VVAZ analysis in Altamont-Bluebell Field

Khaled Al Dulaijan & Gary Margrave

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Objective

- To identify density and direction of fractures for new drilling opportunities and for effective development of reservoirs.

URTeC(Adams et. al., 2014)

Outline

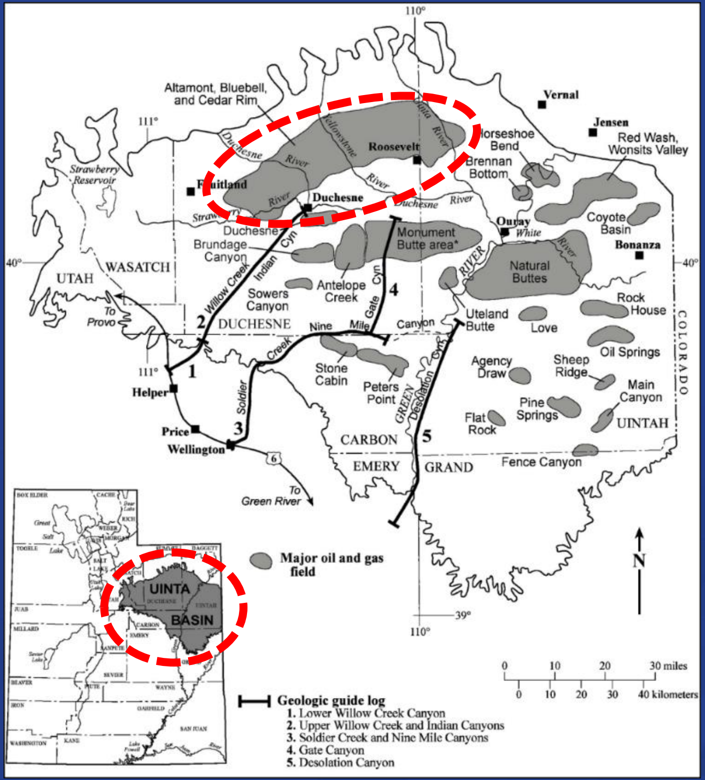
- Introduction
  - Altamont-Bluebell field
- VVAZ and interval VVAZ analysis:
  - Offset VSPs
  - 3D surface seismic
- Conclusions

Uinta Basin & Altamont-Bluebell Field

Source: Morgan et. al., 2003

- Northeastern Utah
- Northern-central part of the basin.
- Lake bounded by:
  - North: Uinta mountains making steep north flank.
  - South: gentle slope
- Accumulative production (2014):

  336 MMBO, 588 BCFG, and 701 MMBW



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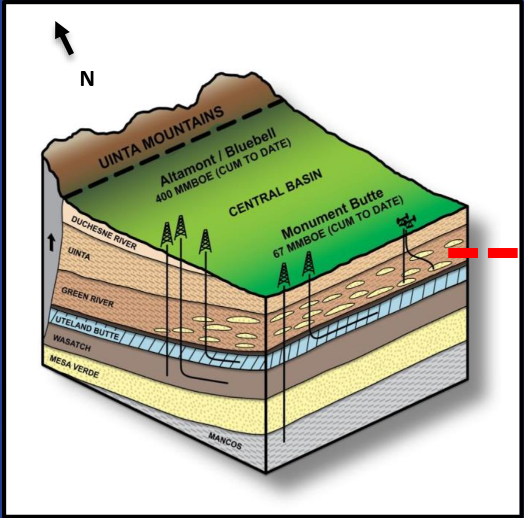
Stratigraphy and targets

3 main targets are:

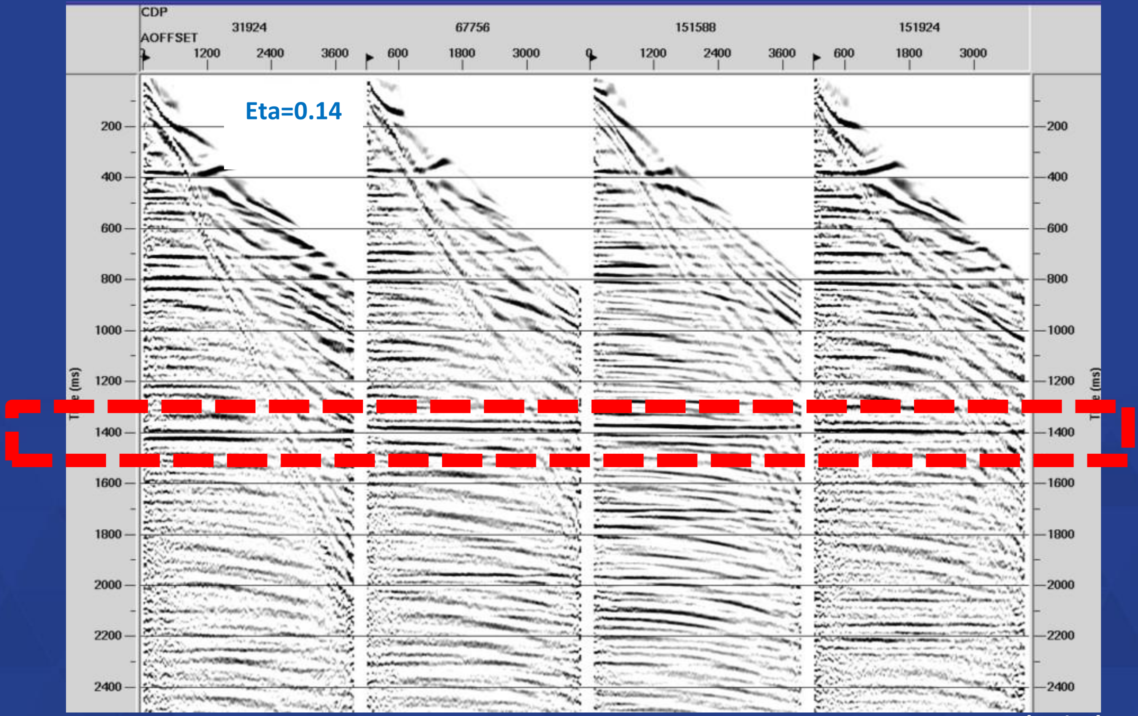
1. Upper Green River
2. Lower Green River (Uteland Butte and Castle Peak)
3. Wastach/ Colton



Source: Newfield Report

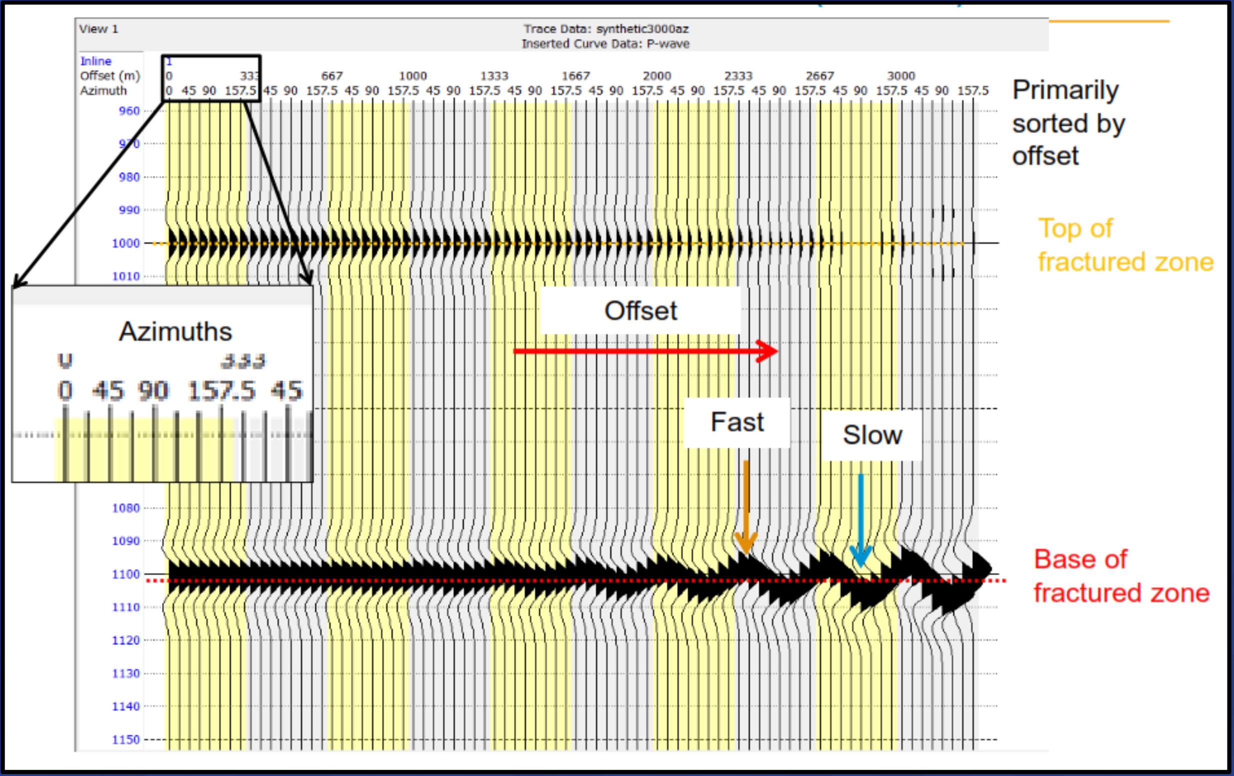
Source: Wooster Geologist Blog

Horizontal fractures (VTI)



Source: Sensor Geophysical

Vertical fractures (HTI)



Source: Hampson-Russell ProAz notes

Elliptical NMO (Grechka and Tsvankin, 1998)

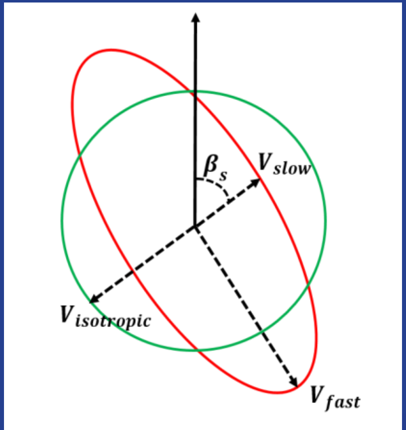
$$T^2 = T_0^2 + \frac{x^2}{V_{NMO}^2(\phi)}$$

