Geophysics for Shale Reservoirs

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Shale Reservoirs – Important Considerations

Shale Gas reservoirs are;

- Heterogeneous
- Structured
- Highly variable producers

Optimized production from shales require a complete understanding of the reservoir.

Integrated geological, geophysical and reservoir engineering studies are the only way the develop this complete understanding.

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Geophysical (Seismic) Studies

Prior to drilling seismic studies are the only method that can be used to obtain information about the reservoir.

When updated with well data obtained during the initial phases of the play seismic can improve play economics by identifying reservoir sweet-spots.

Recent seismic studies have been successful in determining;

- What controls shale heterogeneity,
- How to use this to determine:
  - best drill locations.
  - best completion practices.

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Geophysical Studies

These studies have resulted in the detection of

- Better quality reservoir
- Natural fracture trends

Techniques used for these include;

- Amplitude versus Azimuth (AVAZ) (azimuthal 3D)
- Azimuthal Velocity (azimuthal 3D)
- Multi-Variant Blended Attribute Analysis (2D, 3D or azimuthal 3D)
- Variance Studies (2D or 3D)
- Inversion (2D or 3D or azimuthal 3D)
- Spectral Decomposition (3D or azimuthal 3D)

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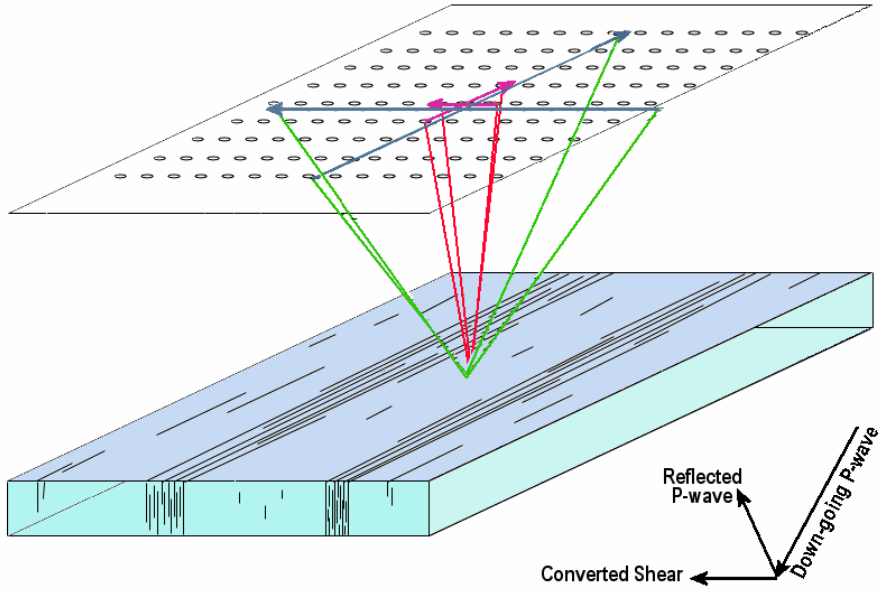
Azimuthal Seismic Analysis

Azimuthal seismic is also referred to as Azimith Limited seismic.

This type of seismic is extremely valuable in detecting fracture systems.



Fracture trend directions can be determined using this type of seismic.

