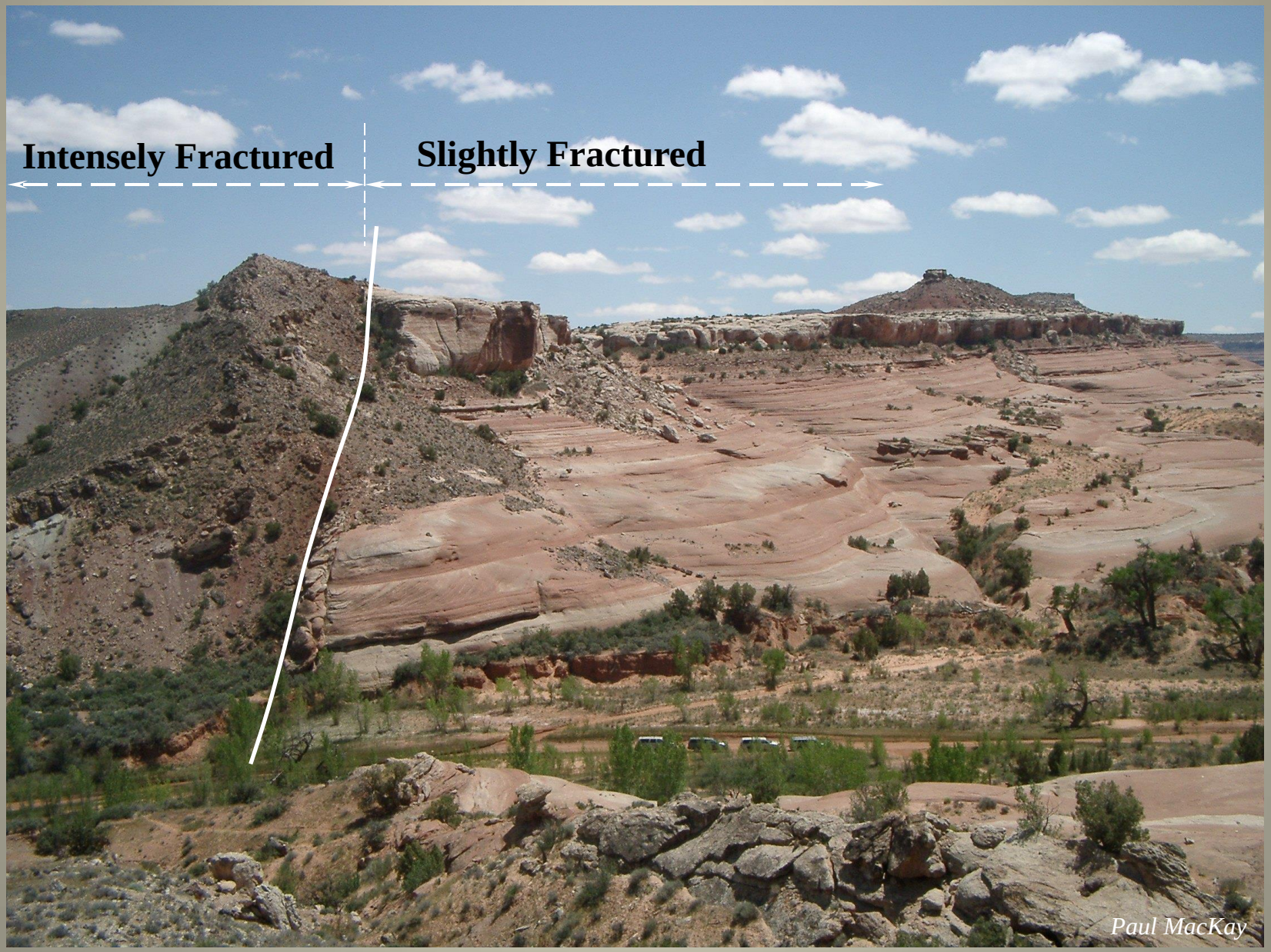
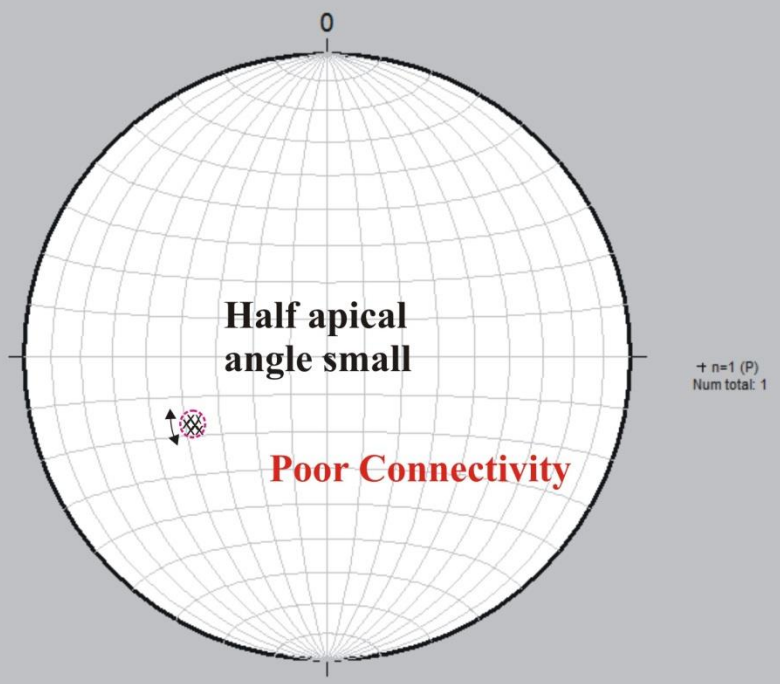
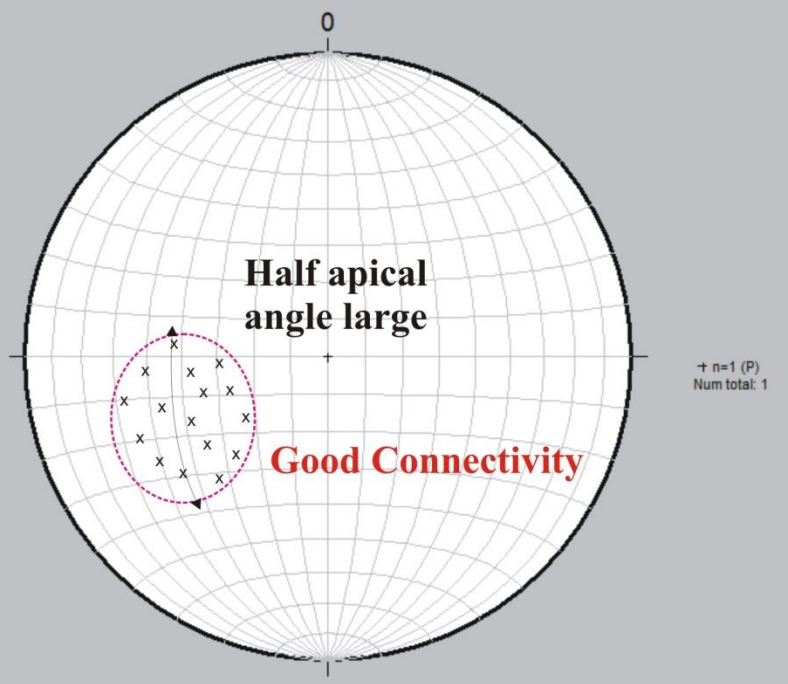
How to quantify fracture intensity