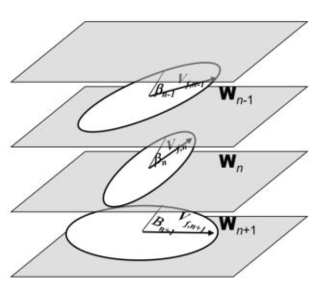
$$\frac{1}{V_{NMO}^2(\phi)} = \frac{1}{V_{slow}^2} cos^2(\phi - \beta_s) + \frac{1}{V_{fast}^2} sin^2(\alpha - \beta_s)$$

$$T^2 = T_0^2 + x^2 \, cos^2(\phi) W_{11} + 2x \, cos(\phi) \sin(\phi) W_{12} + x^2 \, sin^2(\phi) W_{22}$$

$$solve \; for \; T_0 and \; W_{ij} \; which \; yeilds \;\; V_{fast}, V_{slow}, and \; B_s$$

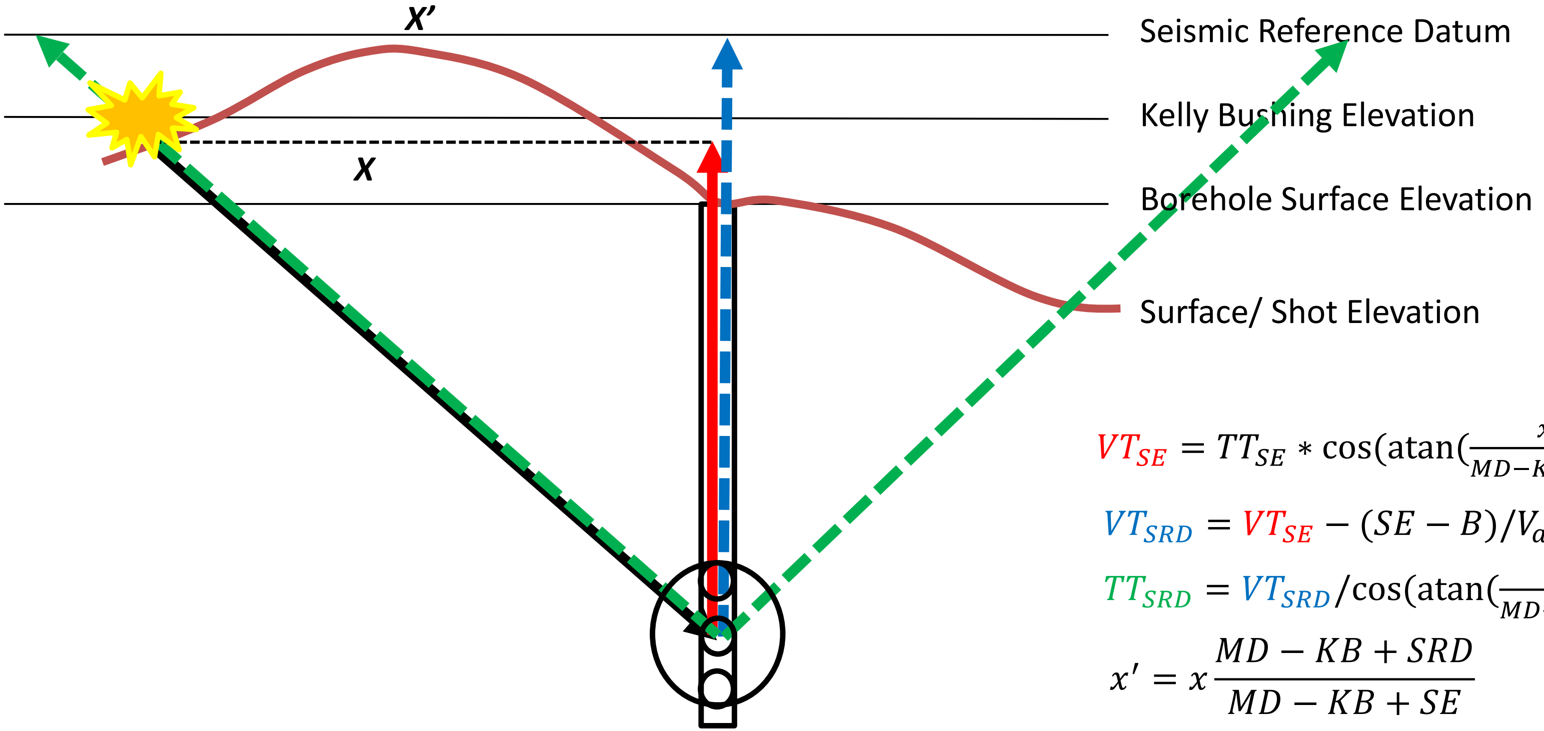
$$W^{-1}{}_l = \frac{T_0(l) W^{-1}(l) - T_0(l-1) W^{-1}(l-1)}{T_0(l) - T_0(l-1)}$$





Source: Hampson-Russell RroAZ notes

VVAZ workflow for offset VSPs



$$VT_{SE} = TT_{SE} * \cos(\mathrm{atan}(\frac{x}{MD-KB+SE}))$$

$$VT_{SRD} = VT_{SE} - (SE - B)/V_{avg} + (\mathrm{SRD} - \mathrm{B})/V_R$$

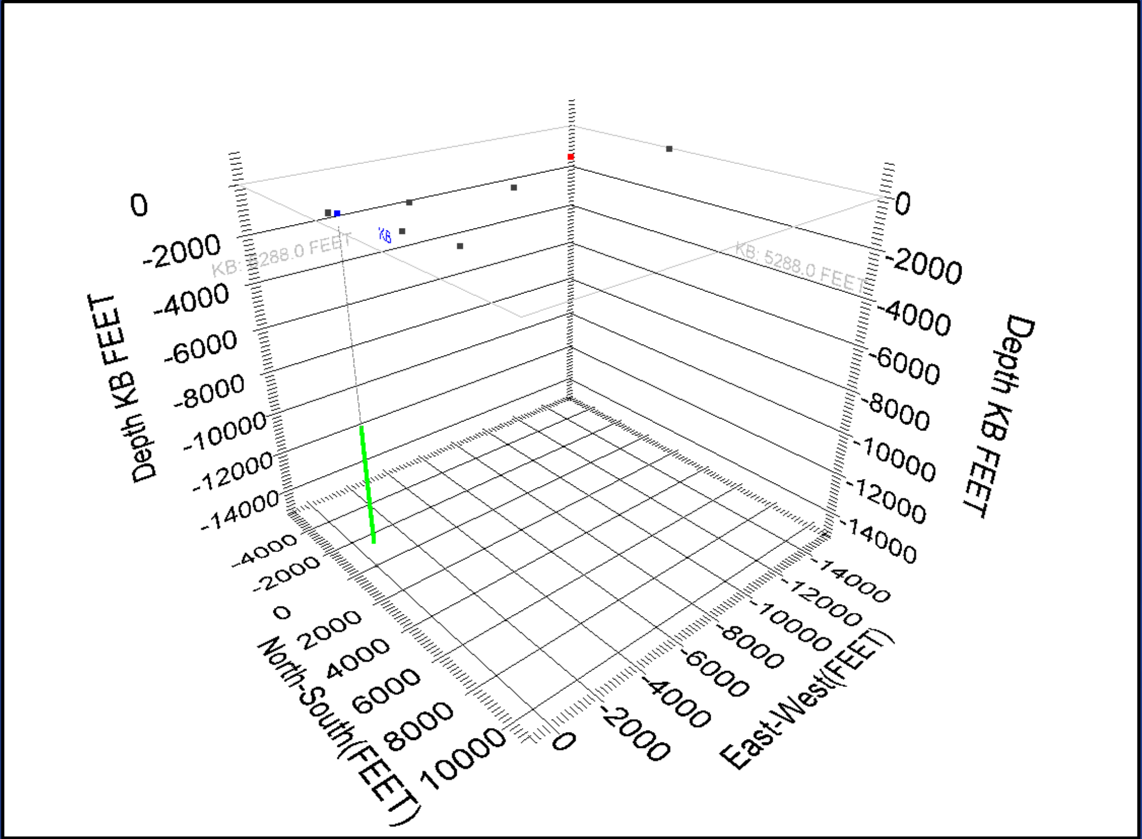
$$TT_{SRD} = VT_{SRD}/\cos(\mathrm{atan}(\frac{x}{MD-KB+SE}))$$

$$x' = x\frac{MD - KB + SRD}{MD - KB + SE}$$

Offset VSPs acquisition

- 7 VSP Shots: 1 near offset and 6 offset VSPs
- Source: single vertical Vibroseis (4-96 Hz linear sweep)
- Receiver: 2-level tool of 3-C geophone, every 50’
- Shot-borehole offset: 360’, 1089’,1495’, 2543’, 3148’, 5755’, and 6332’.

