Summary of FracView* Image Natural Fracture Interpretation for Well Completions – Boggess-3H, 5H, 9H and 13H
- Prepared for Northeast Natural Energy

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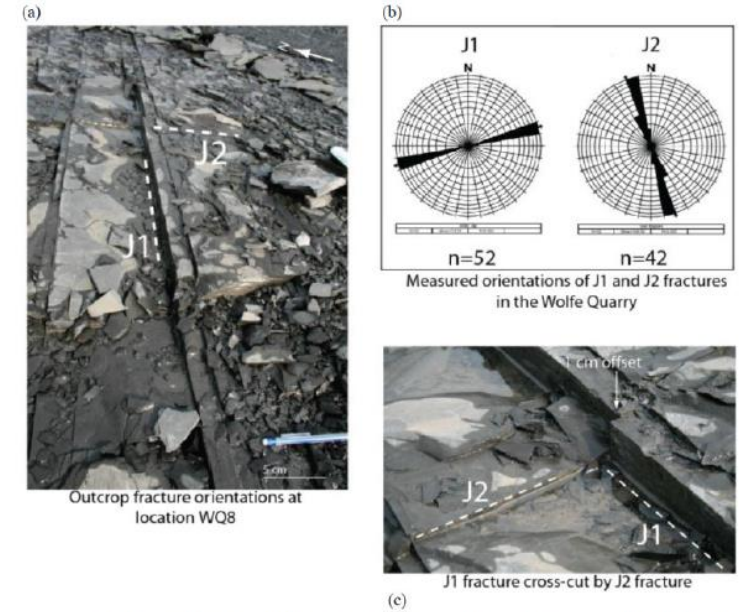
- Natural fractures in Marcellus
- FracView* Image Data quality review
- Fracture types used in this study & examples
- Fracture summary for Boggess-3H, 5H, 9H and 13H
- Conclusion of the fracture study
- Fracture data application in well completions
- Discussion

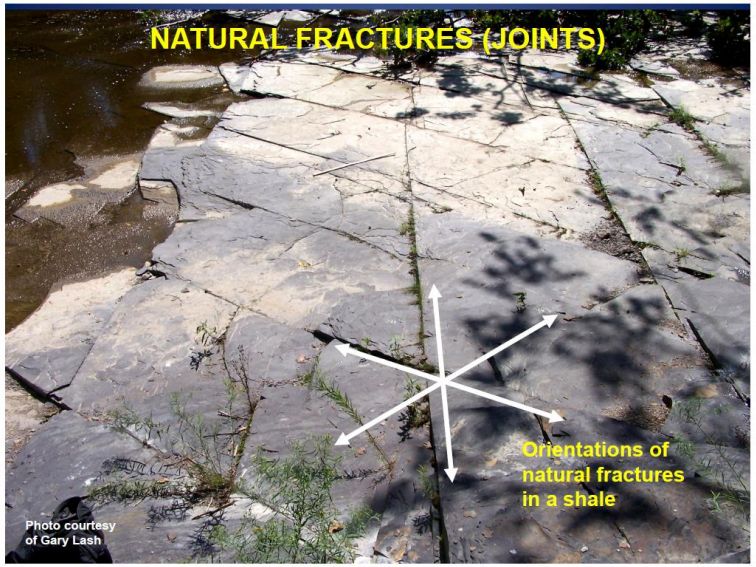
Project objectives

- Getting all acquired FracView images processed & interpreted for four laterals – Boggess-3H, 5H, 9H and 13H
- Characterizing natural fractures & sub-seismic faults for well completion input

Natural fractures in Marcellus outcrop



Outcrop photo showing two natural fracture sets in Marcellus shale at Wolfe Quarry (Pommer et al, 2013). Rose diagram shows the strike orientations for both J1 and J2 sets.



(Harper et al)

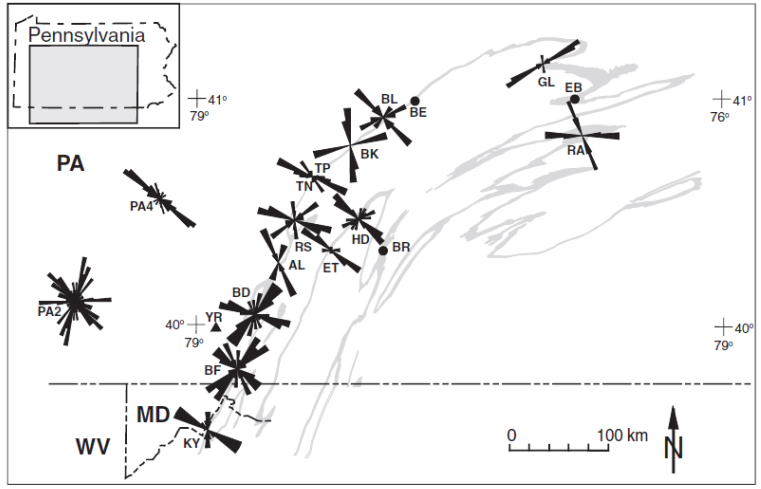
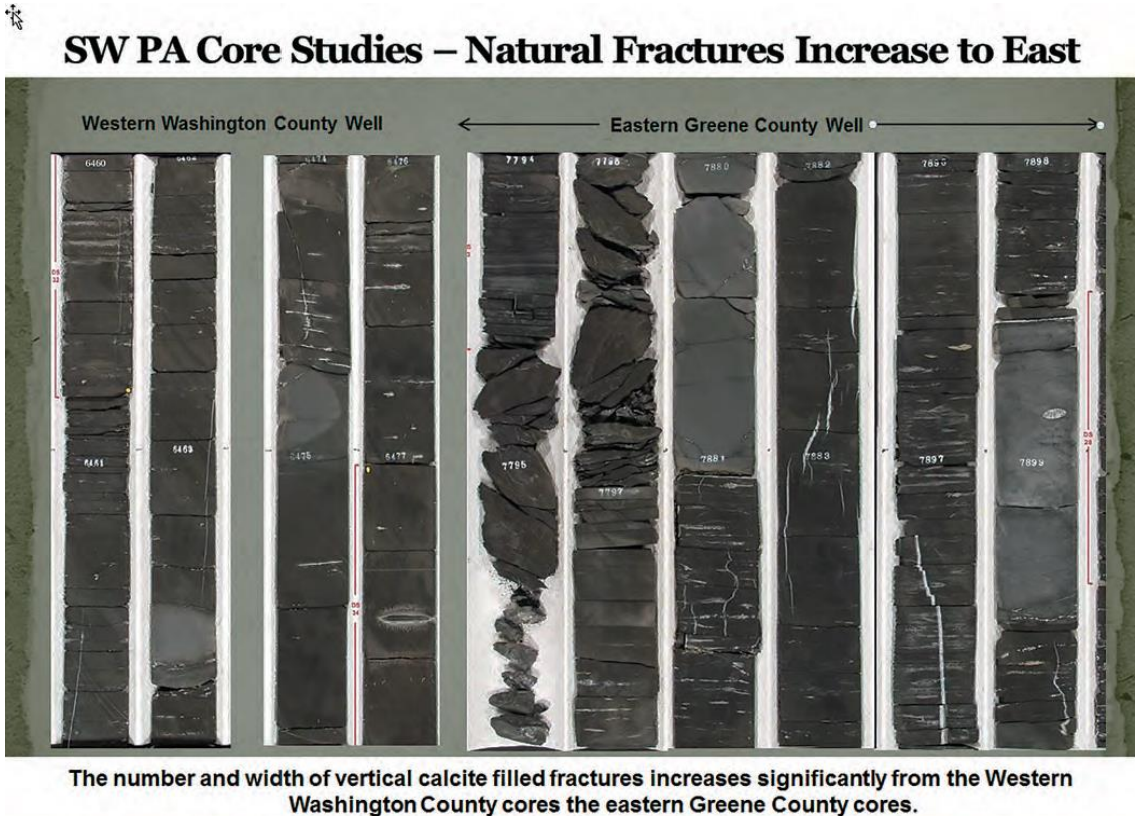


Figure 3. Rose diagrams showing fracture orientations in the Devonian shale sequence. All data are rotated to bedding horizontal. PA2 and PA4 data are from oriented core (Figure 1). Other data are from outcrop measurements, except fracture orientations for site GL (Figure 1) are taken from Engelder et al. (2011, Figure 12), and for site RA are from Engelder et al. (2011, Figure 19).

