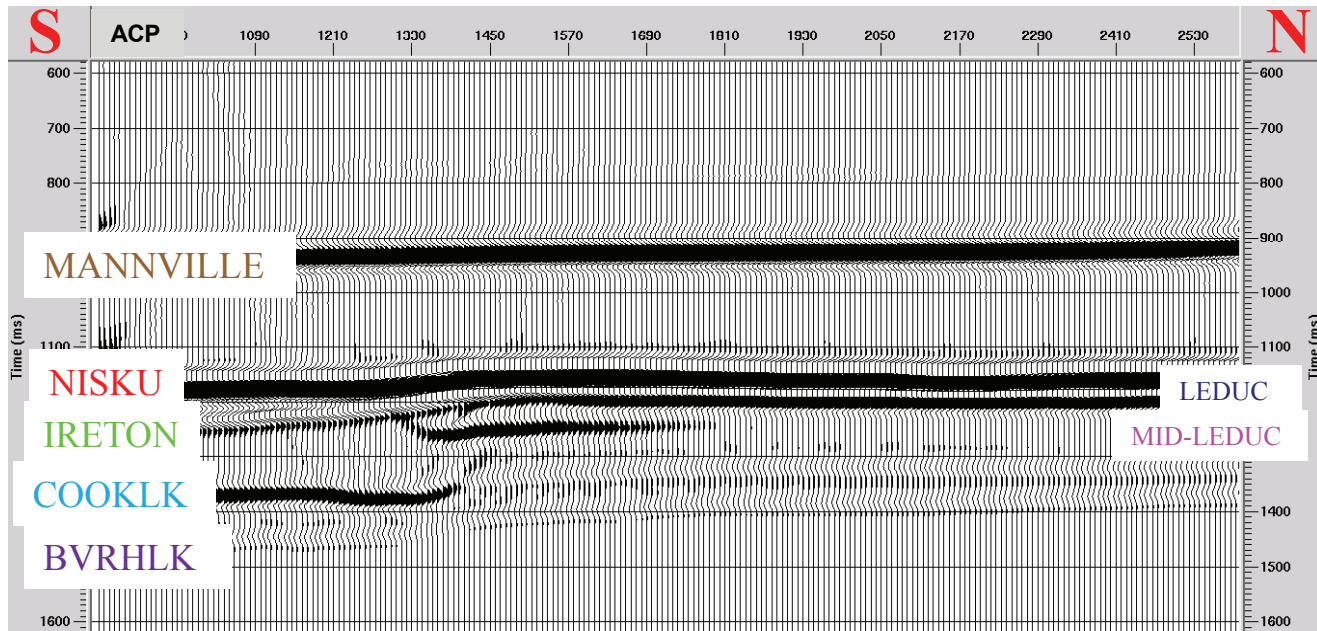


PSTM seismic section (Monitor)