Location of Offset VSPs



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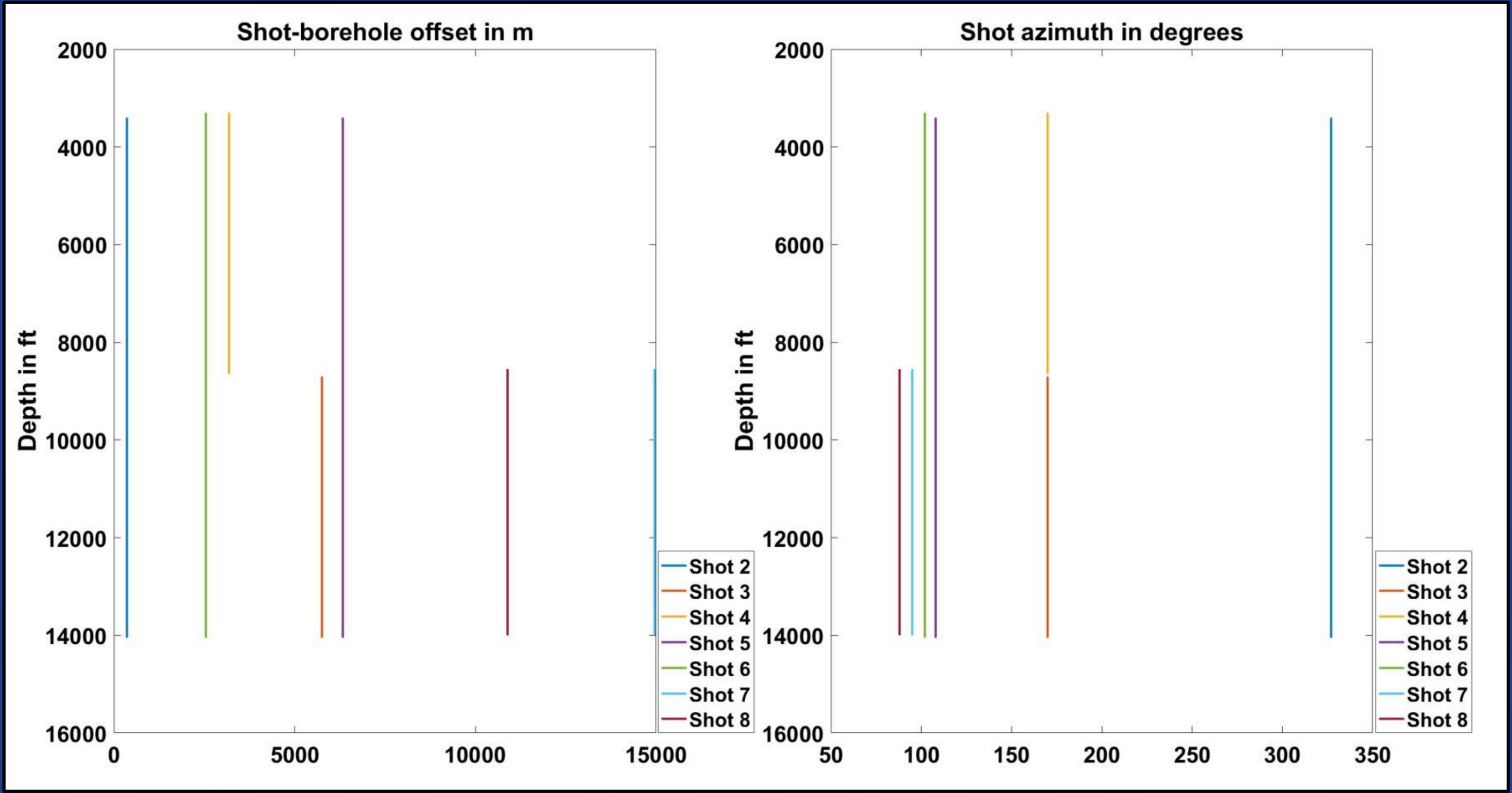
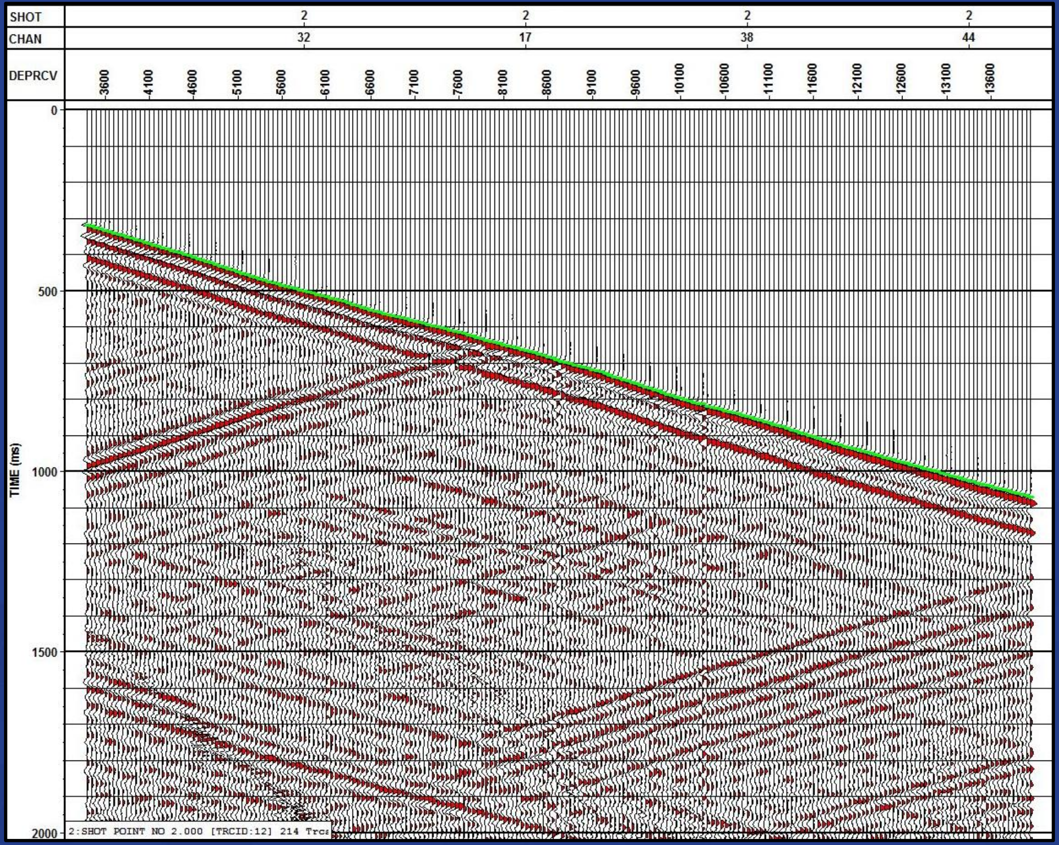
VSPs: offset & azimuth



First P-wave arrivaltimes



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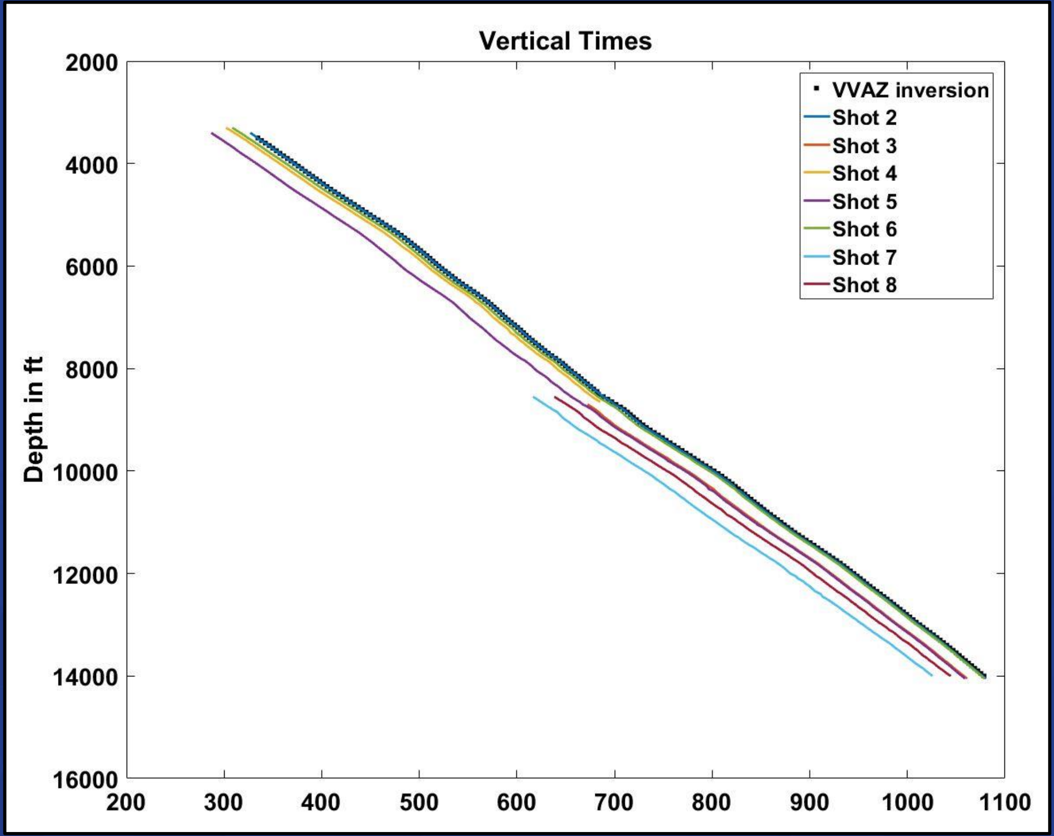
Vertical times: inverted vs calculated