(Wilkins, et al, 2014)

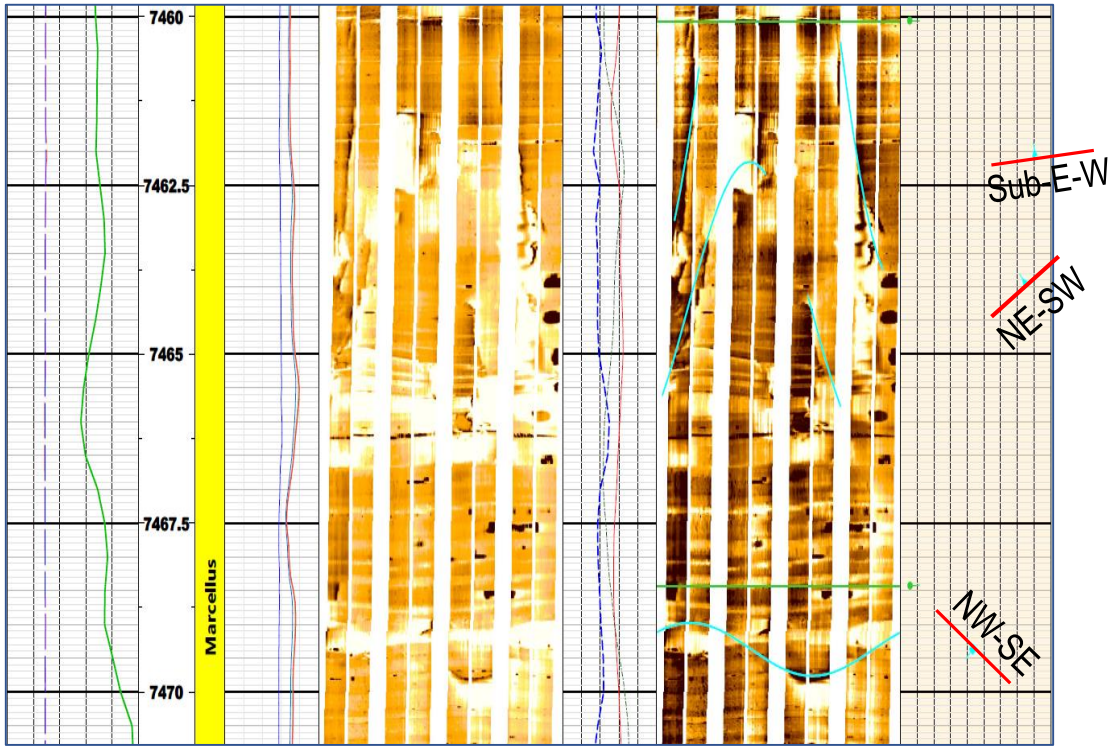
- Natural fractures in Marcellus are very common;
- Multiple fracture sets (more than J1 & J2) and fracture orientation varies from one region to another.

Natural fractures in Marcellus core & borehole image logs in vertical well



(Zagorski et al, 2017)

Fractures observed in Well MIP-3H Pilot



- Calcite-filled & short-length fractures are common in the Marcellus (core);
- Multiple fracture sets observed in vertical wells (3 sets and high angle & low angle)

FracView Image Quality Review

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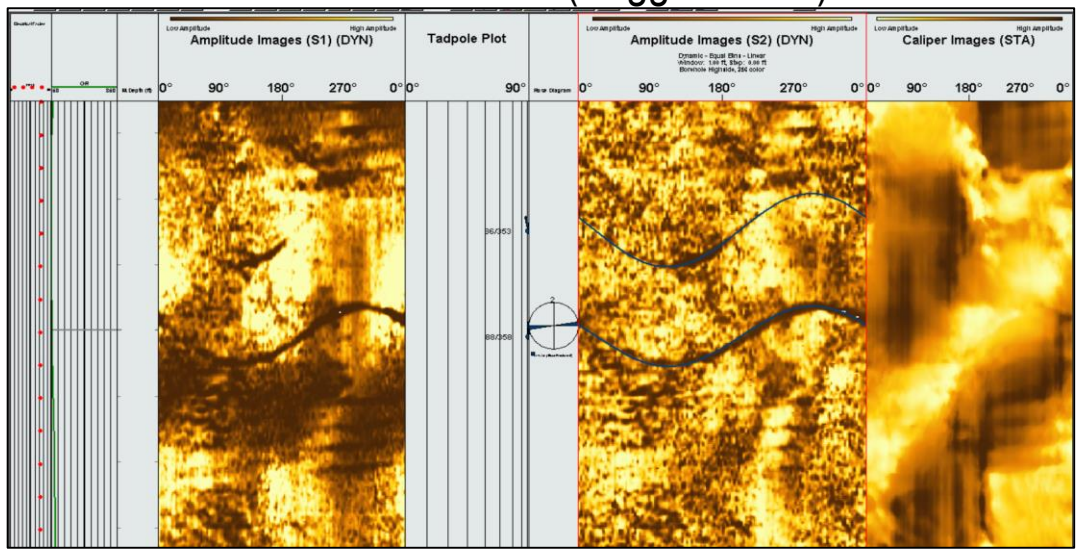
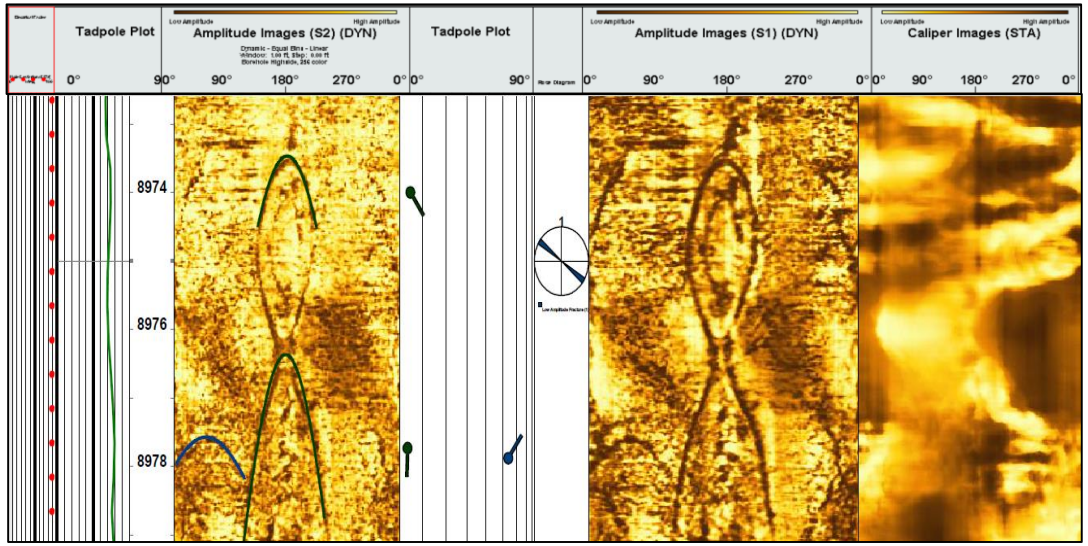
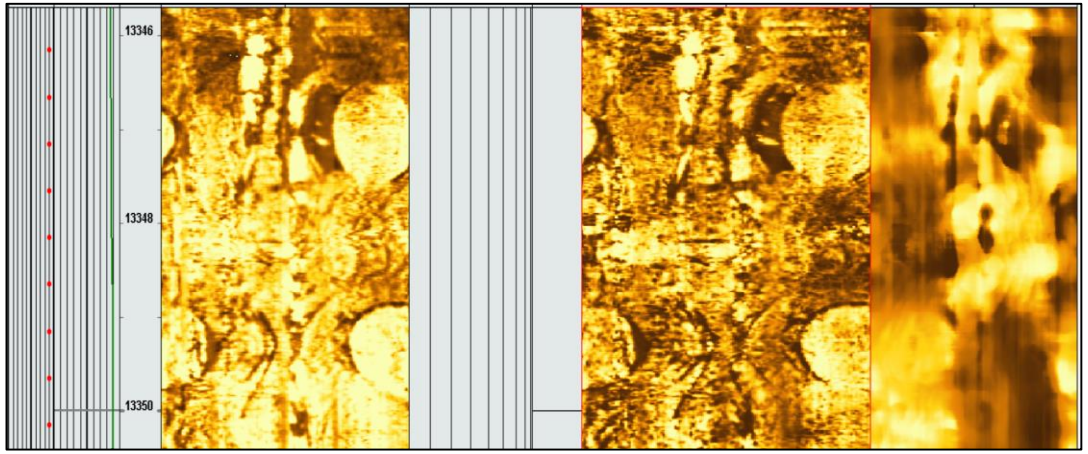
Natural Fractures (Boggess-13H)



Bedding (Boggess-3H)





Rock Texture (Boggess-3H)

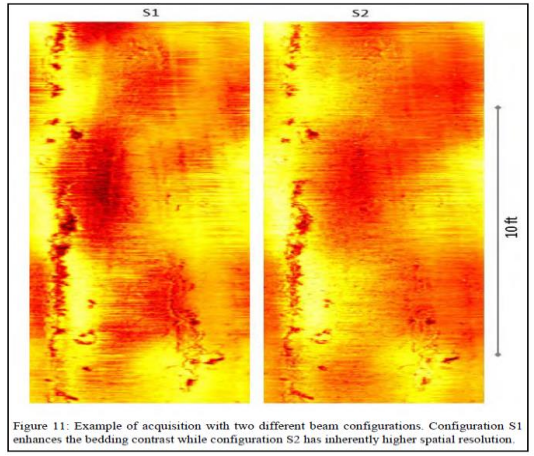


Figure 11: Example of acquisition with two different beam configurations. Configuration S1 enhances the bedding contrast while configuration S2 has inherently higher spatial resolution.

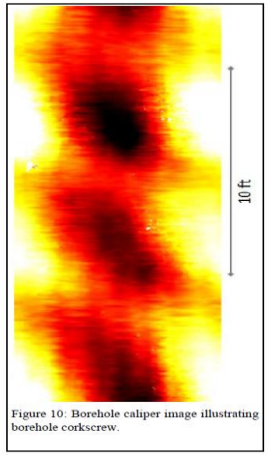


Figure 10: Borehole caliper image illustrating borehole corkscrew.