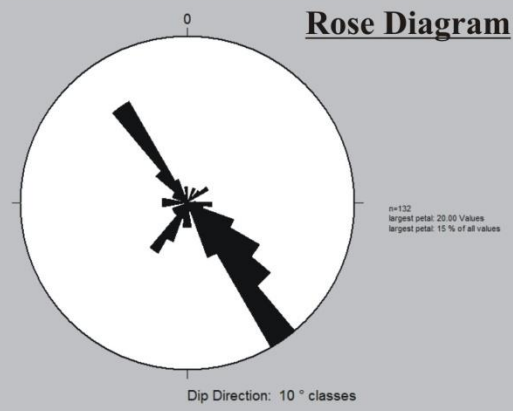
Connectivity



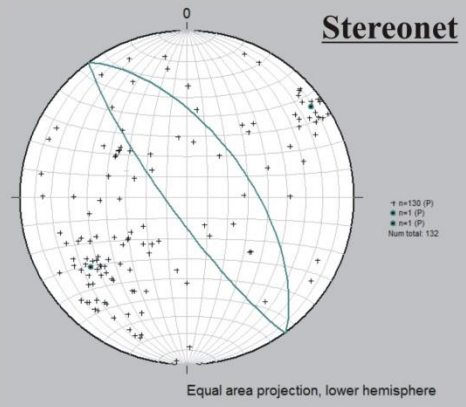


Stereonet

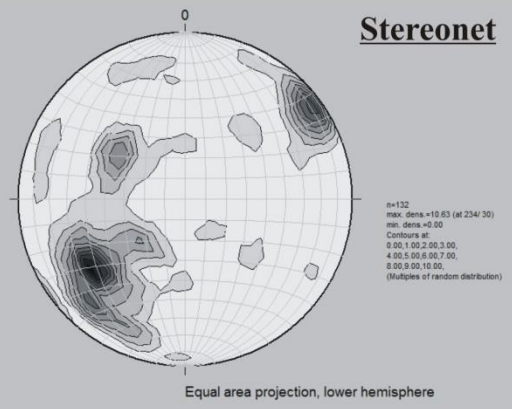
Analysis



Rose Diagram of fractures- Distribution of fractures shows a single set trending northwest - southeast