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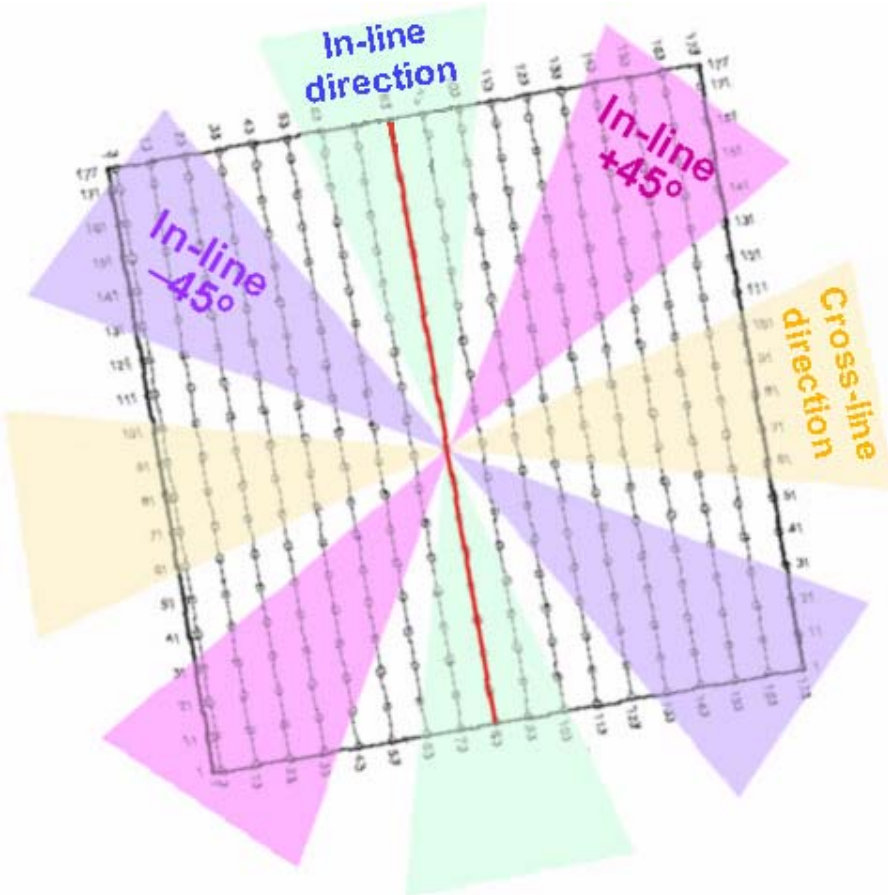
Azimuthal Seismic Volumes

Azimuths are selected based on the believed fracture orientation.

Volumes stack in those directions are created and then interpreted.



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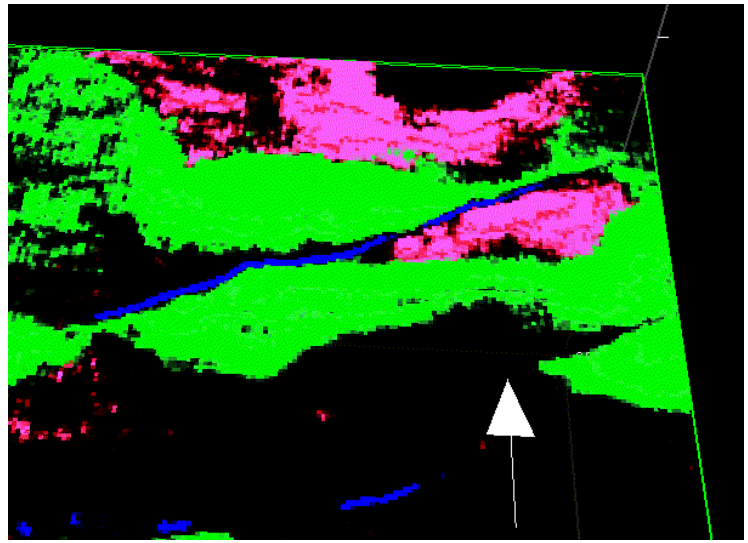
Geophysical Studies – Reservoir Imaging

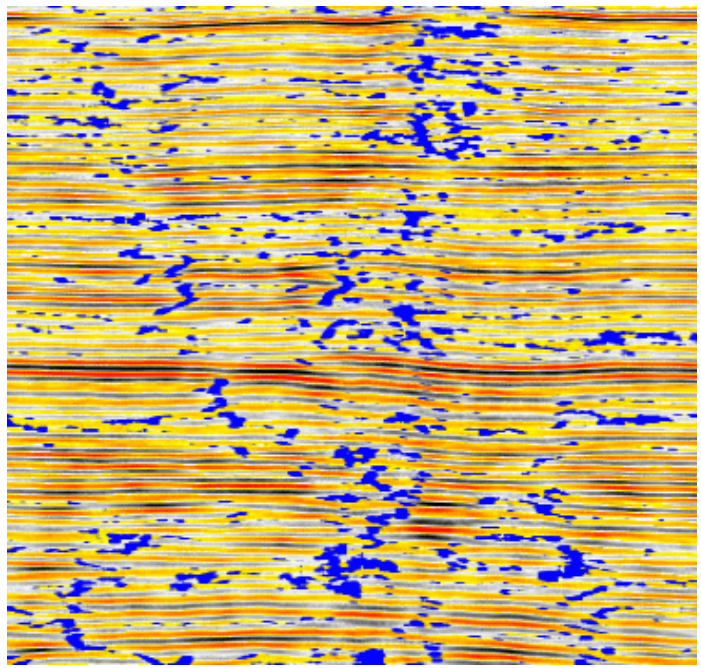
Shale Reservoir Quality

- Controls include;
  - Minerology / Clay content
  - Amount of Cementation
  - Presence of Natural Fractures