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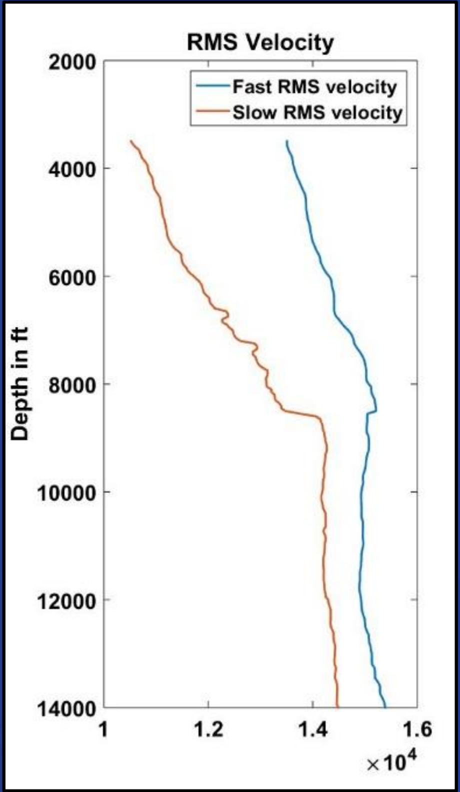
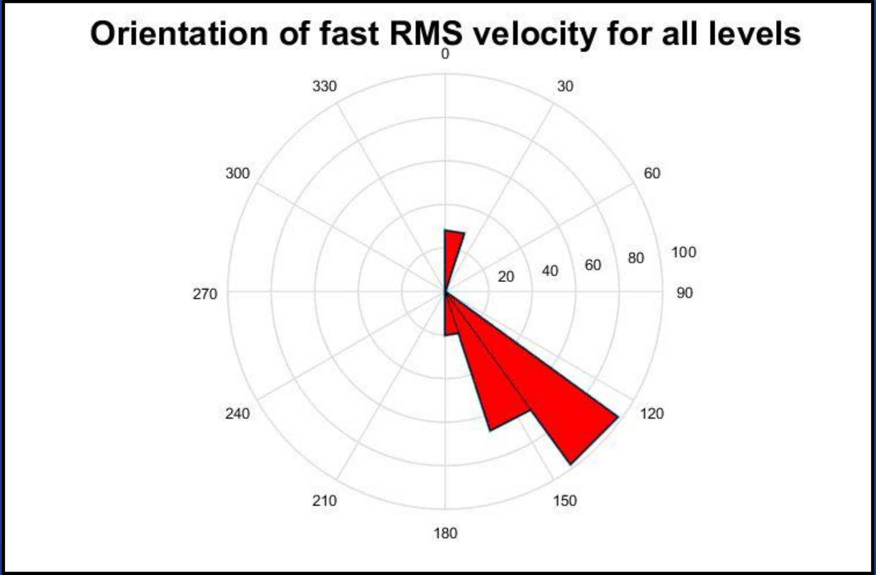
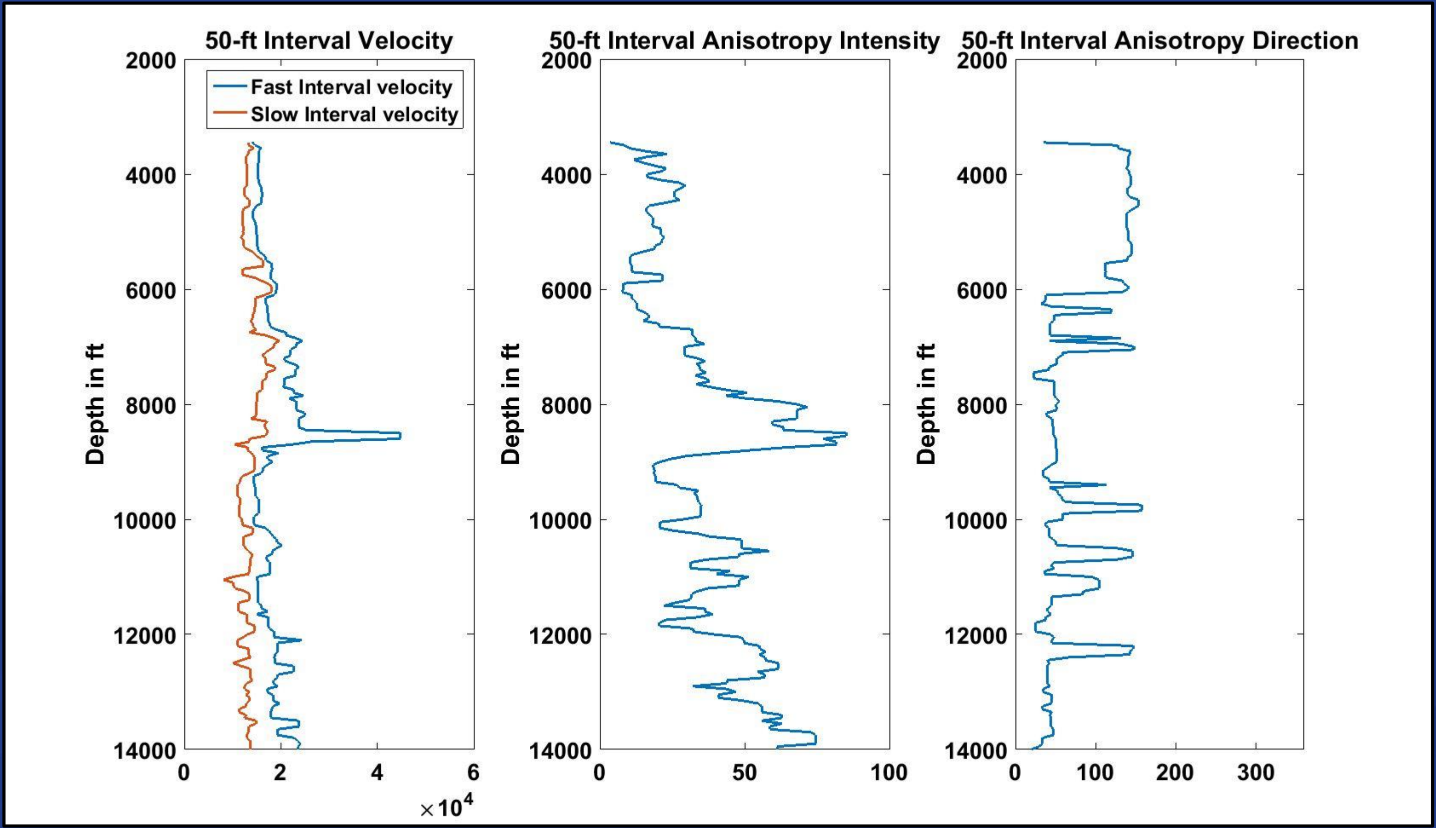
VRMS & anisotropy direction





50’- Interval VVAZ



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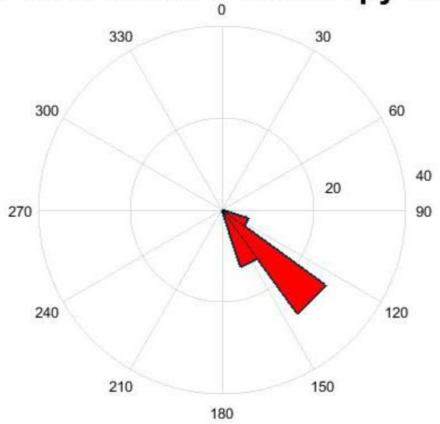
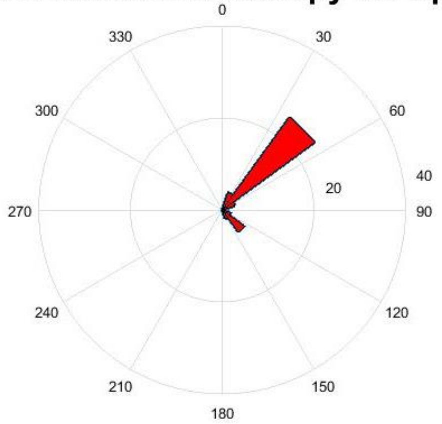
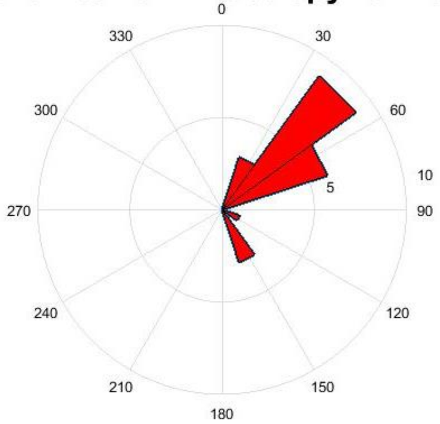
Orientation of 50-ft Interval Anisotropy for Overburden



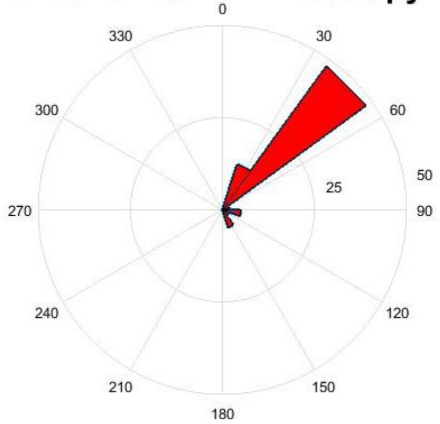
Orientation of 50-ft Interval Anisotropy for Upper Green River



Orientation of 50-ft Interval Anisotropy for Lower Green River



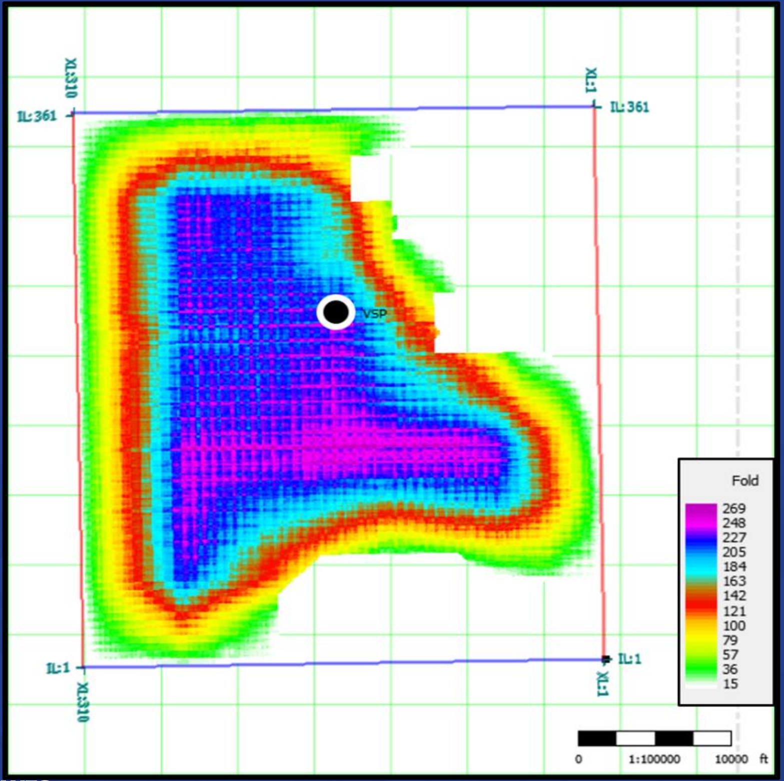
Orientation of 50-ft Interval Anisotropy for Wastach