PP

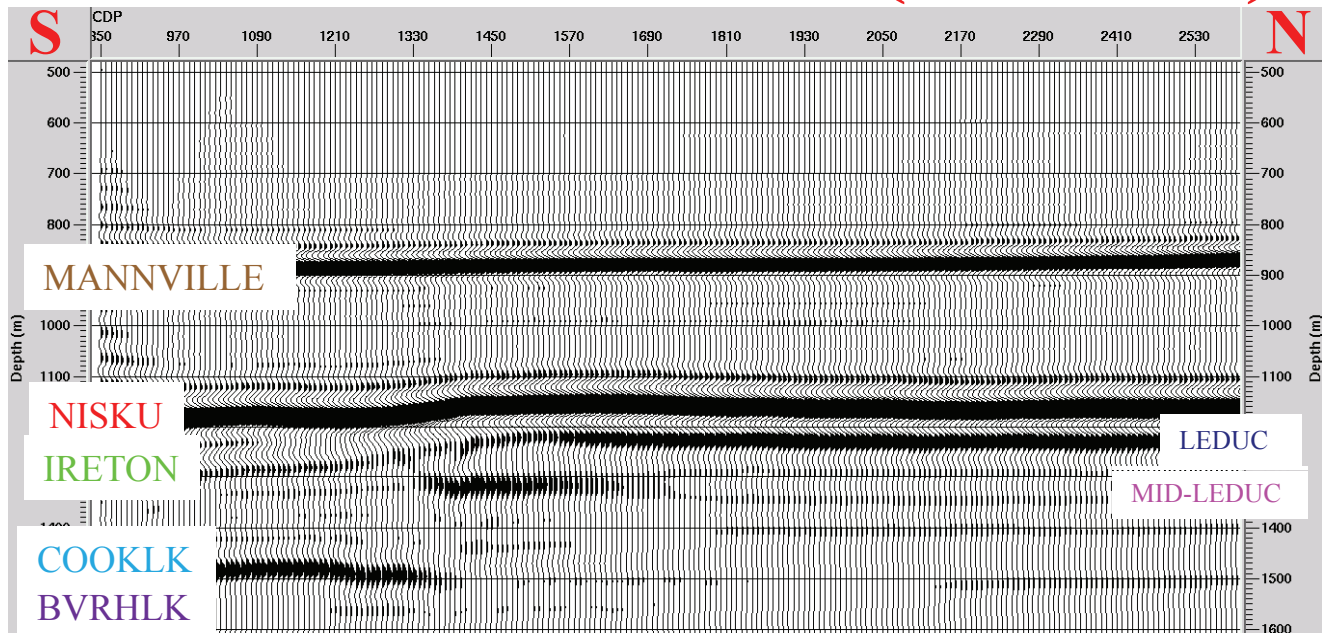


PS

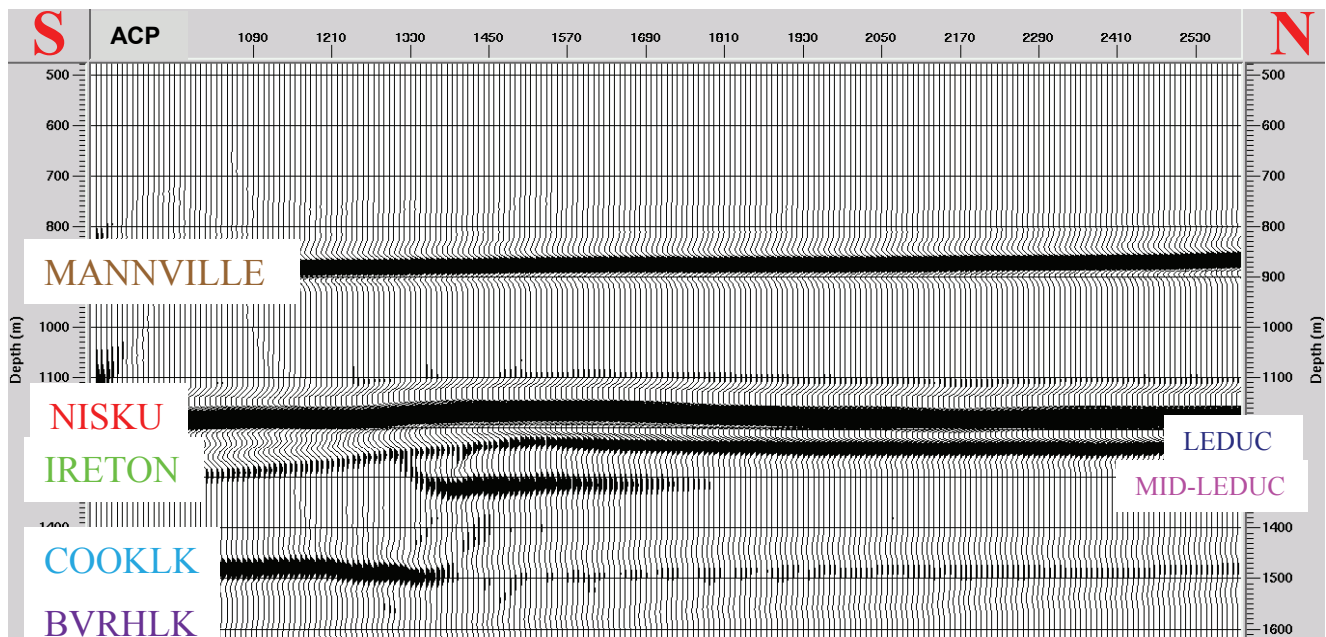


PSDM seismic section (Monitor)