Shale Reservoir Completion Planning

- Considerations include;
  - Location of Major & Minor Faults
  - Size of Fault's Structurally Damaged Zone



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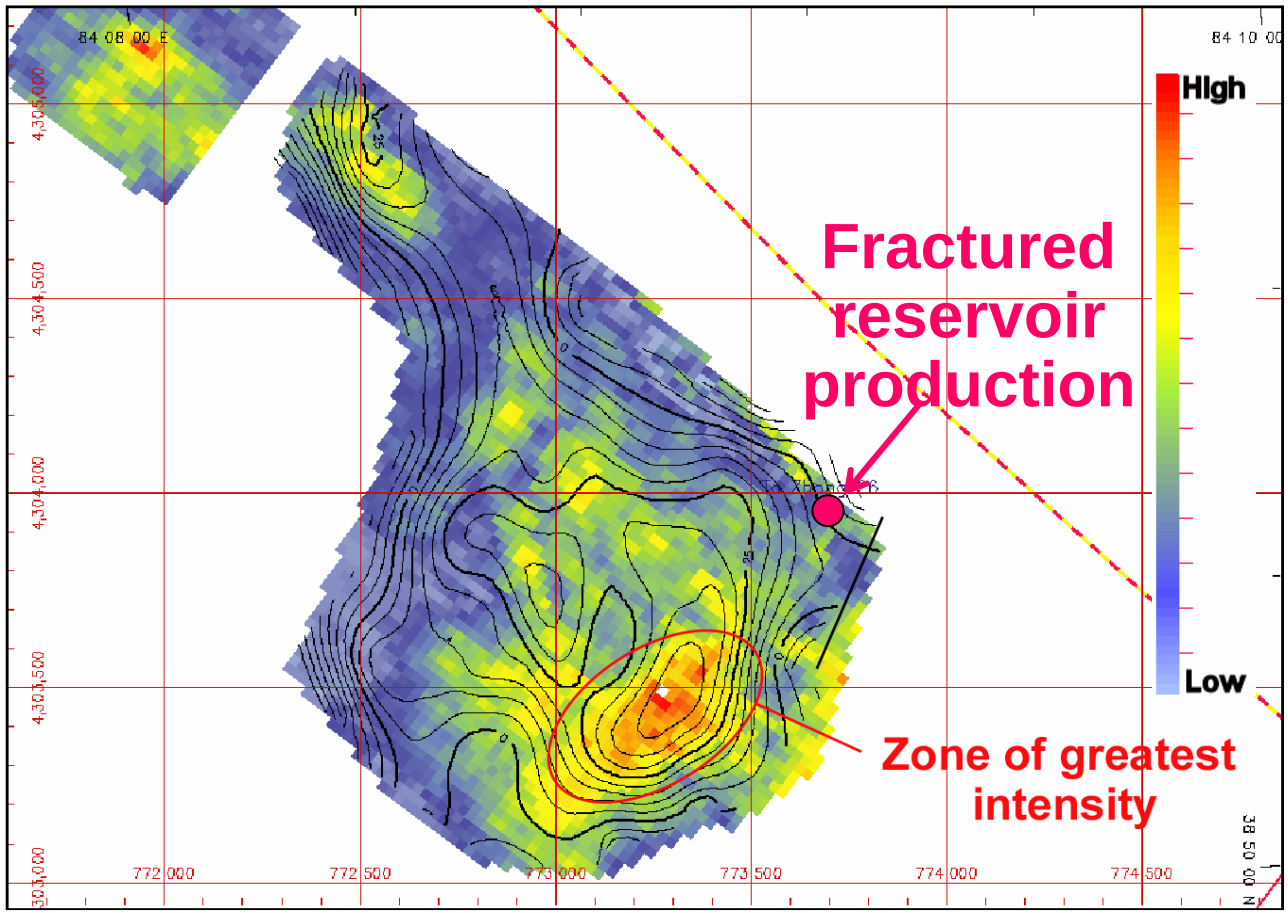
Tarim Basin, China Seismic Fracture Study

Seismically detected sweet-spot in fractures near producing well.