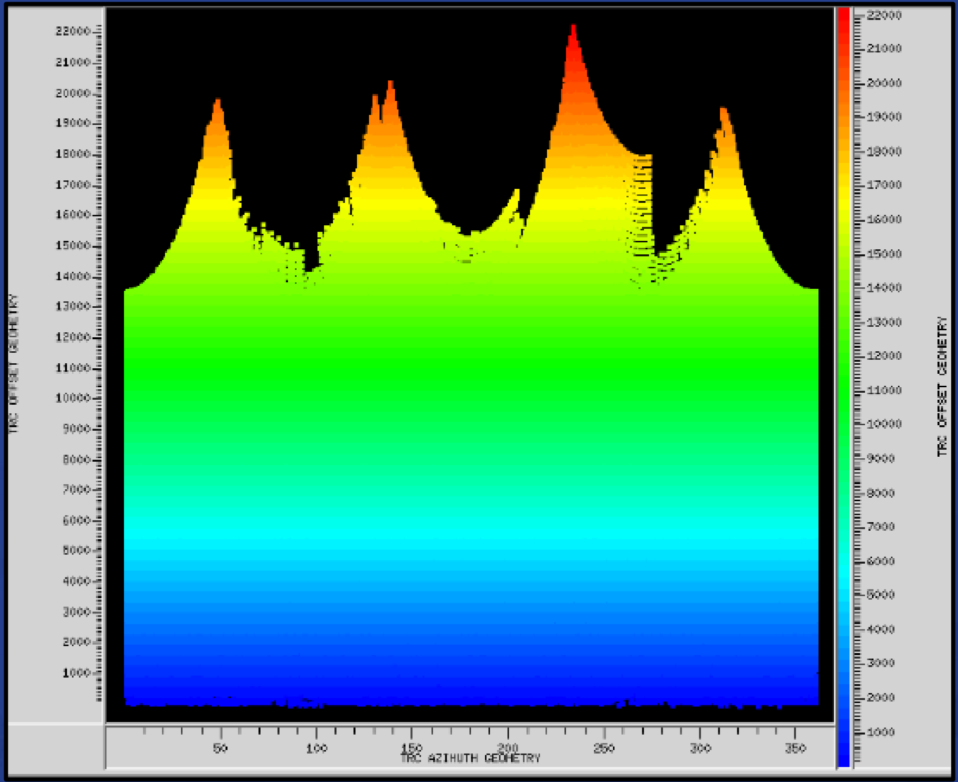


3D seismic data acquisition

- Acquisition data & area: 2010 & 35 mi^2
- Source: 2 vibes/shot (4-96 Hz linear sweep)
- Receiver: 6-geophone array/channel
- Source interval: 220’ Receiver interval: 220’
- Source line spacing: 660’ Source line orientation: N-S
- Receiver line spacing: 1100’ Receiver line orientation: E-W
- Bin size: 110’x110’ Nominal fold: 240

Fold & azimuth distribution





Data processing

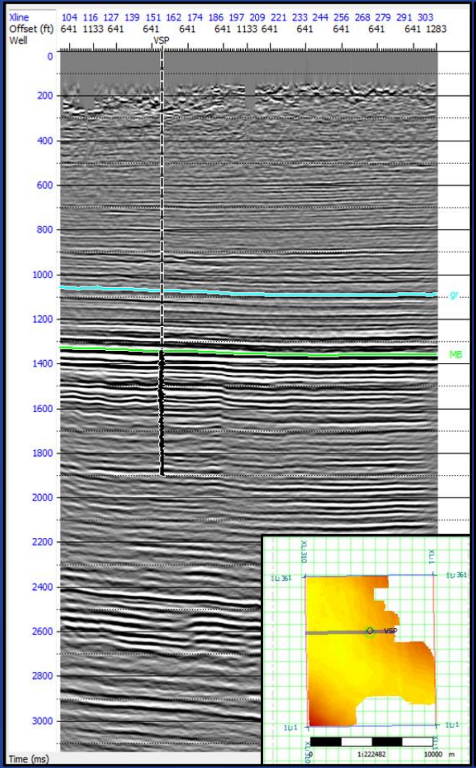
Geometry
Refraction Statics Correction
Amplitude Recovery
Noise attenuation
Surface-cons amp & decon
NMO &Velocity @ 1x1 mi
NMO &Velocity @ .5x.5 mi
3D COV Binning
Migration Velocity Analysis
3D PSTM

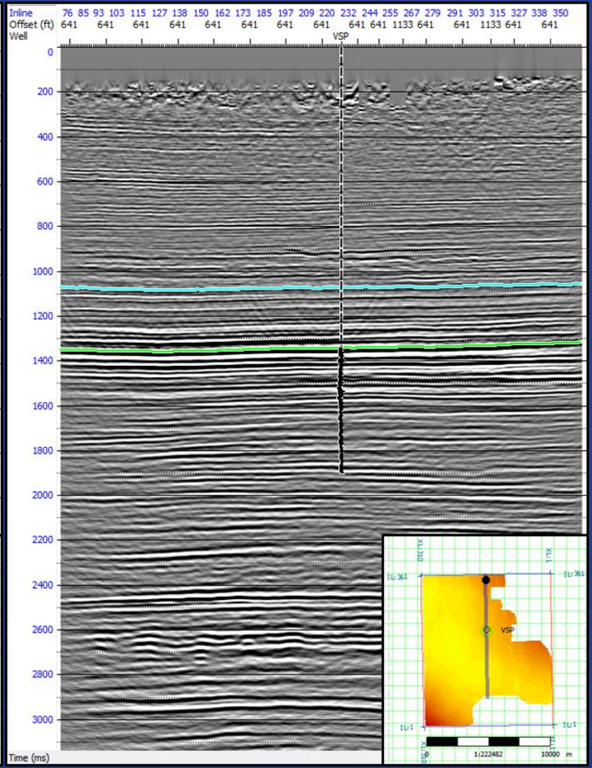
CDP stacks: Inline & Xline

- CDP Stack:

Inline (left) and crossline (right).

VSP borehole is indicated in the middle and basemap Two horizons are indicated Upper Green River (blue) and Mahogany bench (green)





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After & before application of azimuthal residuals

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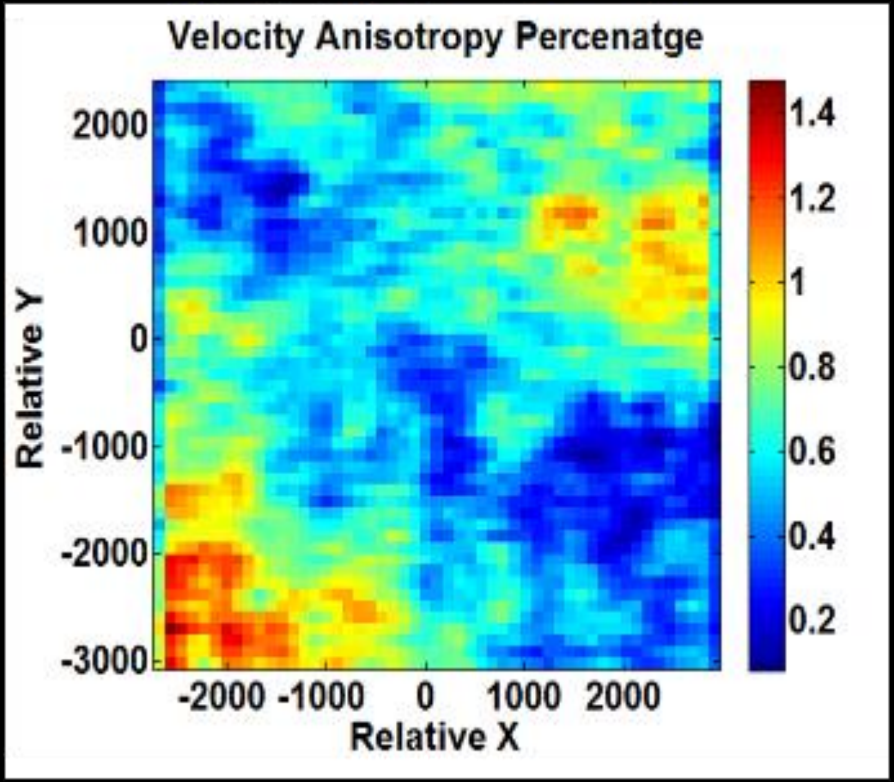
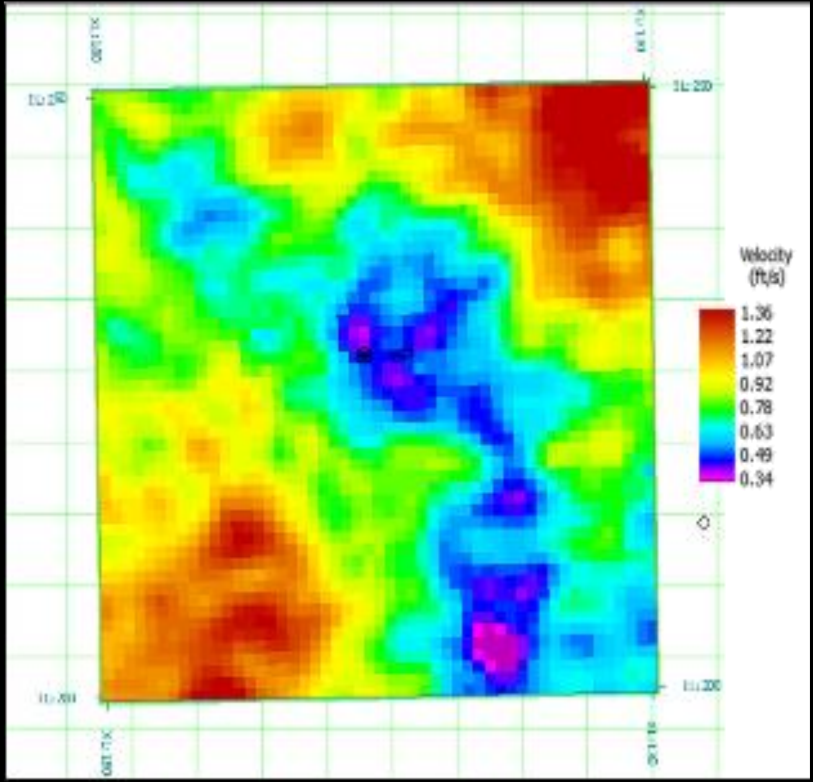
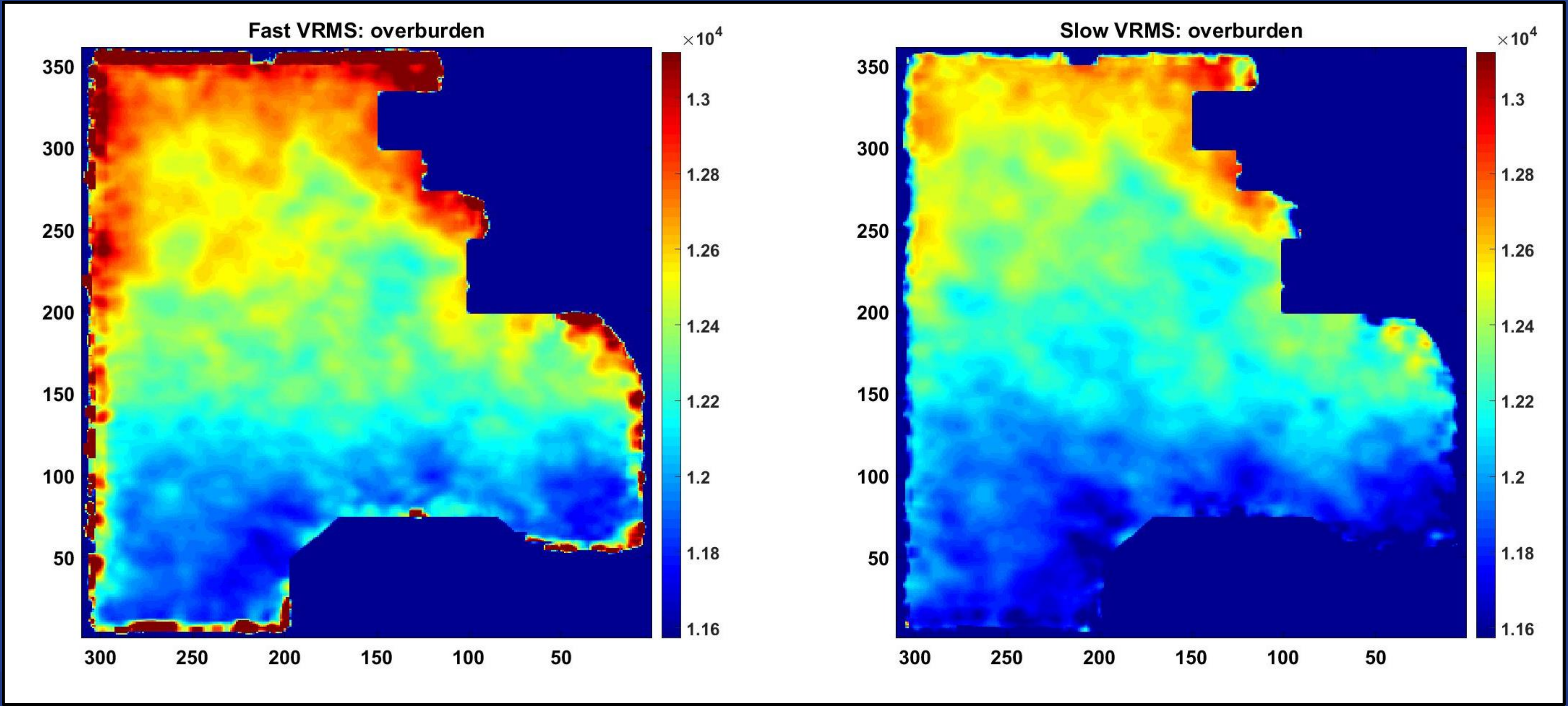
HRS comparison: anisotropy percentage