Amplitude images with multiple simultaneous acquisitions using different beam configureations are generated to enhance sensitivity to specific features, for example bedding contrast (Morys et al, 2018)

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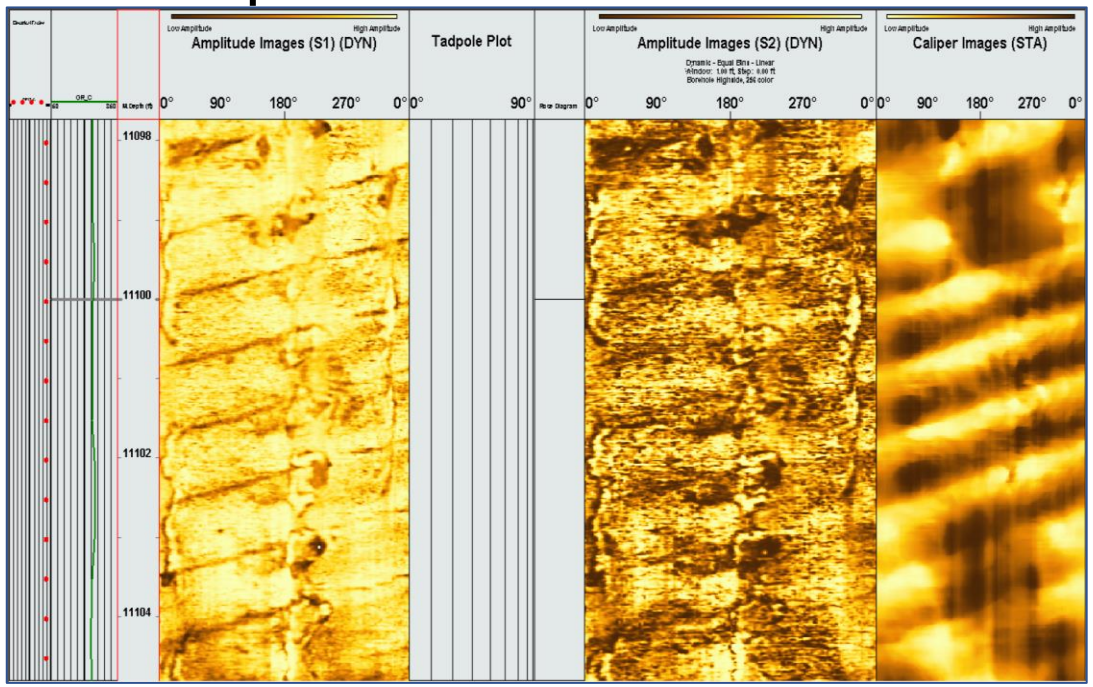
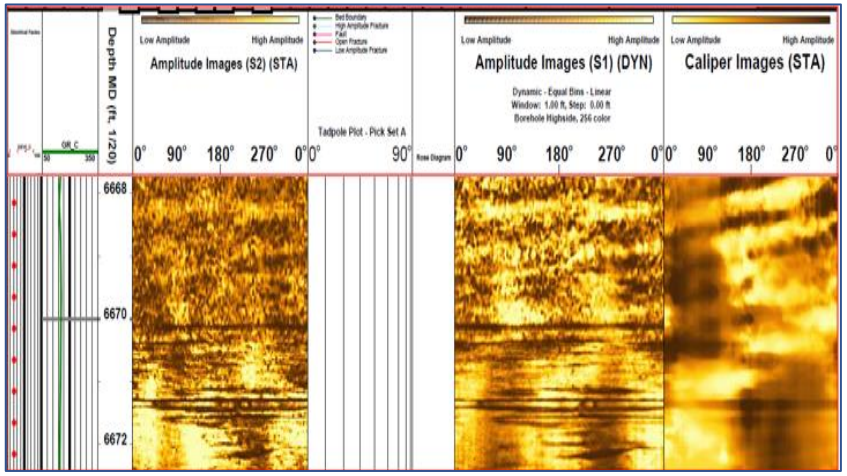
Image interpretation awareness - various types of artifacts

Artifact - Spiral hole

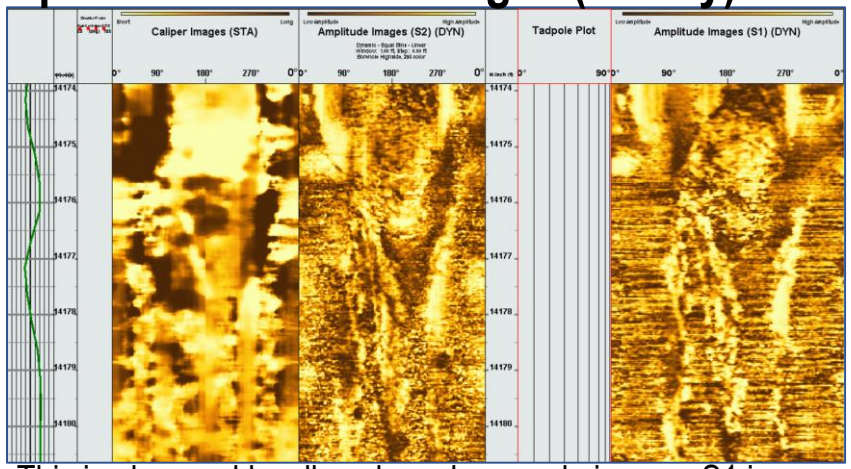


This is observed in many sections in the wells.

Artifact on wellbore



Special “noise” on images (locally)



This is observed locally only and more obvious on S1 images in this example.

Natural Fracture Interpretation

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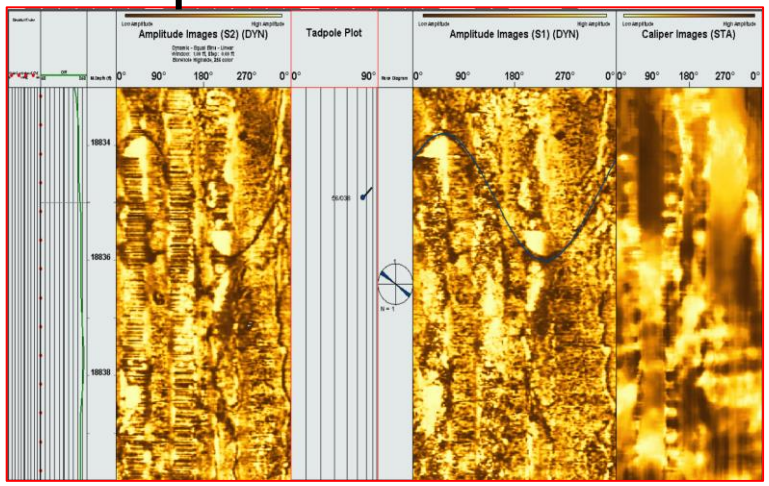
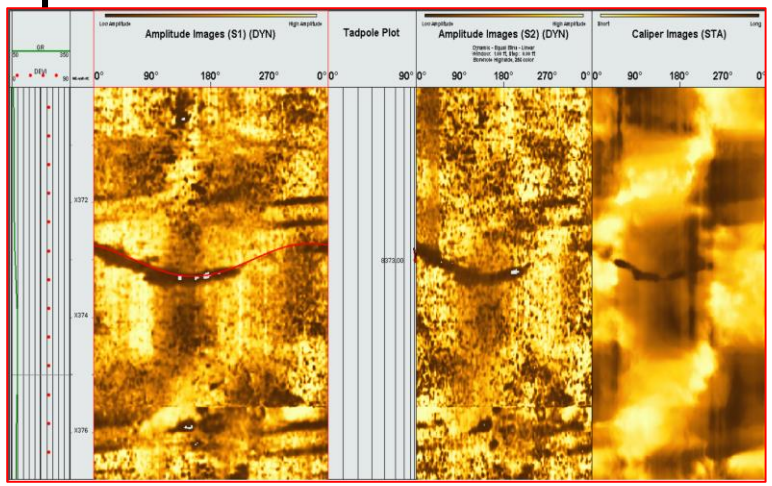
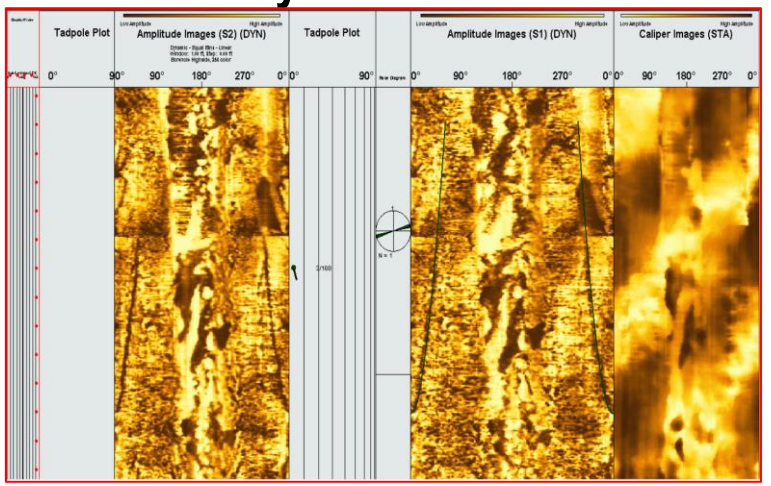
Low Amplitude Fracture



