The Origin of Overpressure in the Nappamerri Trough, Cooper Basin, South Australia

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The Origin of Overpressure

Cooper Basin

Evidence from Wireline Logs

Comparison of Porosity Estimates

Porosity / Effective Stress Relationships

Conclusions
The Origin of Overpressure

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Conclusions
Mechanisms of Overpressure Generation

- Disequilibrium Compaction

- Fluid Expansion at Depth
  
  - Hydrocarbon cracking / gas generation
  - Thermal pressuring
  - Mineral phase transformations
  - Lateral & vertical transfer
  - Osmosis
Disequilibrium Compaction

- Rocks compact as the effective stress acting on the rock matrix increases

\[ \sigma'_v = \sigma_v - P_p \]

where \( \sigma_v = \) overburden stress
\( P_p = \) pore pressure.

- The process of disequilibrium compaction occurs when the rate of increase in stress exceeds the rocks ability to de-water.

- Any additional increase in stress is then borne by the fluid causing
  (a) An increase in pore pressure
  (b) A lower rate of compaction
Fluid Expansion at Depth

- An increase in pore pressure
- A reduction in effective stress
- An increase in porosity (usually small)
  - The elastic component of compaction
  - Secondary porosity generation
• The Origin of Overpressure
• Cooper Basin
• Evidence from Wireline Logs
  Comparison of Porosity Estimates
  Porosity / Effective Stress Relationships
• Conclusions
Location of the Cooper Basin
Well Location Map and Structural Elements

After Apak et al. 1997

Nappamerri Trough

CACTUS 1
CORREA 1
SWAN LAKE 1
BULYEROO 1
MOOMBA
KIRBY 1
MCLEOD 1
A ROONA 1
Nappacoongee Horst

SNAKE HOLE 1
BULYEROO 1
BURLEY 1

28° 00'
140° 00'
141° 00'

kilometres
0 50
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Wireline Log Quality Control

DESPIKE FILTER

COAL SONIC CUTOFF; DT < 330 us/m

DRHO MAX FILTER; DHRO < 100 kg/m³

LITHOLOGY FILTER; Variable GR cut-off
Converting RHOB to Porosity

\[ \phi_{\text{RHOB}} = \frac{(\rho_{\text{ma}} - \rho_{\text{b}})}{(\rho_{\text{ma}} - \rho_{\text{f}})} \]

Fluid Density
1.05 g/cc

Grain Density values
2.70 g/cc from core samples

Callamurra Member, Murteree Shale and the Roseneath Shale have high grain densities due to mineralisation.

Siderite 3.89 g/cc
Pyrite 4.99 g/cc
Normal Compaction Trend

\[ \varphi = 0.6 \exp(-0.00095z) \]
Comparison of Porosity Estimates

Depth (z) vs Porosity (\(\varnothing\))

- Normal Compaction Trend
- Fluid Retention Depth

Points A and B on the graph represent different depths and porosity values.
Wyllie Equation Calibration

\[ \varphi = \left( \frac{1}{C_p} \right) \left( \frac{\Delta t - \Delta t_{ma}}{\Delta t_r - \Delta t_{ma}} \right) \]

Correction factor = 1.97
Matrix transit time = 175 us/m
Fluid transit time = 620 us/m

\[ R^2 = 0.65 \]
Acoustic Formation Factor Calibration

\[ \varphi = 1 - \left( \frac{\Delta t_{ma}}{\Delta t} \right)^{\frac{1}{x}} \]

Acoustic Formation Factor = 2.64
Matrix transit time = 190 us/m

\( R^2 = 0.63 \)
Normally Pressured Wells

- RHOB Porosity
- DT Porosity (Wyllie)
- Normal compaction trend
Normally Pressured Wells

Porosity

Depth (m)

RHOB Porosity

DT Porosity (Acoustic Formation Factor)

Normal compaction trend
Overpressured Wells

Porosity vs Depth (m)

- RHOB Porosity
- DT Porosity (Wyllie)
- Normal compaction trend
Overpressured Wells

Porosity vs Depth (m)

- RHOB Porosity
- DT Porosity (Acoustic Formation Factor)
- Normal compaction trend
Porosity / Effective Stress

A Disequilibrium compaction
B Fluid expansion at depth

A

Fluid Retention Point

B

Loading curve

Unloading curve

Porosity (Ø)

Effective Stress

Porosity at maximum burial depth

($\sigma' = \sigma - Pp$)
Porosity / Effective Stress

Burley 2

- Normally Pressured
- Overpressured
- Normal Compaction Trend

Porosity / Effective Stress

Vertical Effective Stress (MPa)
• The Origin of Overpressure
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• Evidence from Wireline Logs
  Comparison of Porosity Estimates
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• Conclusions
Conclusions

Overpressure exists within the Nappamerri Trough

Lateral extent of overpressure poorly constrained

Normal compaction trend

Porosity = 0.6*exp(-0.00095*depth)
Conclusions

Overpressure is associated with a porosity anomaly

Porosity anomaly consistent with disequilibrium compaction

The origin of overpressure in the Nappamerri Trough was disequilibrium compaction
This presentation can be downloaded from the web at:
www.ncpgg.adelaide.edu.au/asm
(click on presentations)