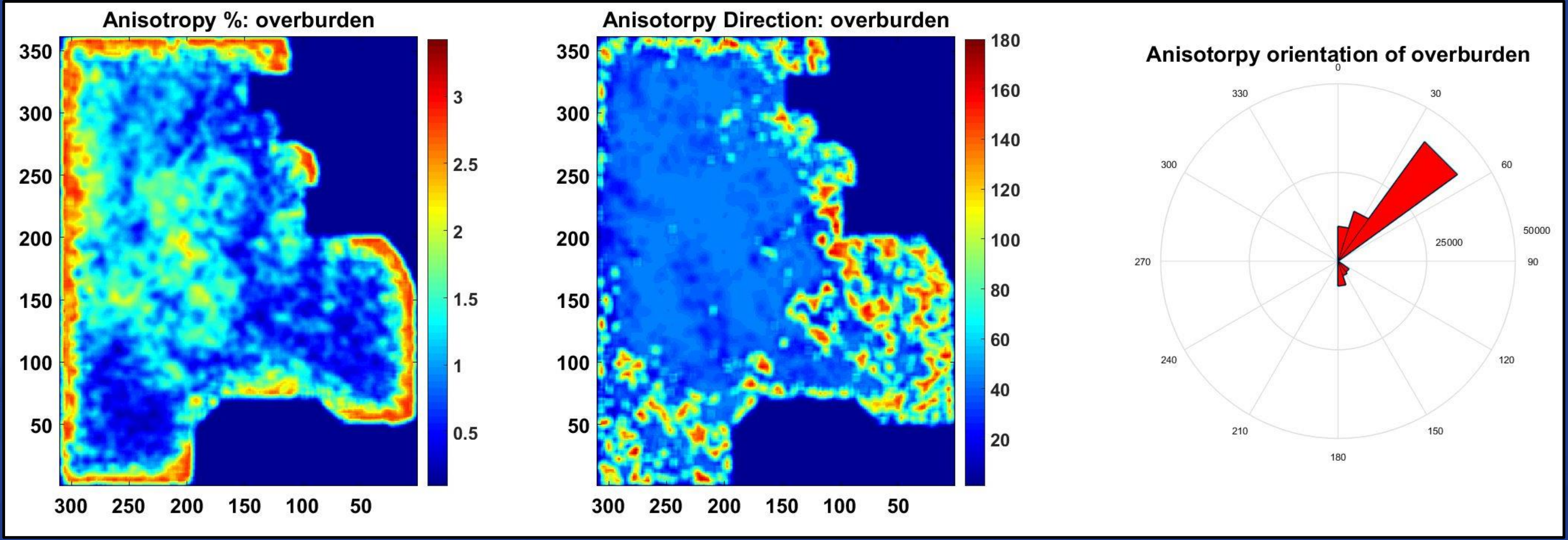




Fast & slow VRMS: overburden



Anisotropy intensity & direction: overburden



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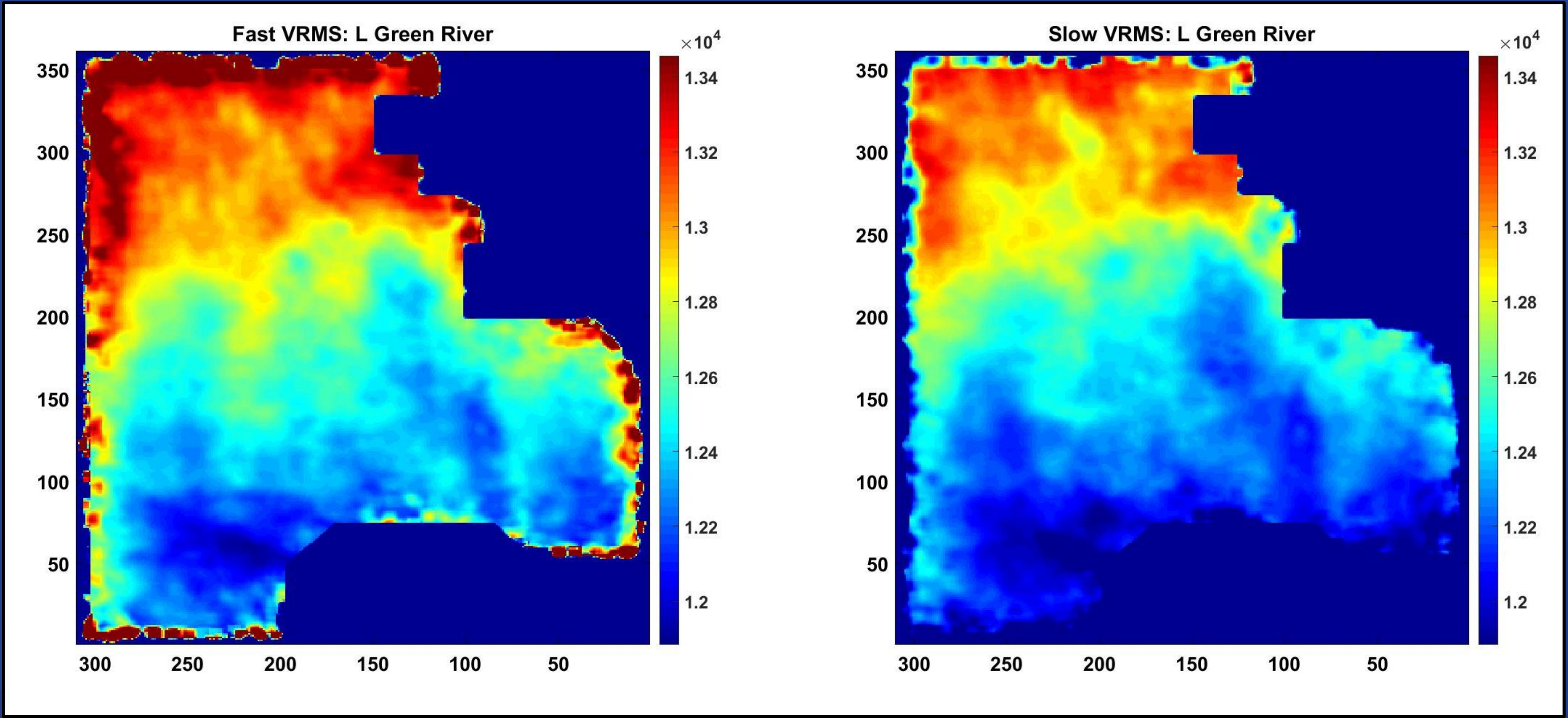