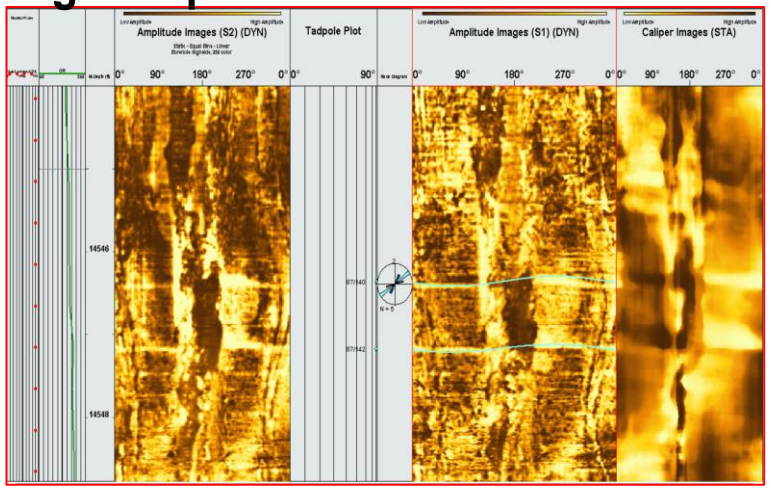
Open Fracture



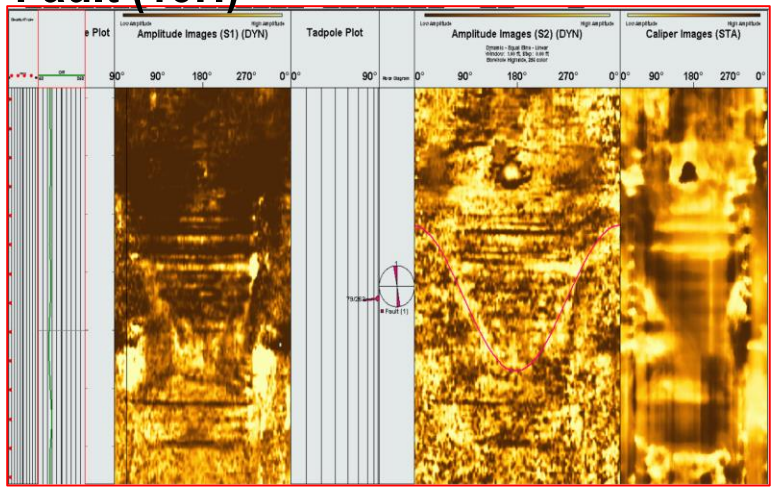
Bed Boundary



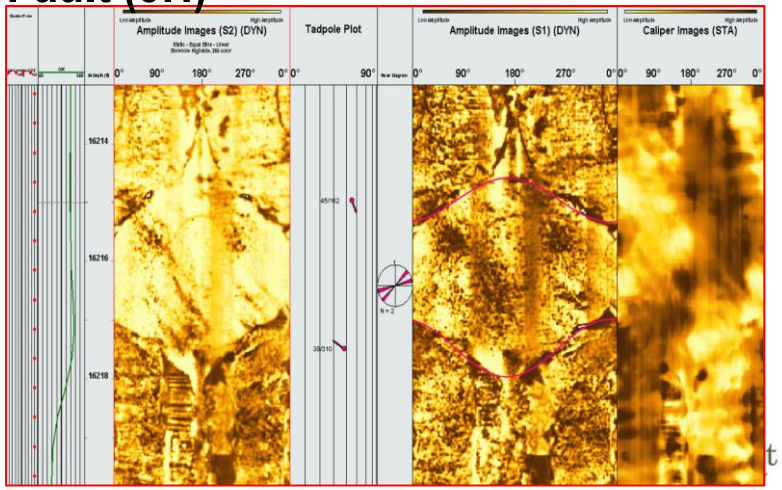
High Amplitude Fracture



Fault (13H)

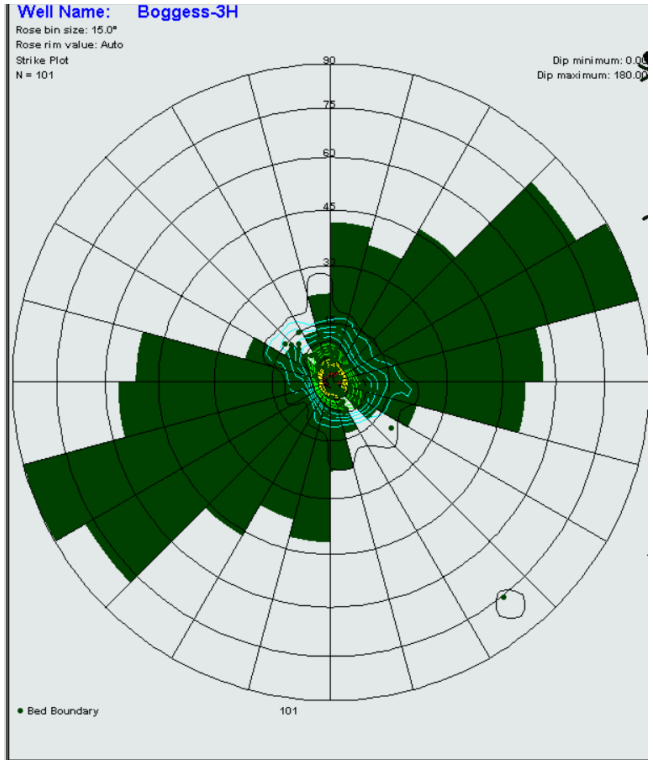


Fault (3H)



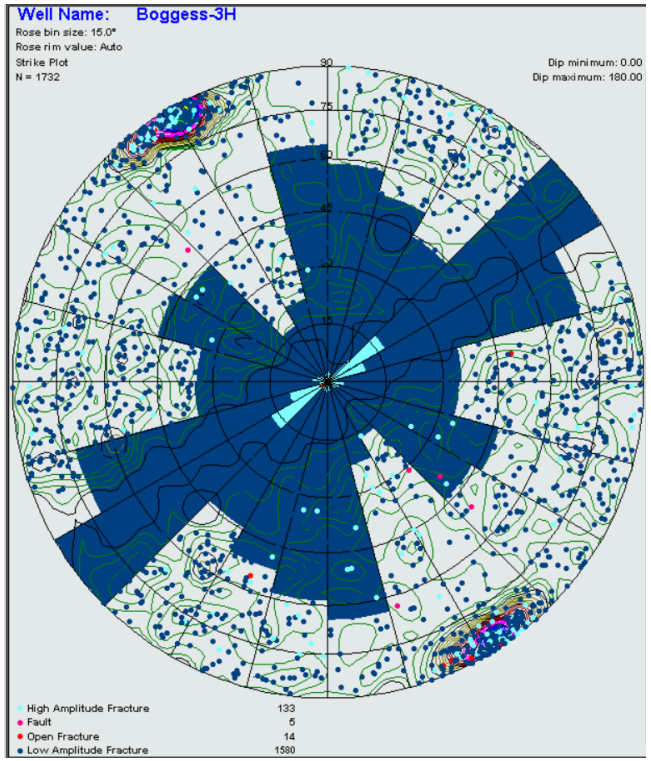
Fracture Summary – Boggess-3H

Rose diagram (strike plot) summary for all bedding dips



Vector mean dip: 2.01 deg

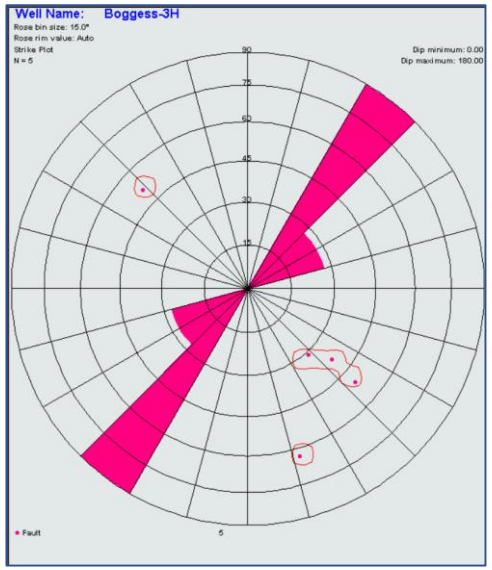
Rose diagram (strike plot) summary for all fracture/fault dips



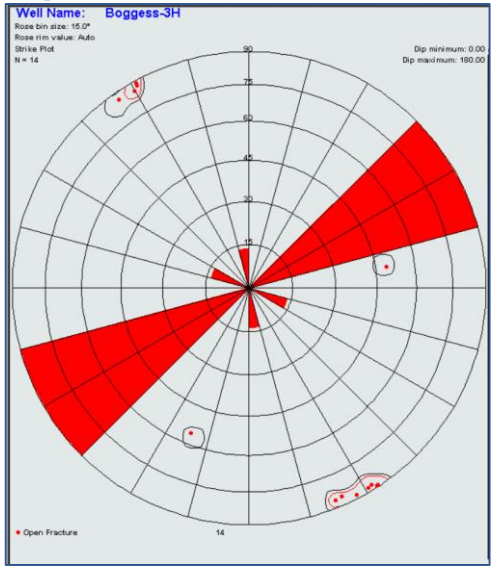
Fracture Type	#
Low amplitude fractures	1580
High amplitude fractures	133
Open fractures	14
Fault	5
Total	**1732**