Top of TG5-1 to 20 ms below



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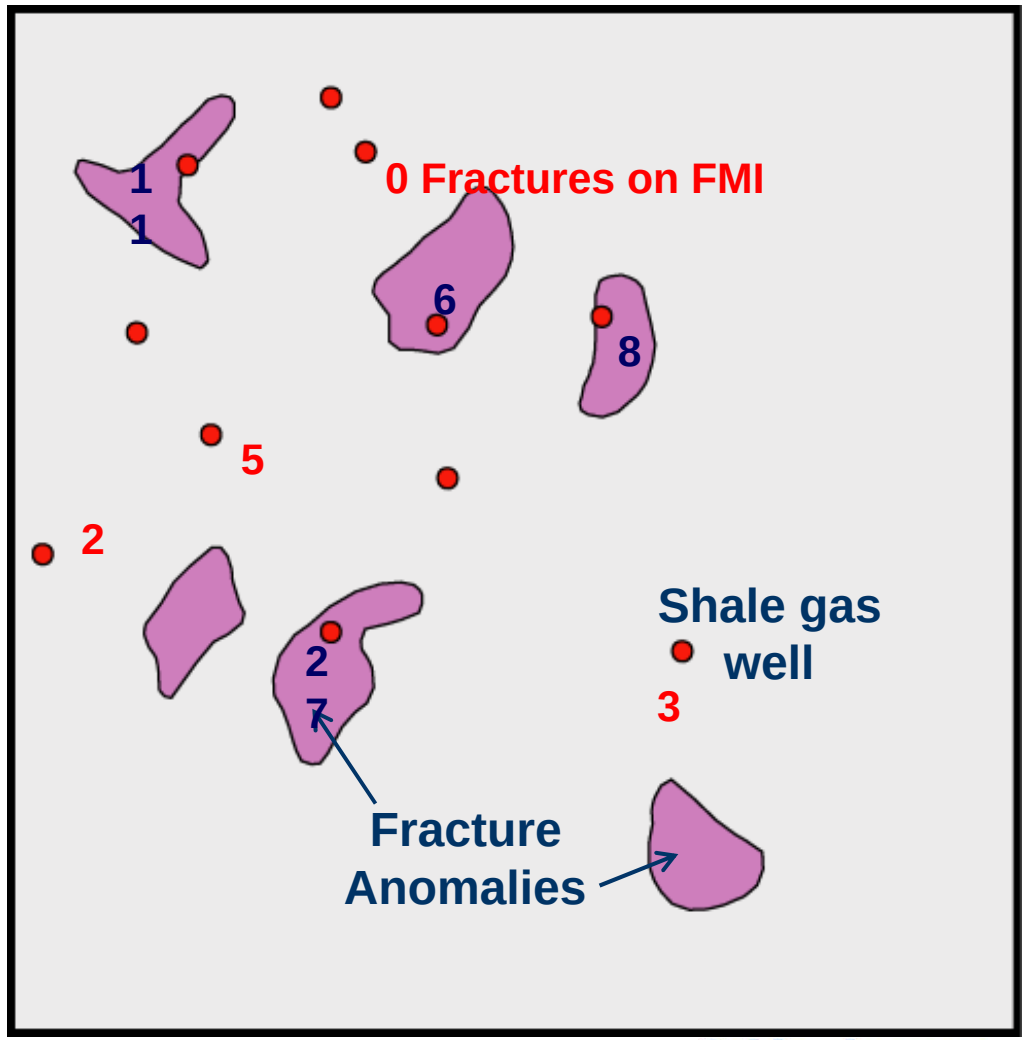
Seismically-Detected Fracture Swarms in Barnett Equivalent Gas Shale

- 8 wells with FMI data
- 4 wells with 5 fractures or less are <u>outside</u> of seismically detected fracture anomalies.
- 4 wells with > 5 fractures occur <u>within</u> seismically detected fracture anomalies.