PP



PS

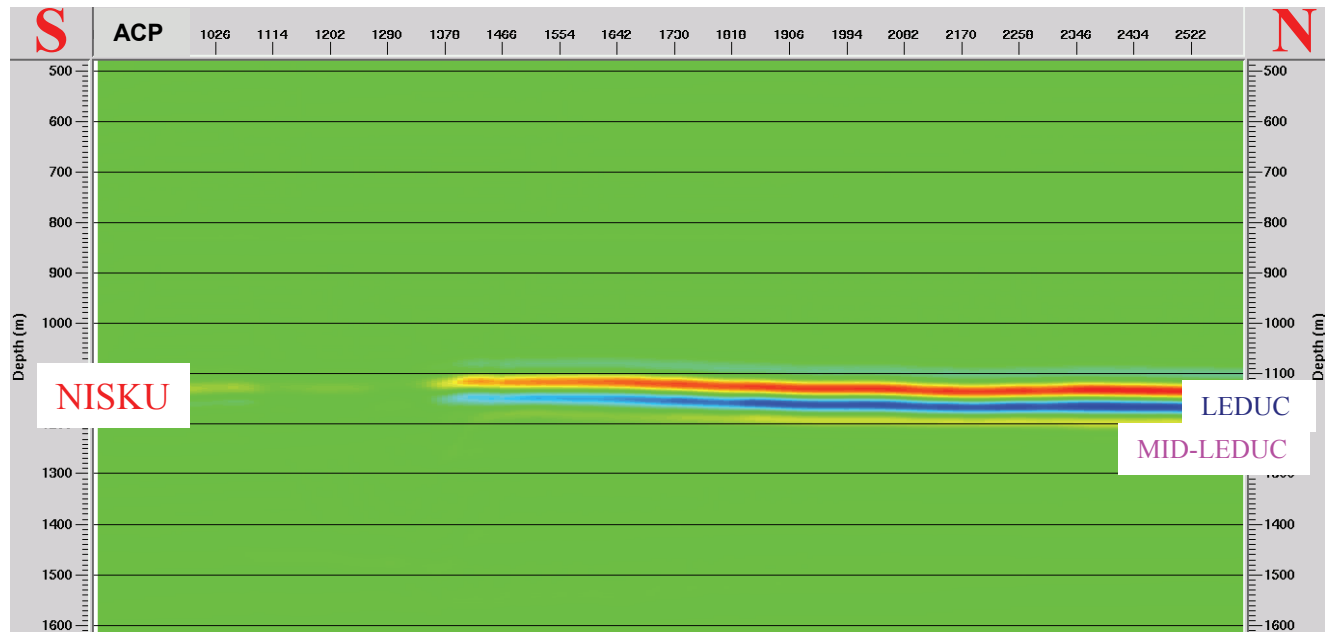


PSDM difference sections

PP



PS



Conclusions

- Cooking Lake and Beaverhill Lake Formations display positive time structure below the reef
- Reef rim, termination and lateral position are observed seismically at the Redwater Leduc reef margin
- PP and PS synthetic seismograms demonstrate similar seismic attributes
- Reef litho-facies are recognized by seismic character particularly on PS data
- Time-lapse PP reflections show strong evidence to detect CO₂ (15 % amplitude difference and 1.6 ms delay)
- Time-lapse PS reflections show weaker evidence to detect CO₂

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