Rose diagram (strike plot) summary for each fracture type – Boggess-3H

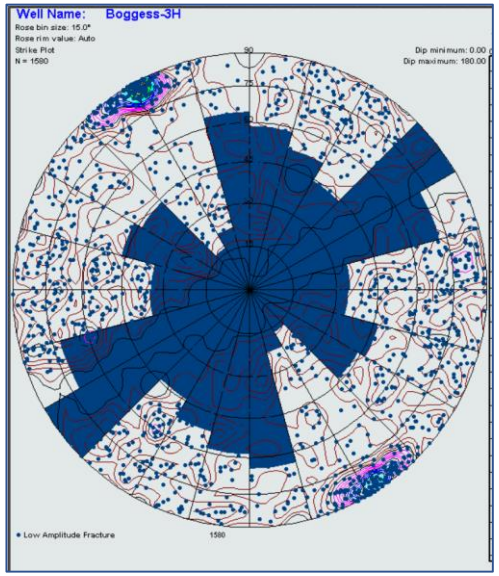
Fault



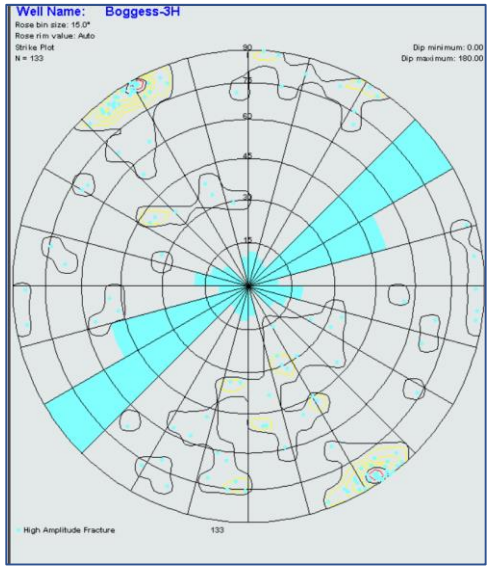
Open Fractures



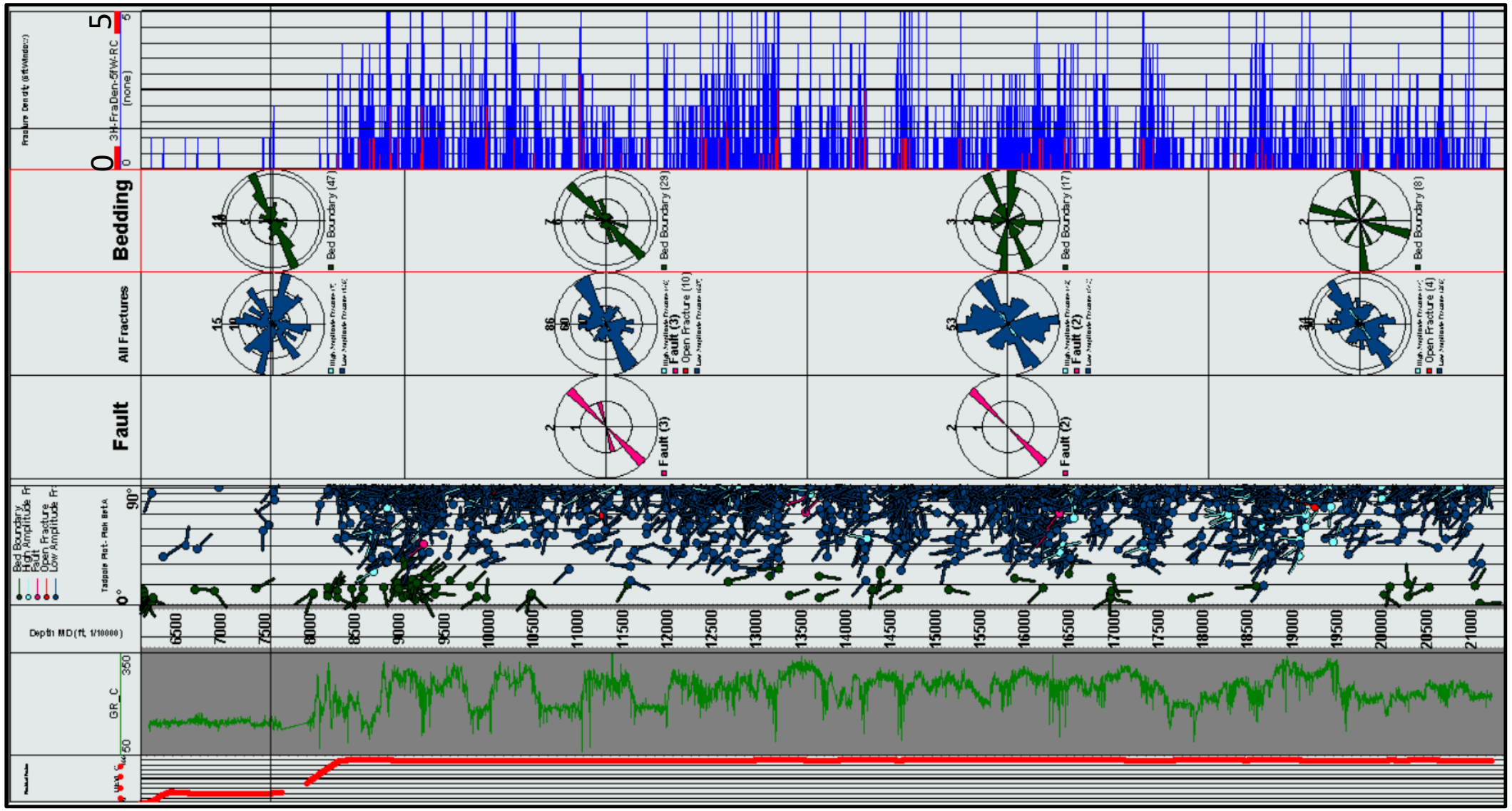
Low Amplitude Fractures



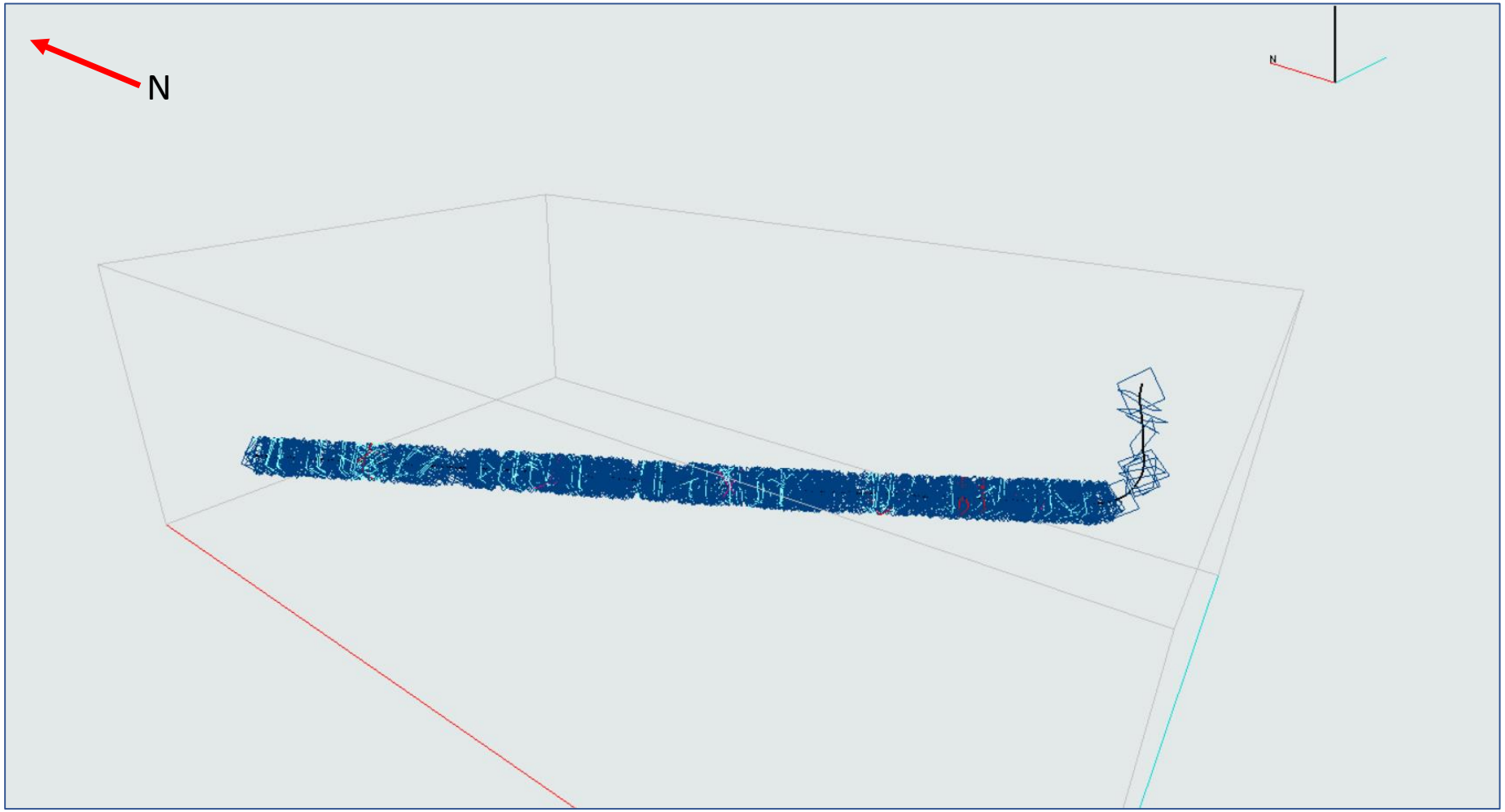
High Amplitude Fractures



Fracture density along the wellbore – Boggess-3H (Horizontal view)