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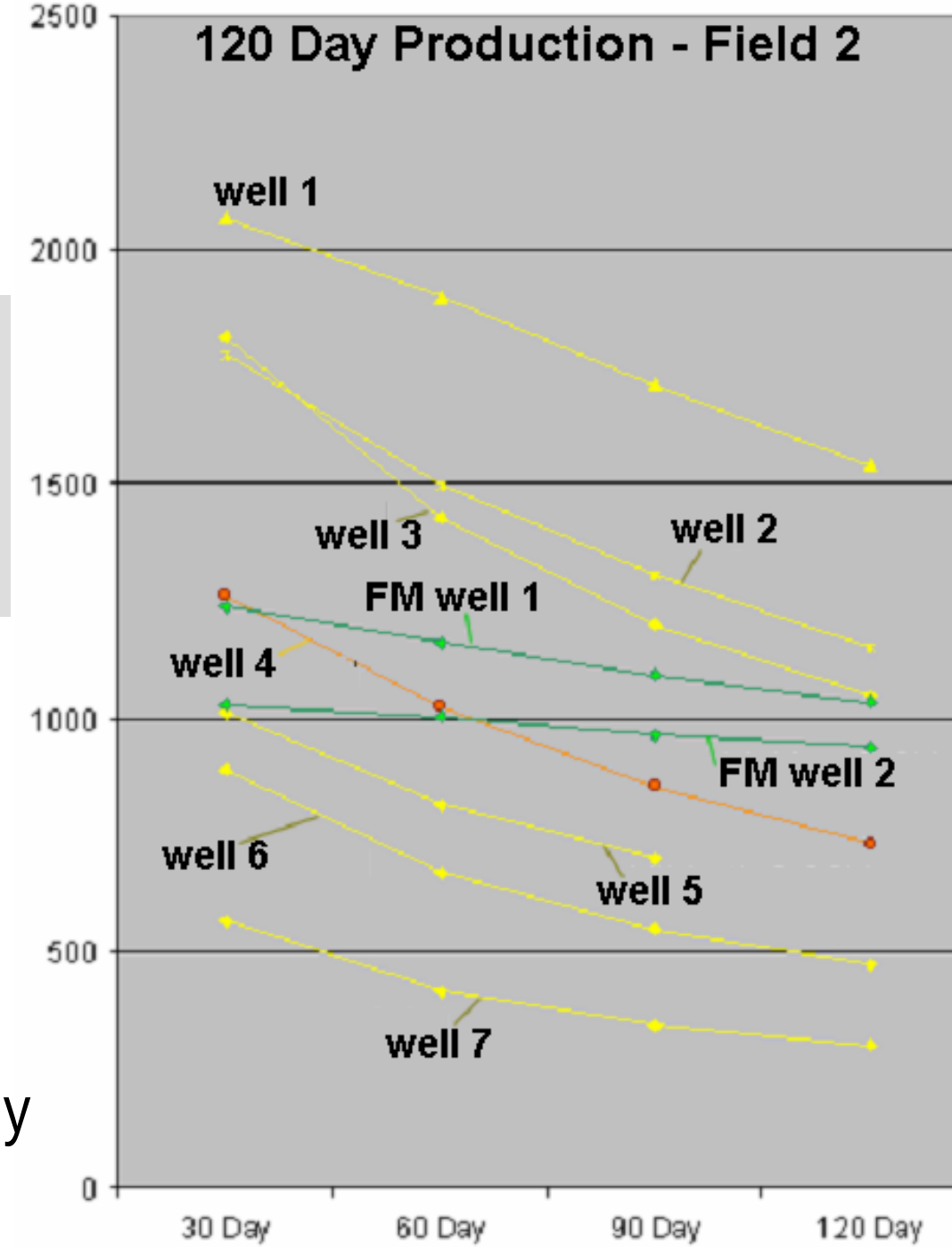
Influence of Fractures on Gas Shale Production