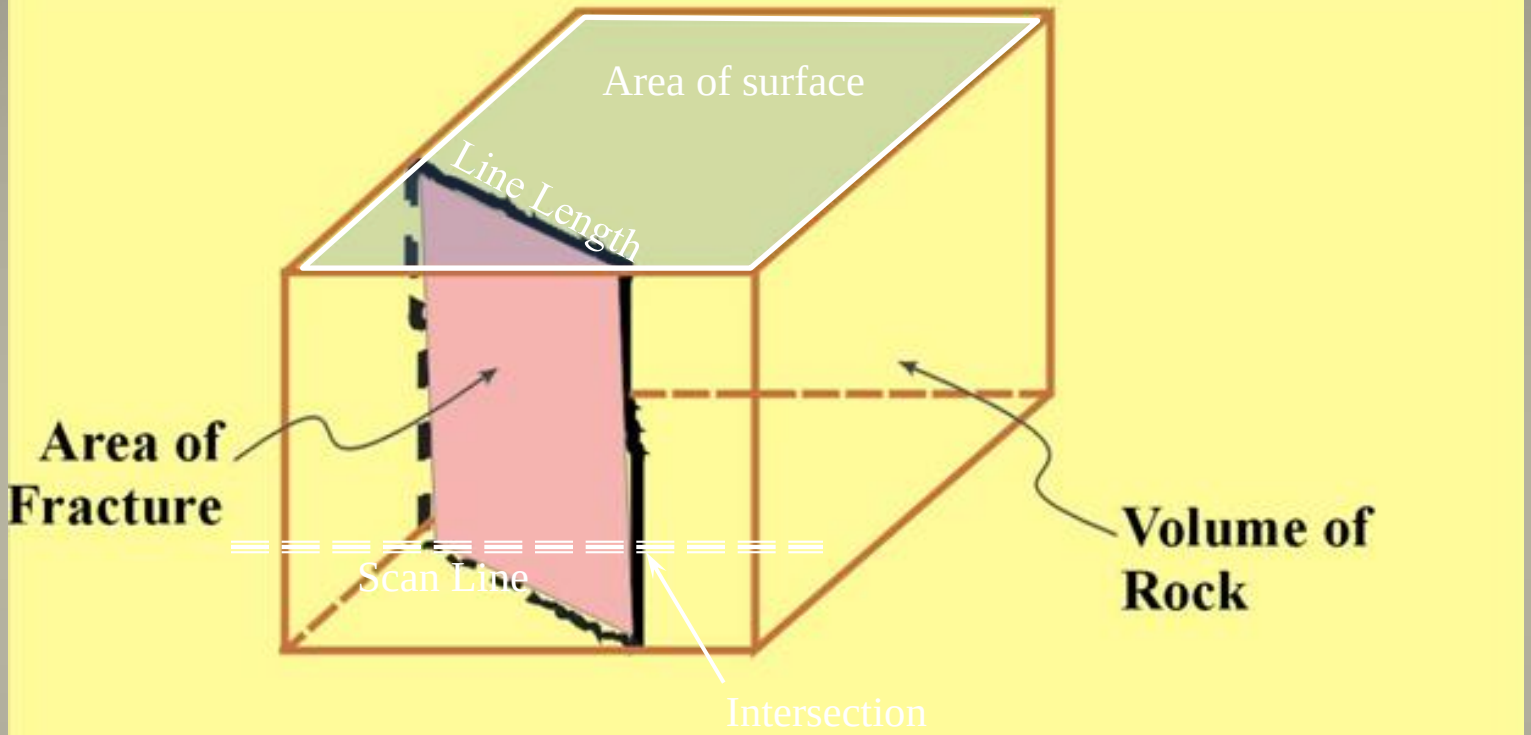


Stereonet of poles to fractures showing a fairly broad distribution of fracture orientation



Density plot on a stereonet of poles to fractures. Contouring of the data reveals two clusters indicating two distinct fracture orientations. The dominant fracture orientations are plotted on the stereonet showing the poles to fracture planes.

Fracture Intensity



$$\text{Fracture Intensity} = \frac{\text{Area of Fracture}}{\text{Volume of Rock}} \text{(FA)}$$