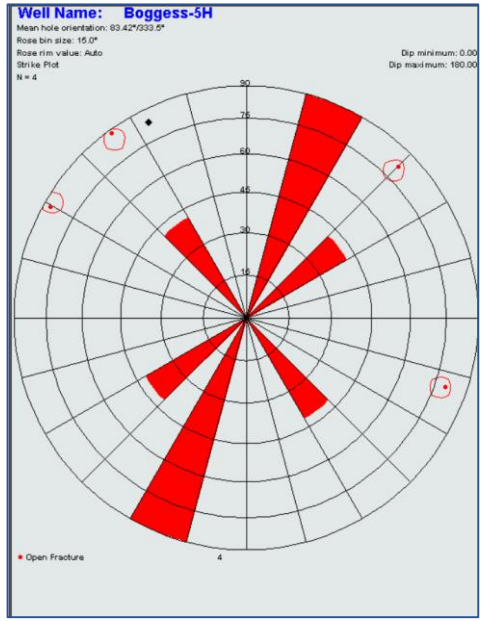


3-D view of all fractures and faults along wellbore – Boggess-3H

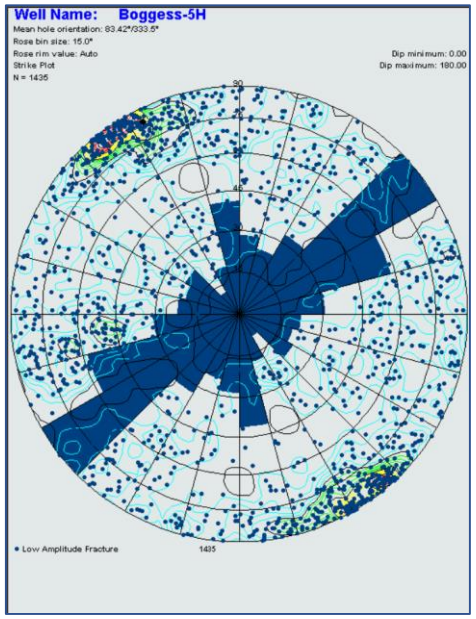


Fracture Summary – Boggess-5H

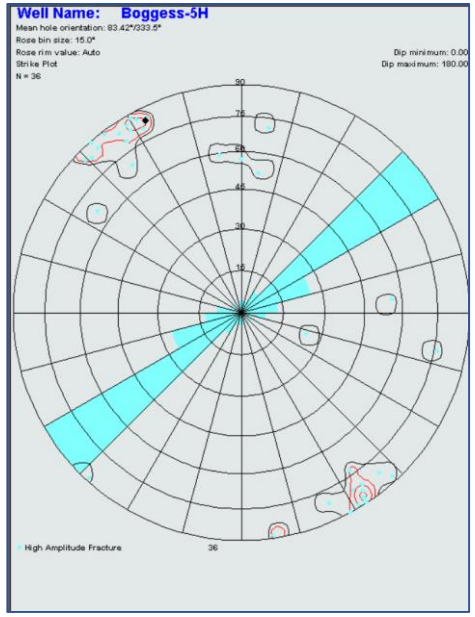
Open Fractures



Low Amplitude Fractures



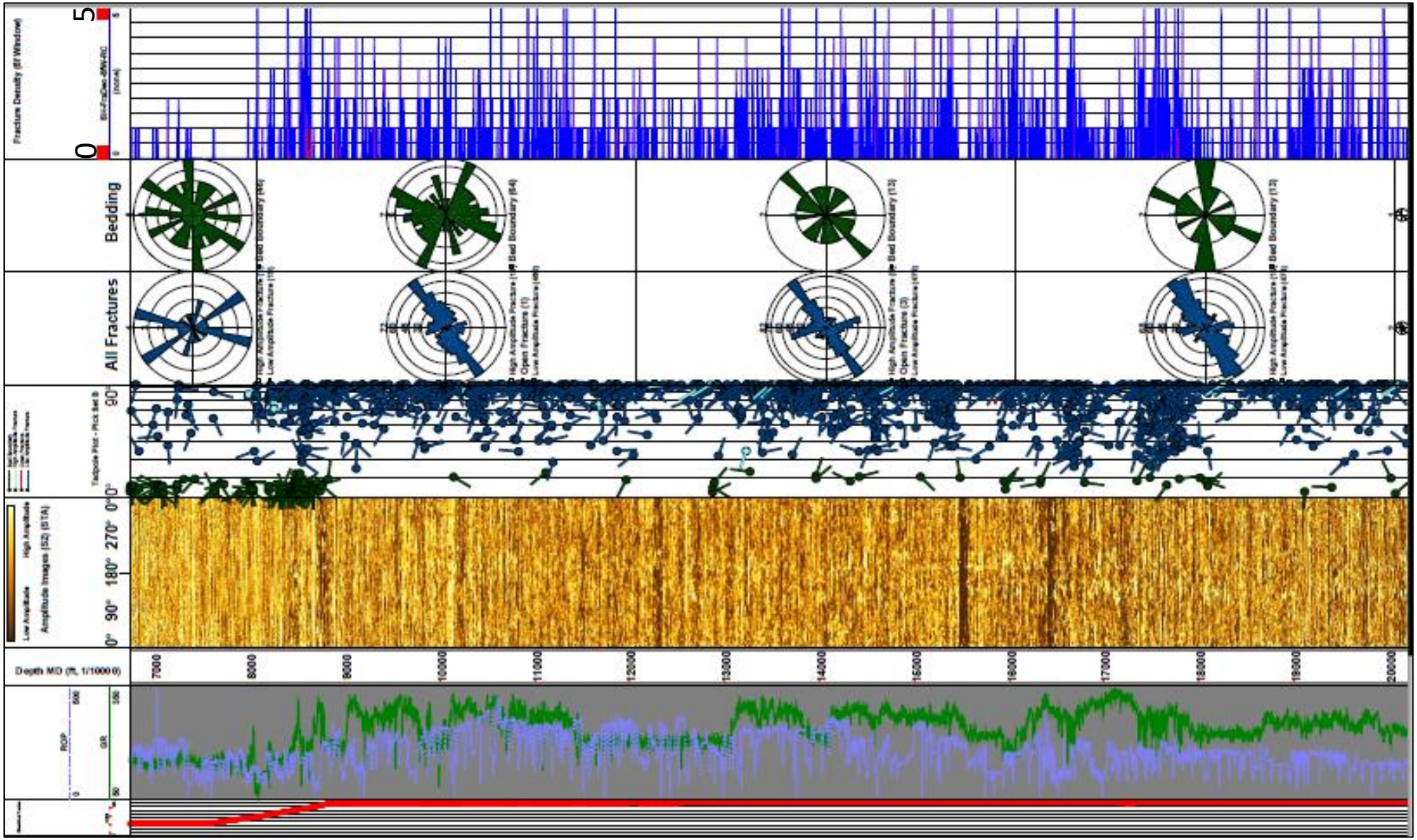
High Amplitude Fractures



Number of fractures

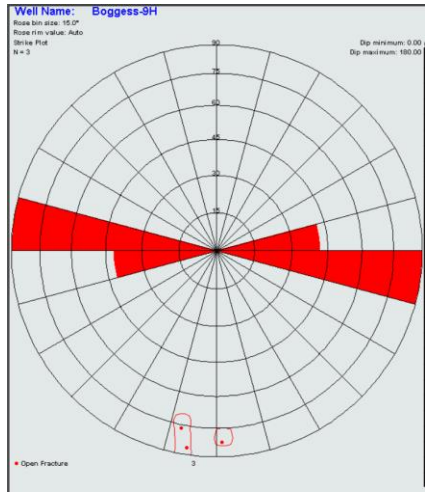
Fracture Type	#
Low amplitude fractures	1435
High amplitude fractures	36
Open fractures	4
Fault	0
Total	**1475**