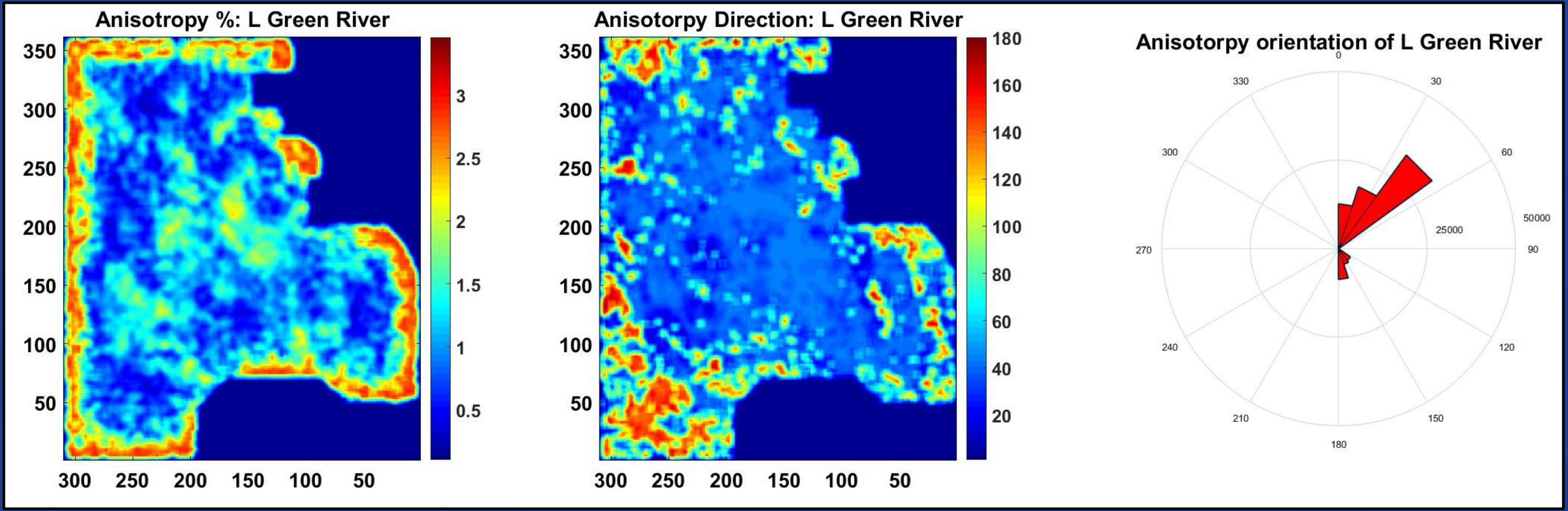
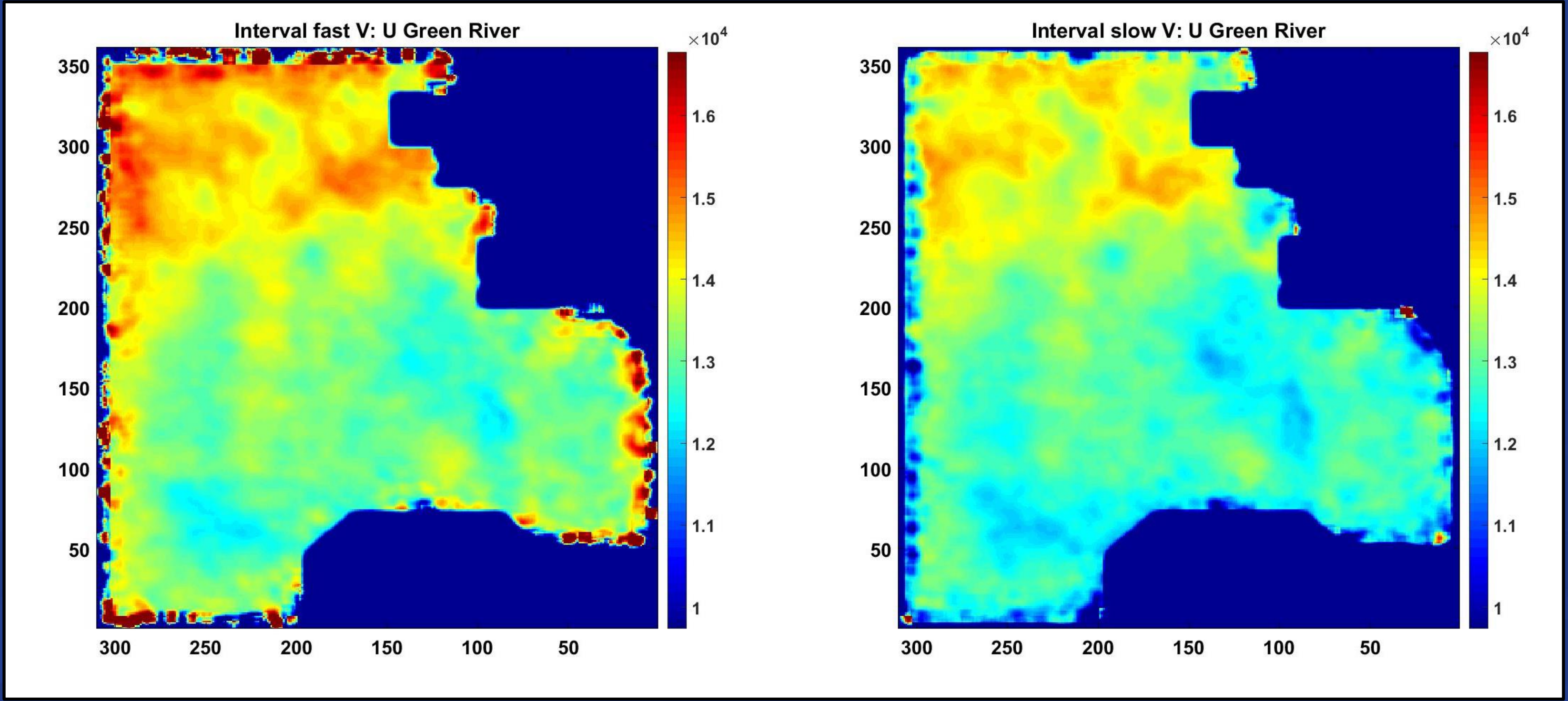
Fast & slow VRMS: Base of Upper Green River



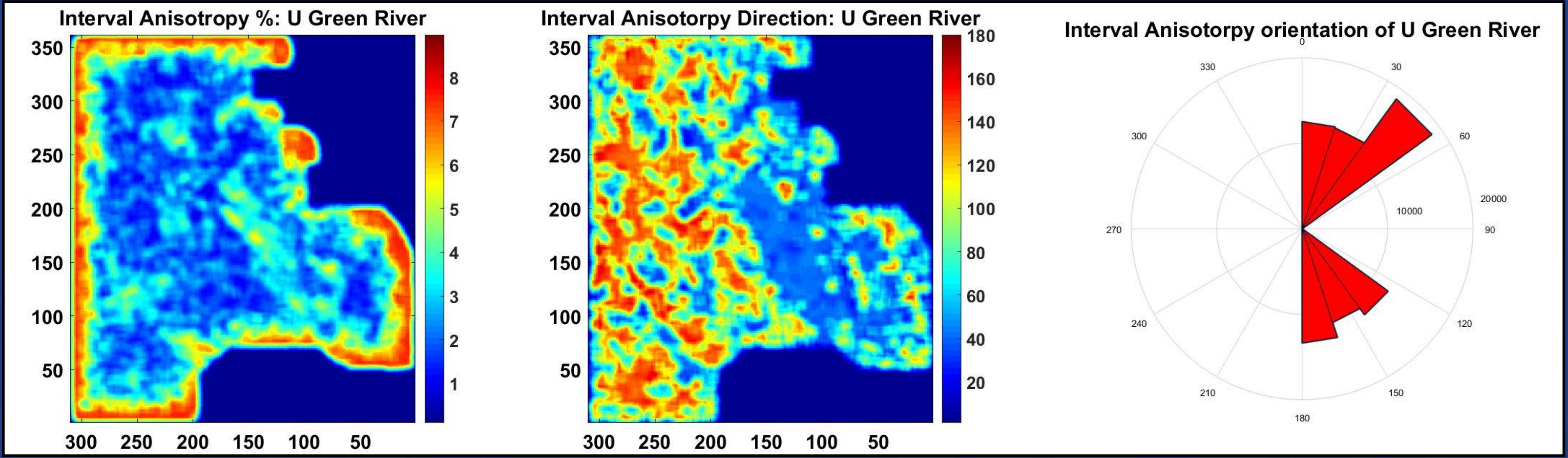
Anisotropy intensity & direction: Base of Upper Green River