FA = Fracture Aperture

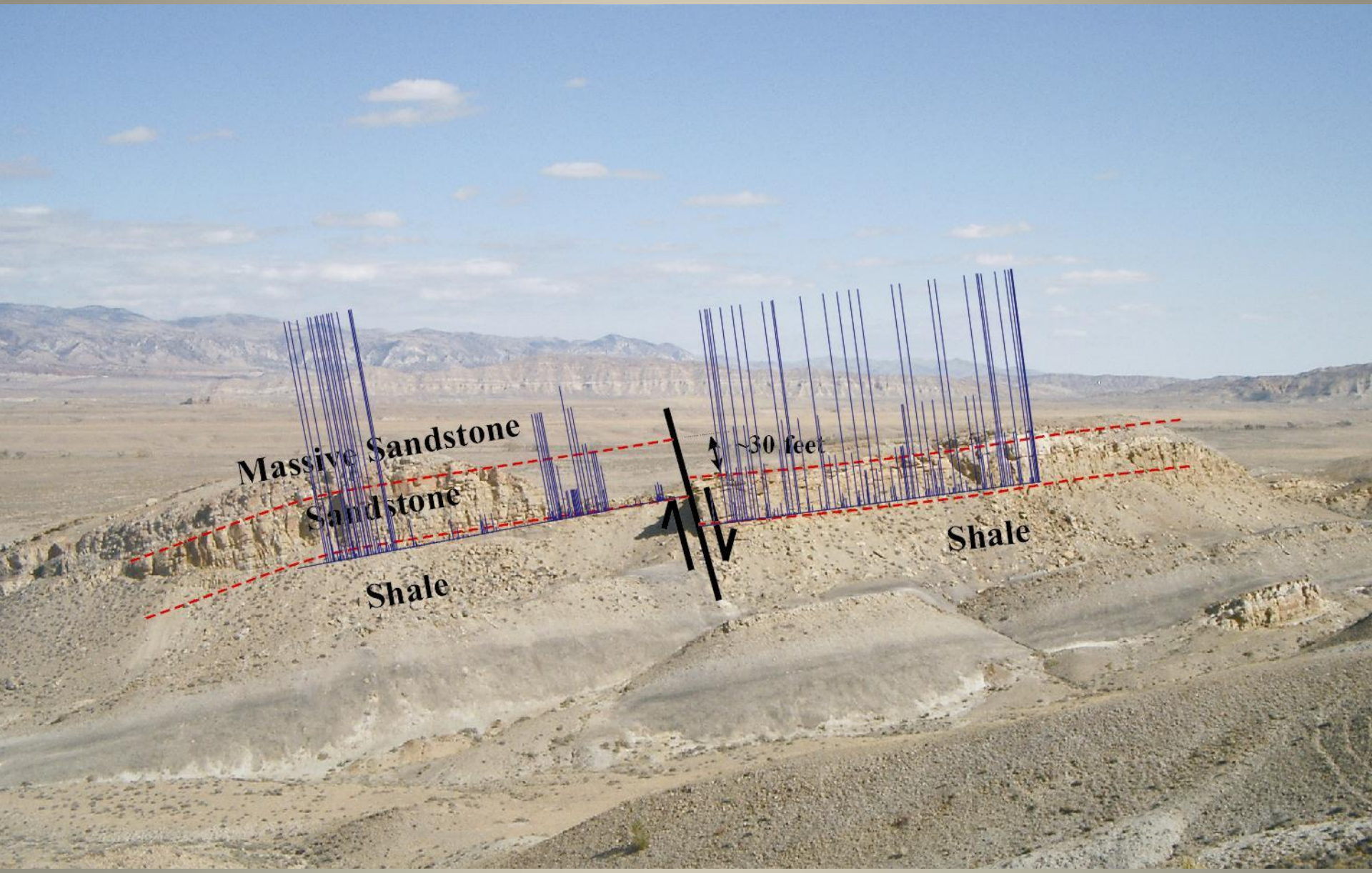
Calculation of Fracture Intensity

Scan Line Analysis

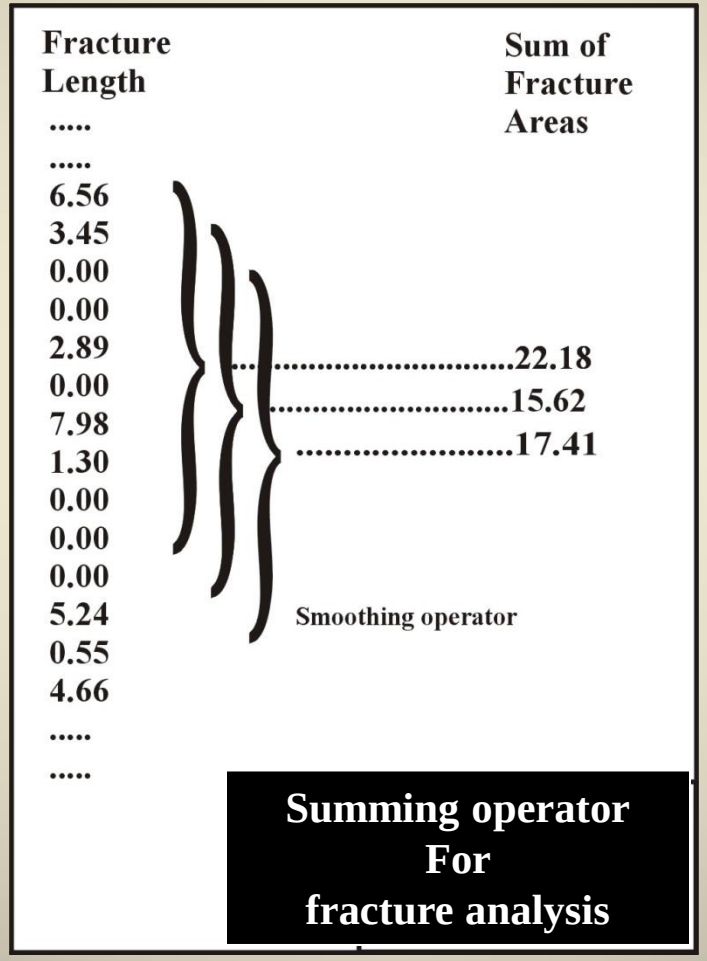
Measure:

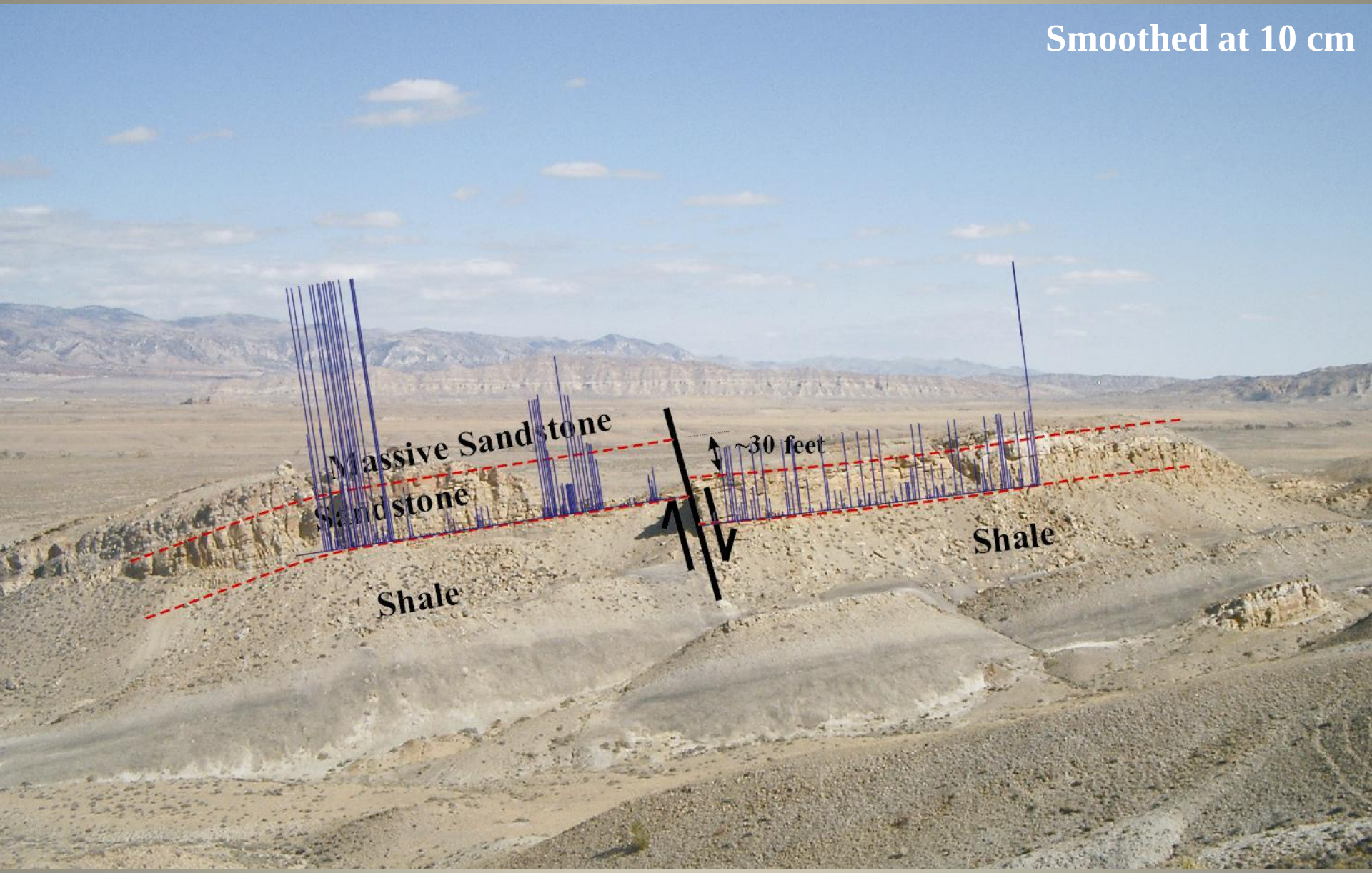
- Intersection point
- Height
- Strike
- Dip
- Location