Fracture density along the wellbore – Boggess-5H

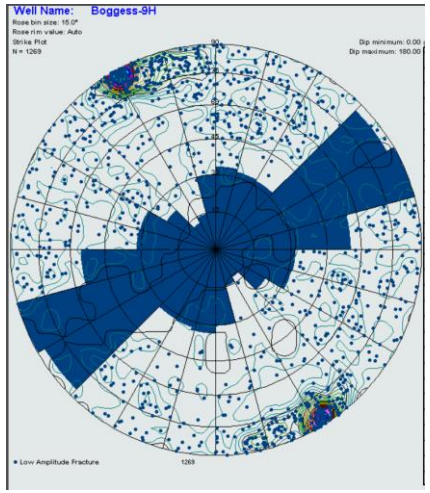


Rose diagram (strike plot) summary for each fracture/fault type – Boggess-9H

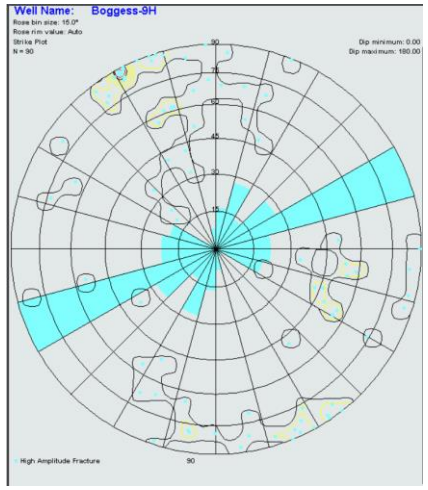
Open Fractures



Low Amplitude Fractures



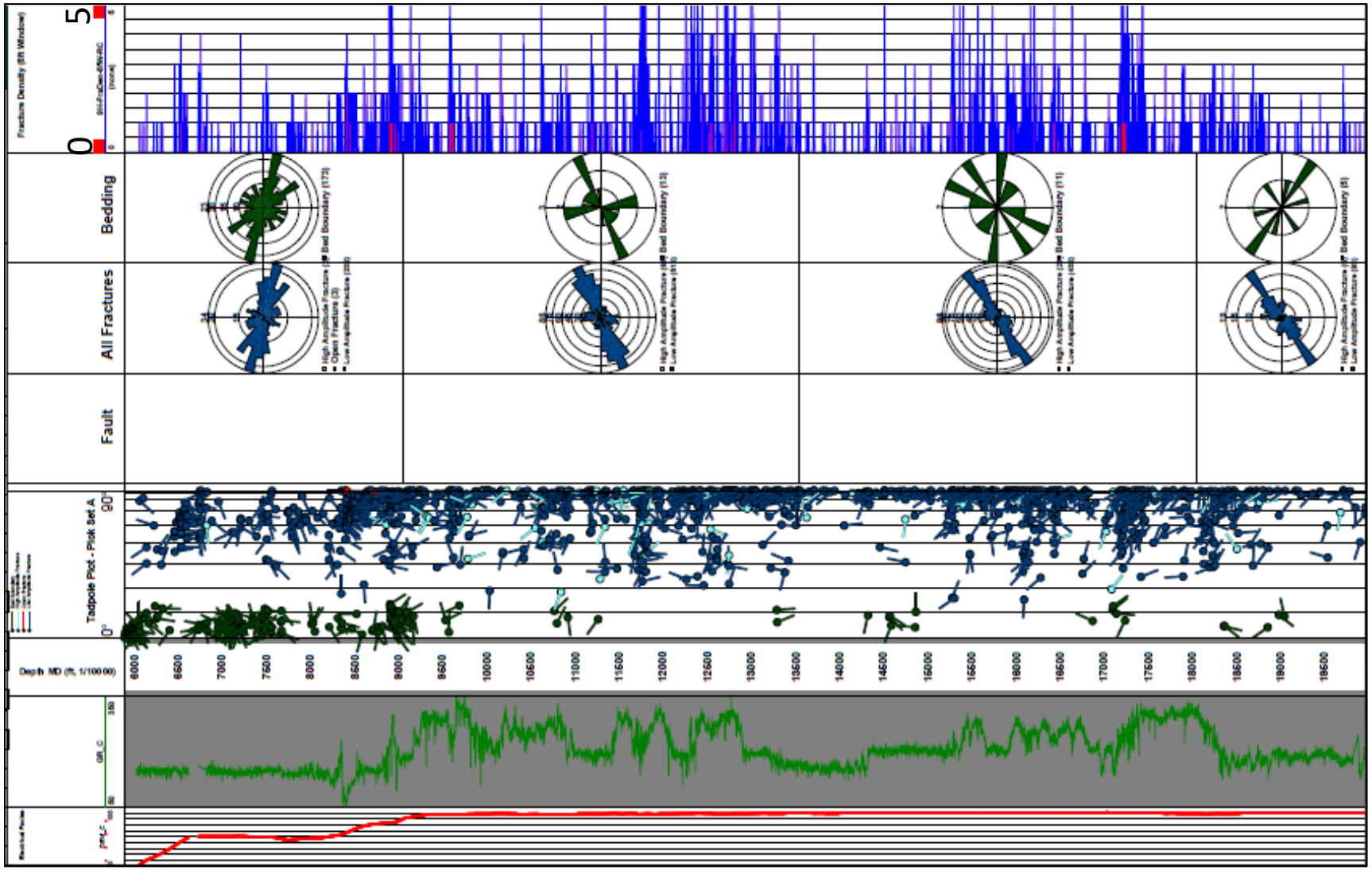
High Amplitude Fractures



Number of fractures

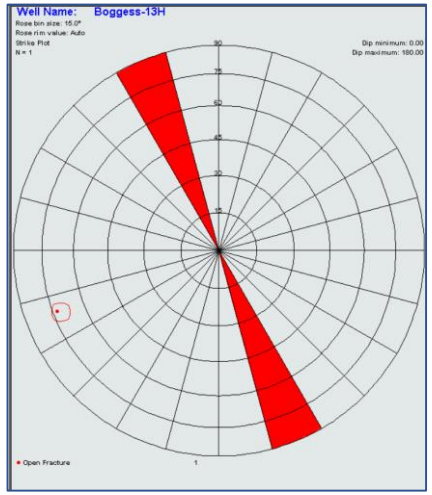
Fracture Type	#
Low amplitude fractures	1269
High amplitude fractures	90
Open fractures	3
Fault	0
Total	**1362**