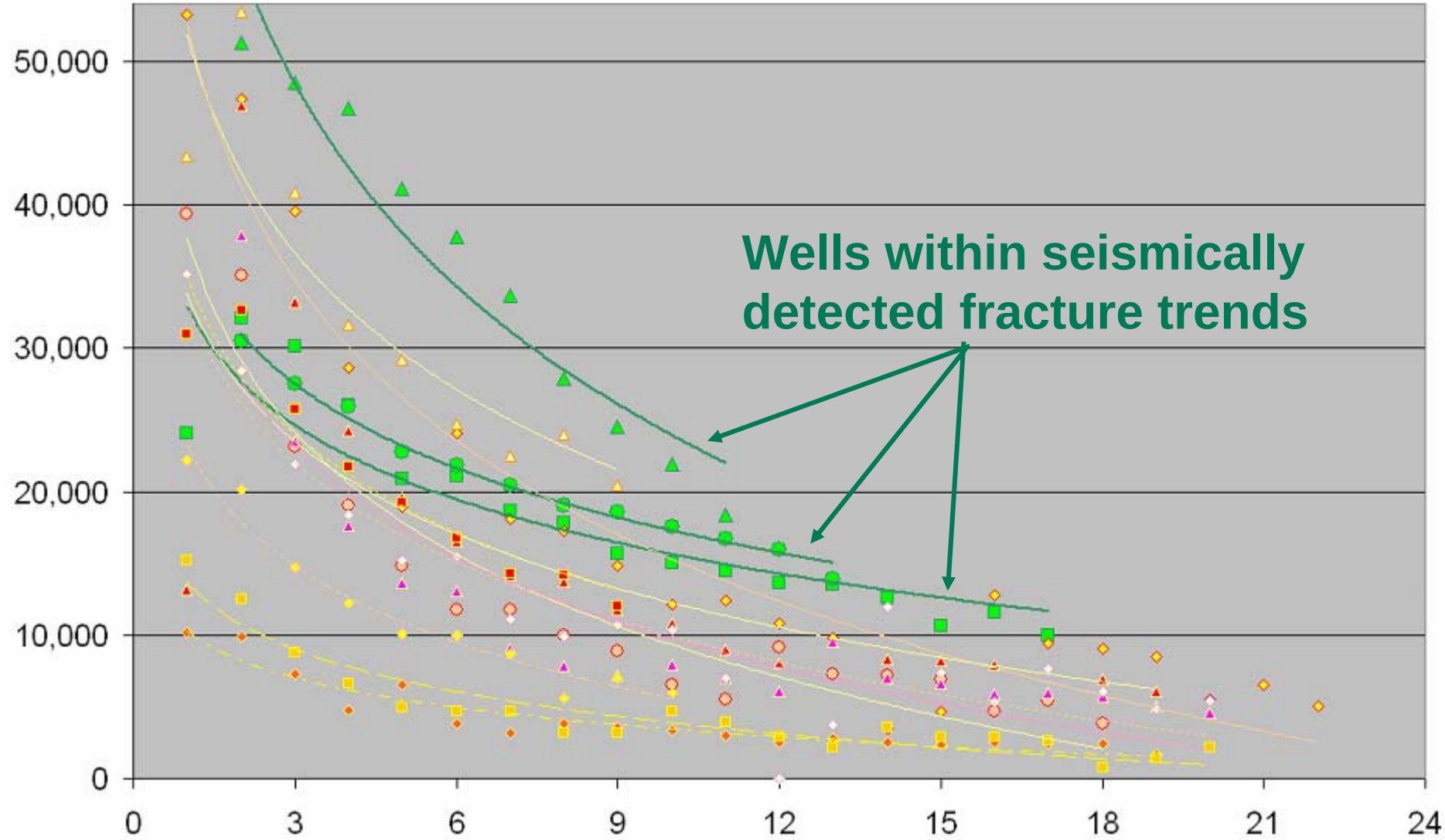
Daily production rates at 30, 60, 90 & 120 days for wells inside (FM) and outside fracture swarms.