Interval fast & slow velocity: Upper Green River



Interval anisotropy intensity & direction: Upper Green River



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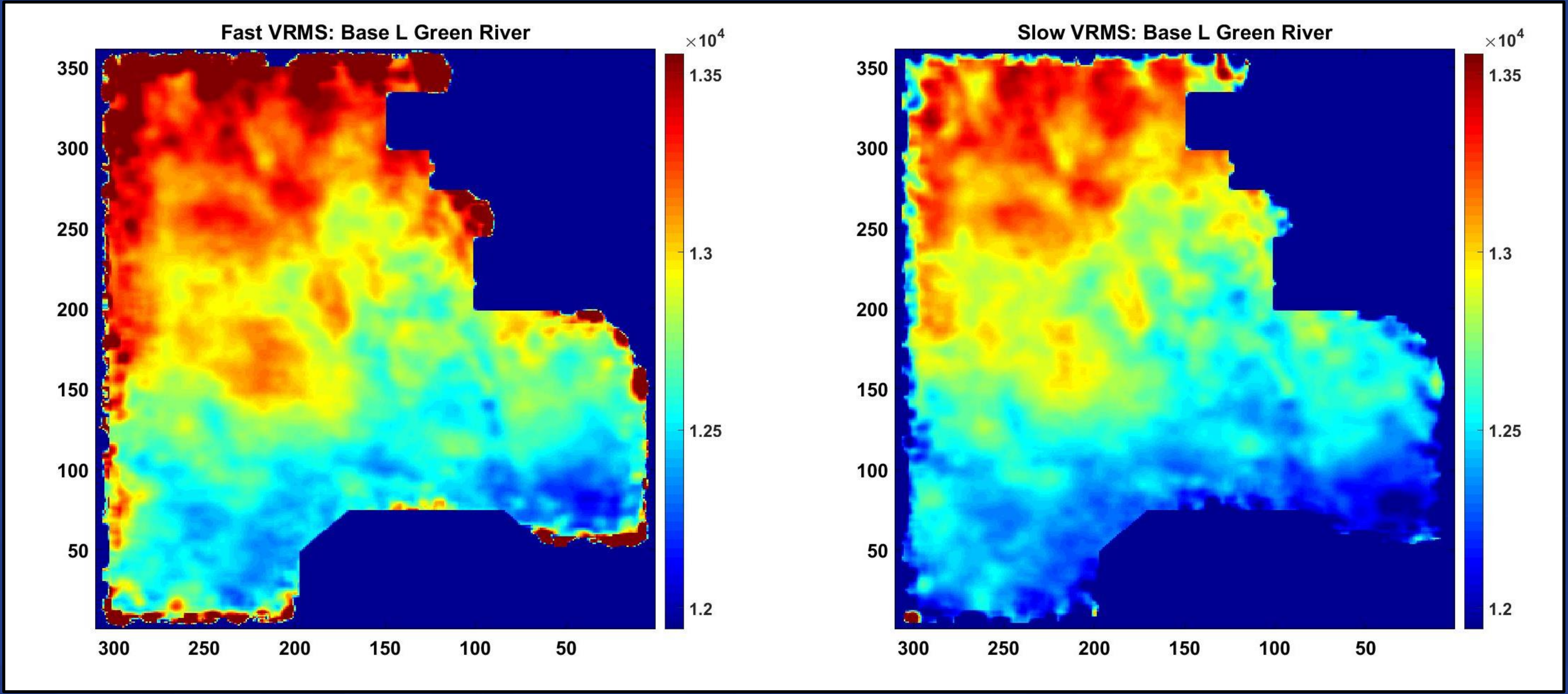
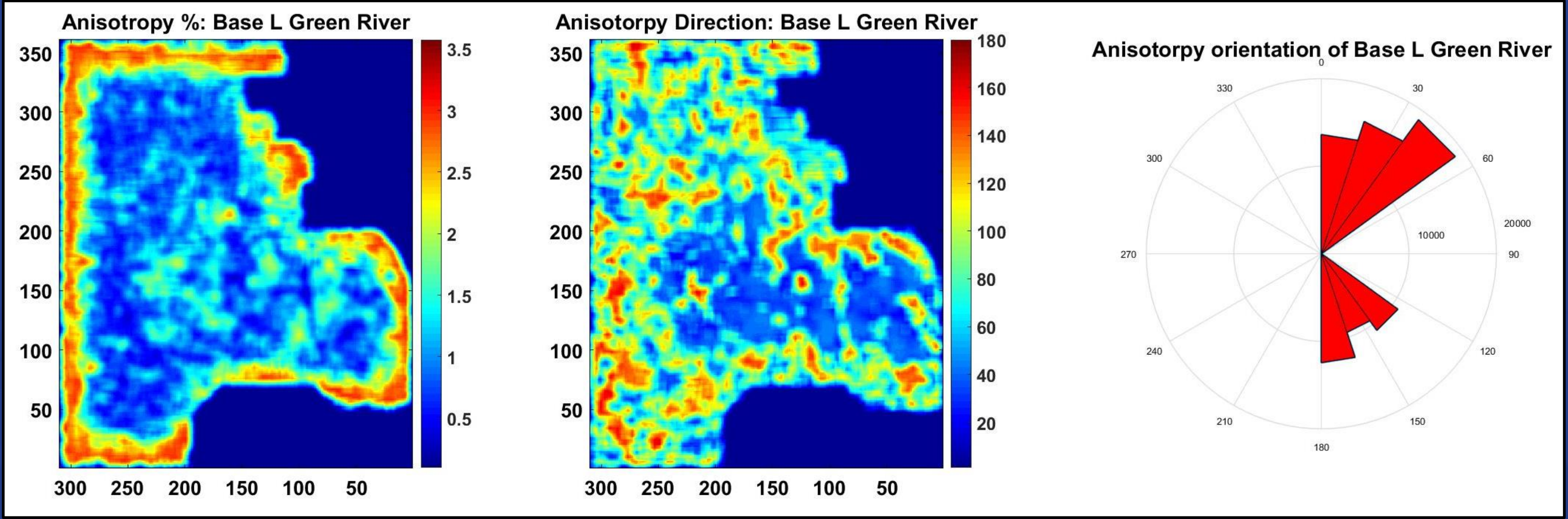
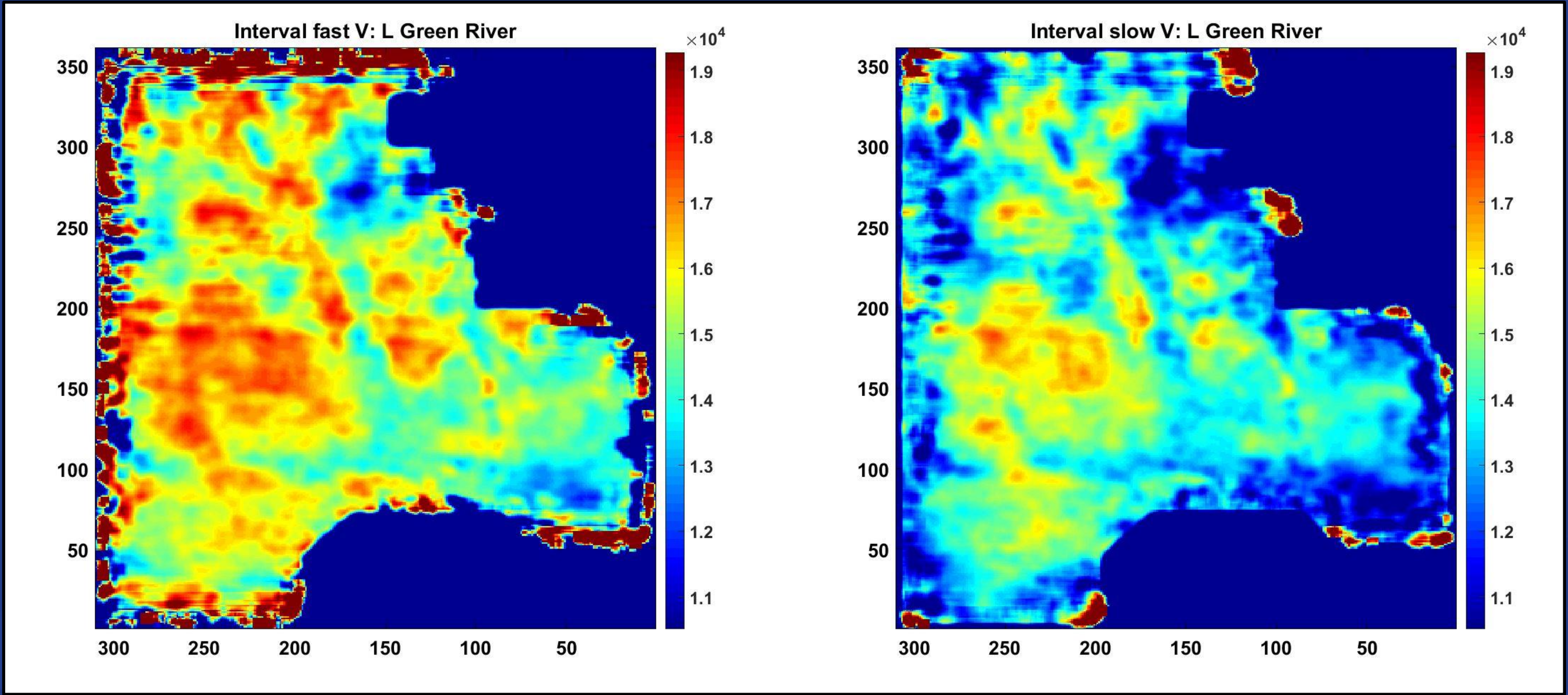
Fast & slow VRMS: Base of Lower Green River



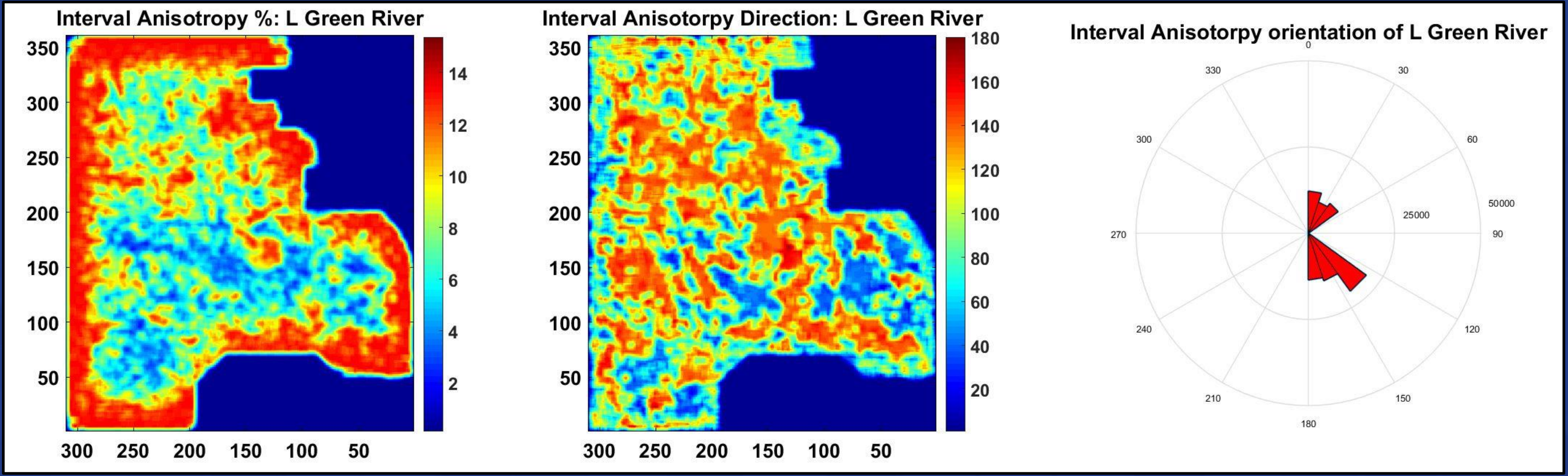
Anisotropy intensity & direction: Base of Lower Green River



Interval fast & slow velocity: Lower Green River



Interval anisotropy intensity & direction: Lower Green River



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Conclusions

- A VVAZ method was used to measure anisotropy percentage and orientation in Altamont-Bluebell field
- Interval anisotropy is estimated to avoid overburden effects
- A VVAZ workflow was developed for offset VSPs
- VVAZ is hugely affected by overburden as evident by offset VSPs

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