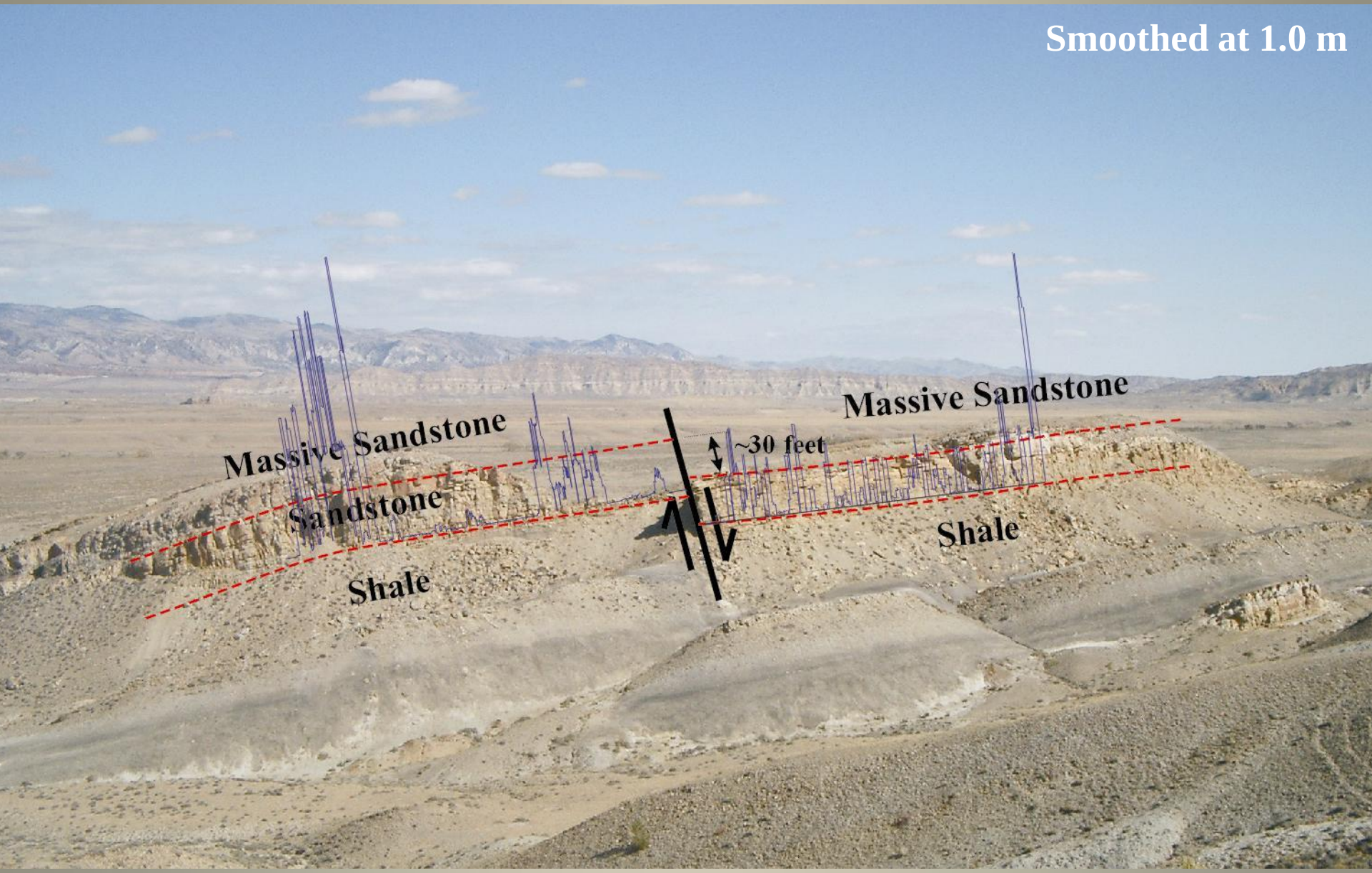
(there is now an App for your Iphone)