Analysis - Sept. 06

Horizontal Wells Only



Monthly Production – Both Fields



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Updated - May 07

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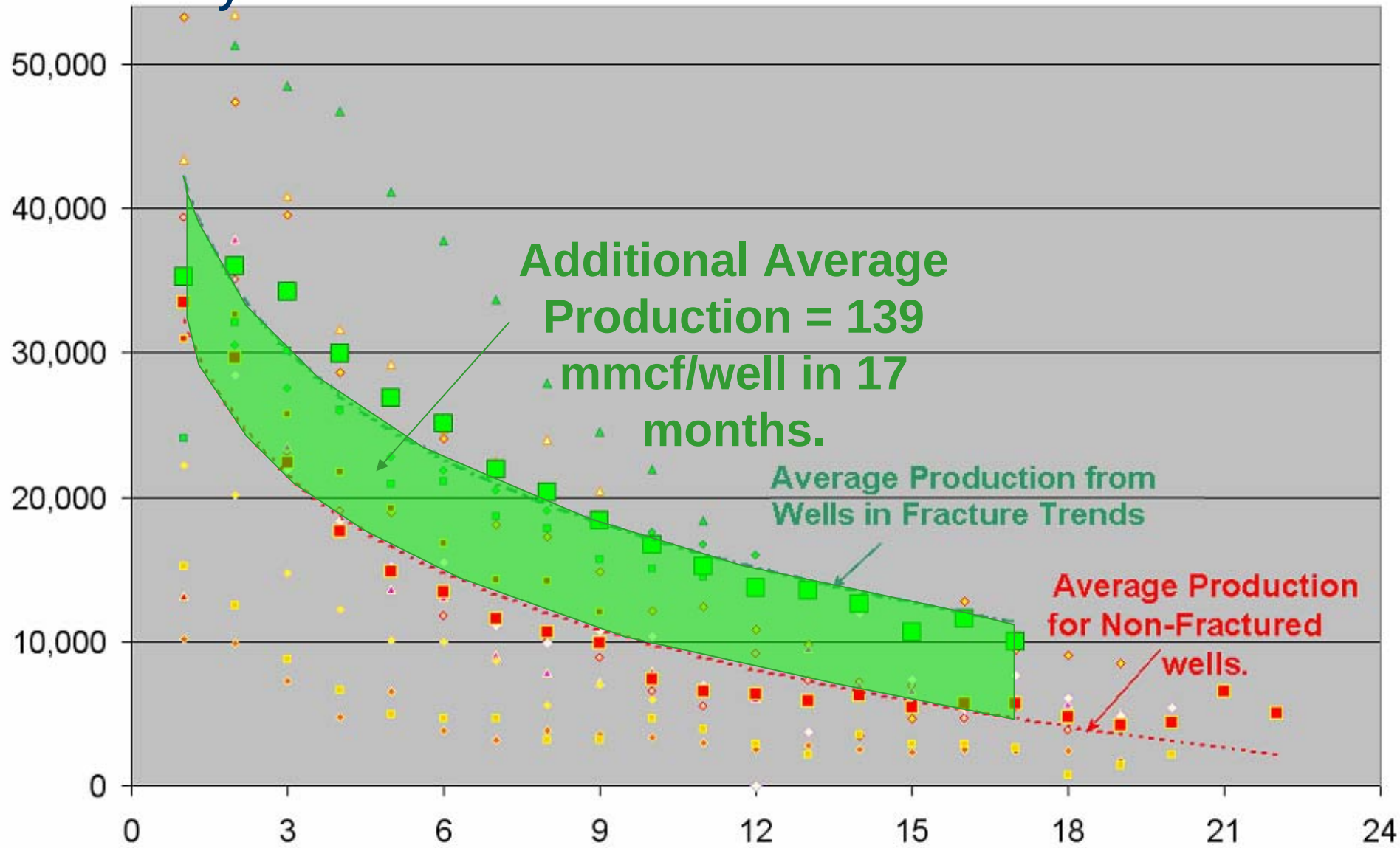
Monthly Production – Both Fields



Updated - May 07

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Conclusions

Past geophysical studies have been shown to be valuable in;

- Identifying better reservoir quality within gas shales through the use of certain seismic attributes.
- Locating reservoir sweet-spots within shales, such as fracture trends, that can be result in significant additional production.
- Identifying trend directions of natural fracture trends, which can be used to plan horizontal drilling directions.

These can be accomplished with;

- AVAZ studies
- Multi-variant attribute analyses
- Azimuthal Velocity analysis
- Spectral Decomposition Studies
- Azimuthal Inversion studies

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