Fracture density along the wellbore – Boggess-9H

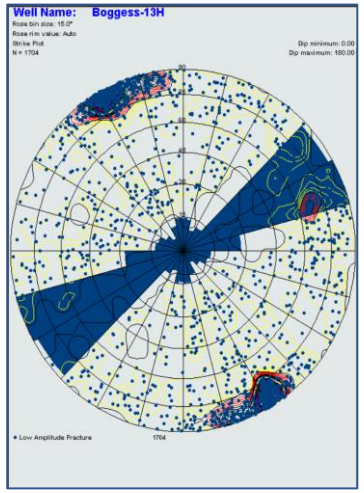


Rose diagram (strike plot) summary for each fracture/fault type – Boggess-13H

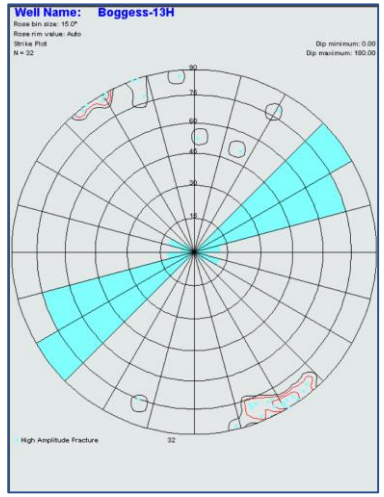
Open Fractures



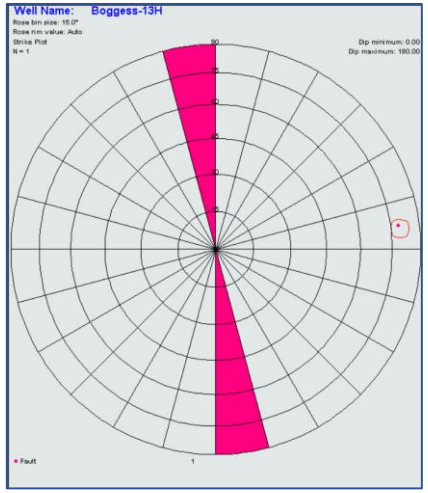
Low Amplitude Fractures



High Amplitude Fractures



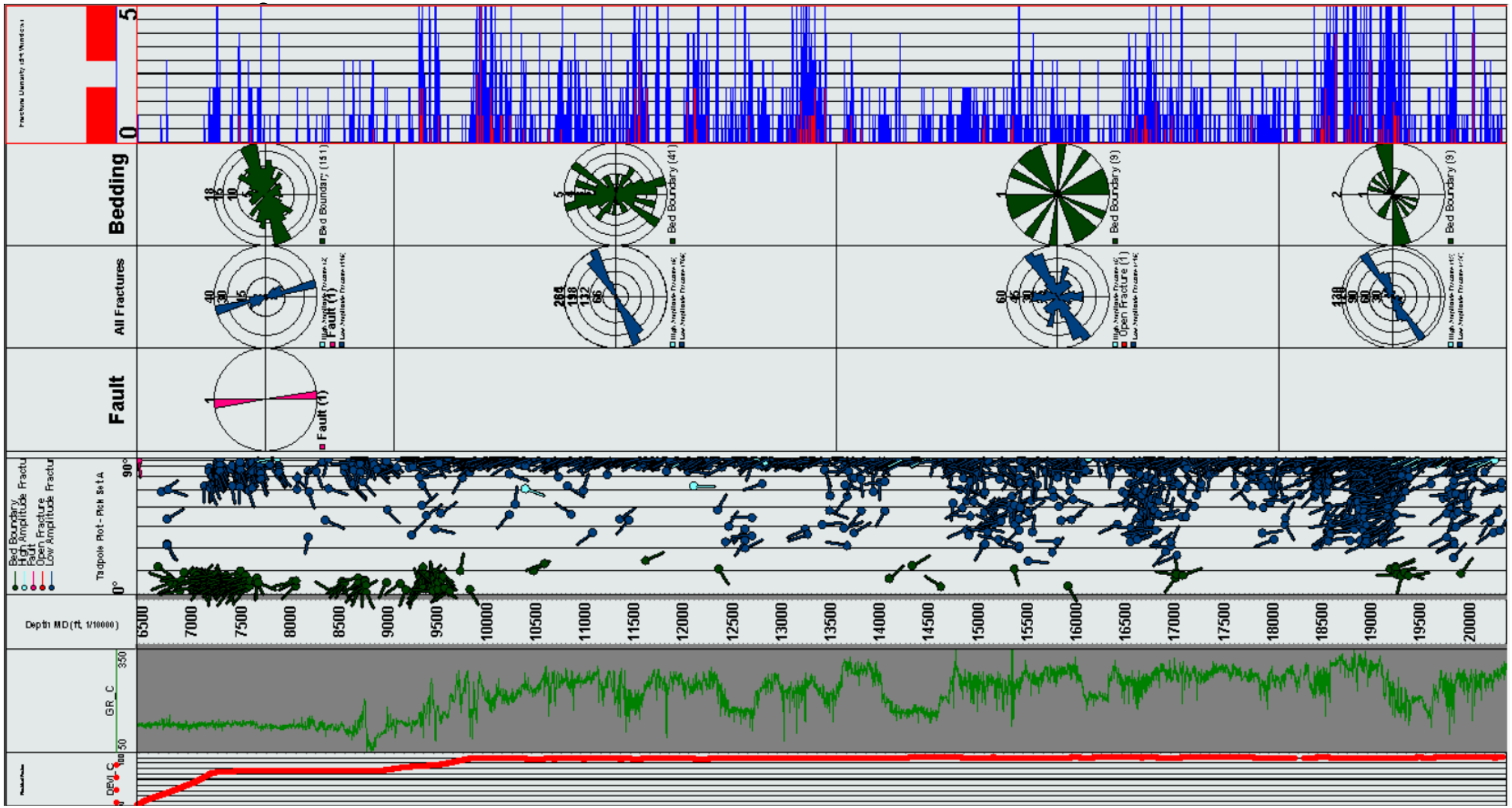
Fault



Number of fractures

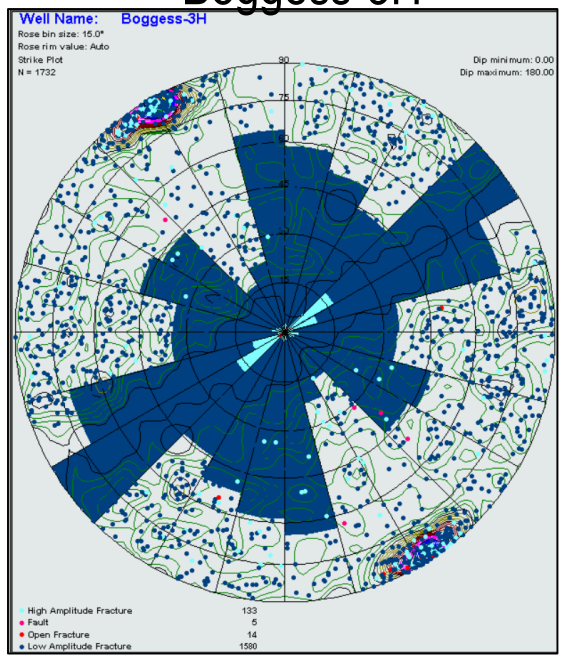
Fracture Type	#
Low amplitude fractures	1704
High amplitude fractures	32
Open fractures	1
Fault	1
Total	**1738**

Fracture density along the wellbore – Boggess-13H



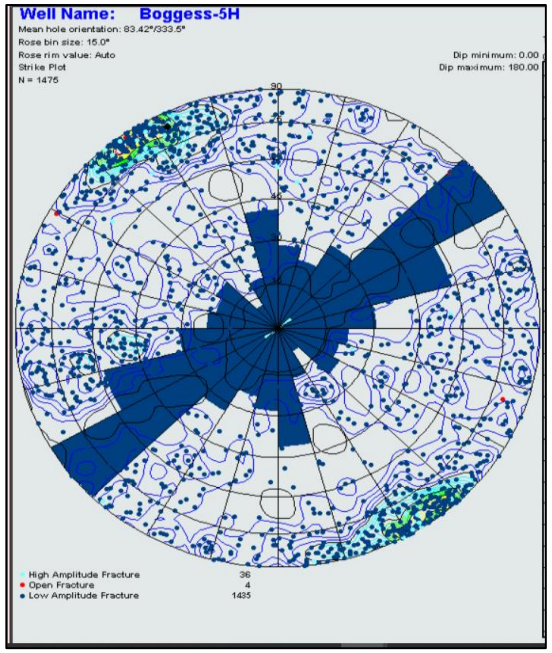
Fracture summary for all four wells

Boggess-3H



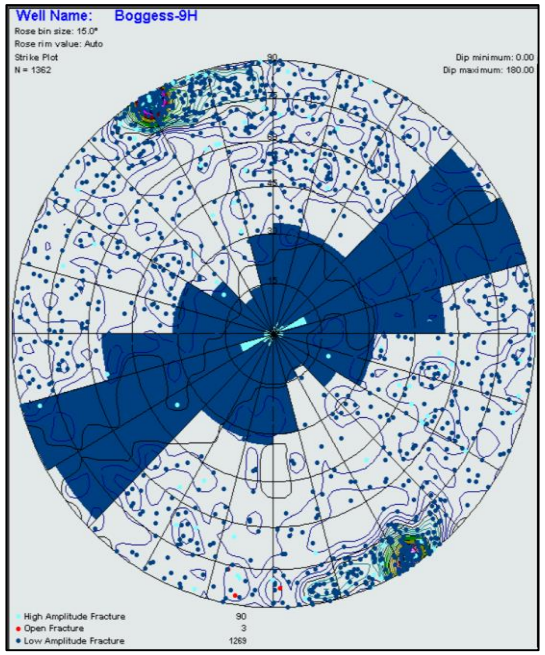
# of total fractures: 1732

Boggess-5H



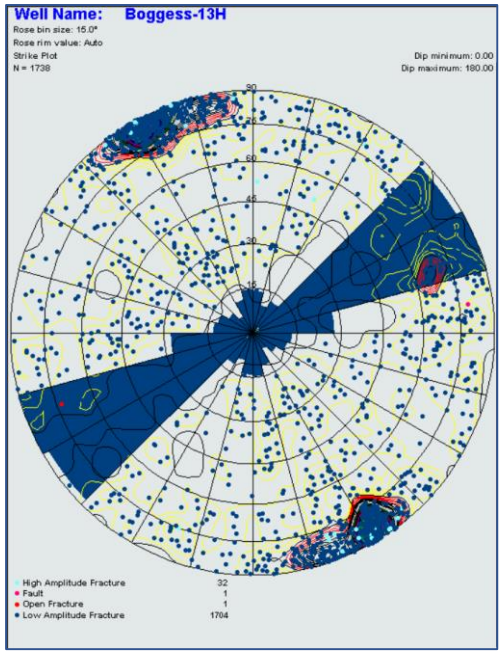
# of total fractures: 1475

Boggess-9H



# of total fractures: 1362

Boggess-13H



# of total fractures: 1738

FracView Fracture Interpretation Summary

- FracView images acquired in the four horizontal wells have all good quality data allowing effectively detecting both fractures, sub-seismic faults and bedding information;
- Natural fractures are well-developed in the Marcellus & expected to impact stimulation;
- The total number of fractures interpreted for Boggess-3H, 5H, 9H and 13H is 1732, 1475, 1362 and 1738 respectively. Majority of them are low amplitude fractures for all wells;
- Multiple fracture sets detected in the Marcellus laterals with a dominant set oriented at NE-SW and two secondary sets (sub-N-S and ESE-WSW);
- Fracture density is generally high in all wells but varied from well to well (3H & 13H highest and decreased in 5H and 9H) and also within any single lateral. It seems more fractures observed in organic material rich shale in general;
- Five faults interpreted in 3H and one in 13H which are all sub-seismic minor ones. None is seen in 5H & 9H;
- Structural dips for all 4 wells are generally flat with vector mean dip as 2, 1.7, 1.4 and 1.9 for 3H, 5H, 9Hand 13H respectively.

Fracture Data Application in Well Completion in Marcellus

- The well-developed natural fractures in the Marcellus expect to impact stimulation;
- Open fractures enhance reservoir perm;
- Other fractures (Low & high amplitude fractures) are all weak planes in the rock which are expected to be easier to be re-open than creating new fractures during stimulation;
- Multiple fracture sets in the Marcellus help to generate more complex hydraulic fracture network for more SRV hopefully;
- Fracture density seems higher in organic material rich shale (landing zone) then better impact from natural fractures can be expected if the lateral stays in target;
- Fracture orientation trends along with in-situ stress data will help better understanding of hydraulic fracture network (orientation & complexity).

Q&A