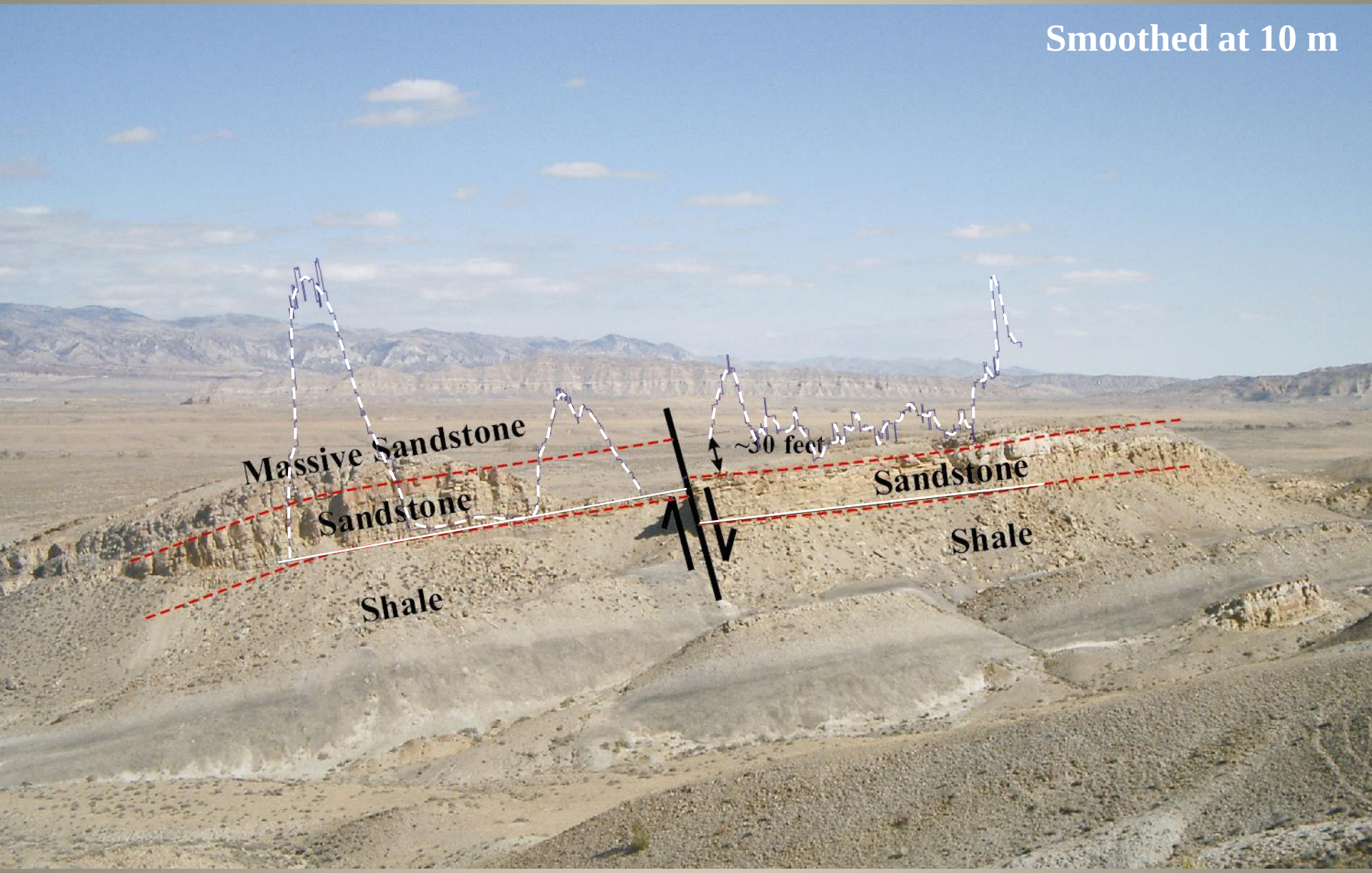

Massive Sandstone
Sandstone
Shale
~30 feet
Shale

Summing Algorithm



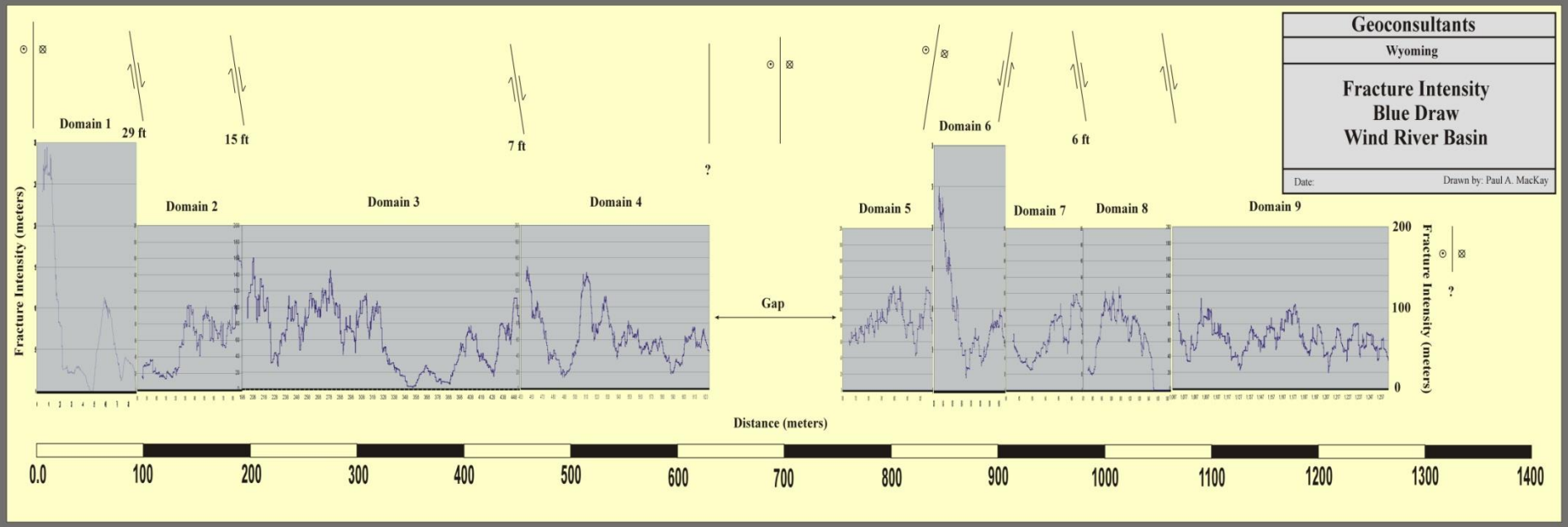

Smoothed at 10 cm
Massive Sandstone
Sandstone
~30 feet
Shale
Shale


Smoothed at 1.0 m
Massive Sandstone
Sandstone
Shale
~30 feet
Massive Sandstone
Shale


Smoothed at 10 m
Massive Sandstone
Sandstone
Shale
~30 feet
Sandstone
Shale

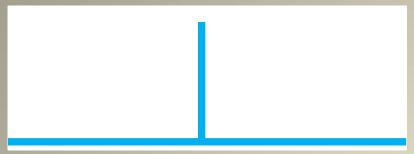
RGH 2003

-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8


Geoconsultants
Wyoming
Fracture Intensity
Blue Draw
Wind River Basin
Date:
Drawn by: Paul A. MacKay
Domain 1
29 ft
15 ft
7 ft
?
Domain 2
Domain 3
Domain 4
Gap
Domain 5
Domain 6
6 ft
Domain 7
Domain 8
Domain 9
Fracture Intensity (meters)
200
100
0
Distance (meters)
0.0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400

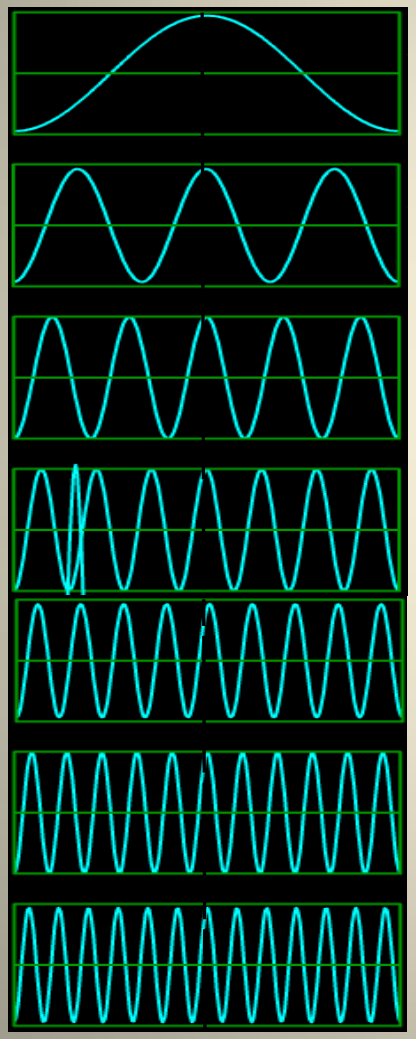
Waveforms are made up of discrete frequencies with different amplitudes and phase

Spike



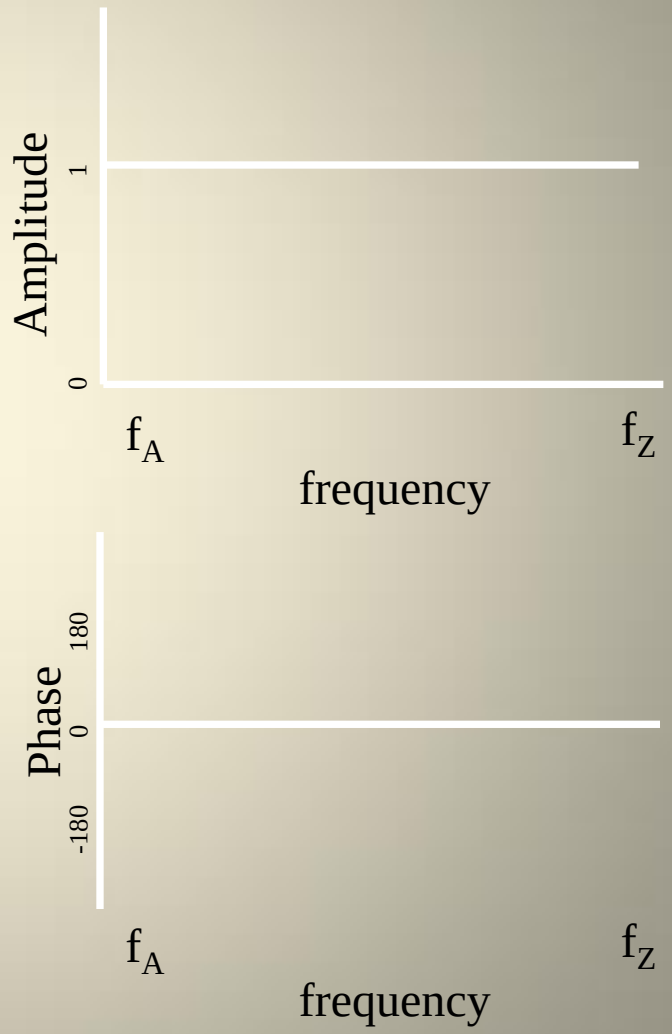
Waveform is the sum of all discrete frequencies (amplitude and phase)

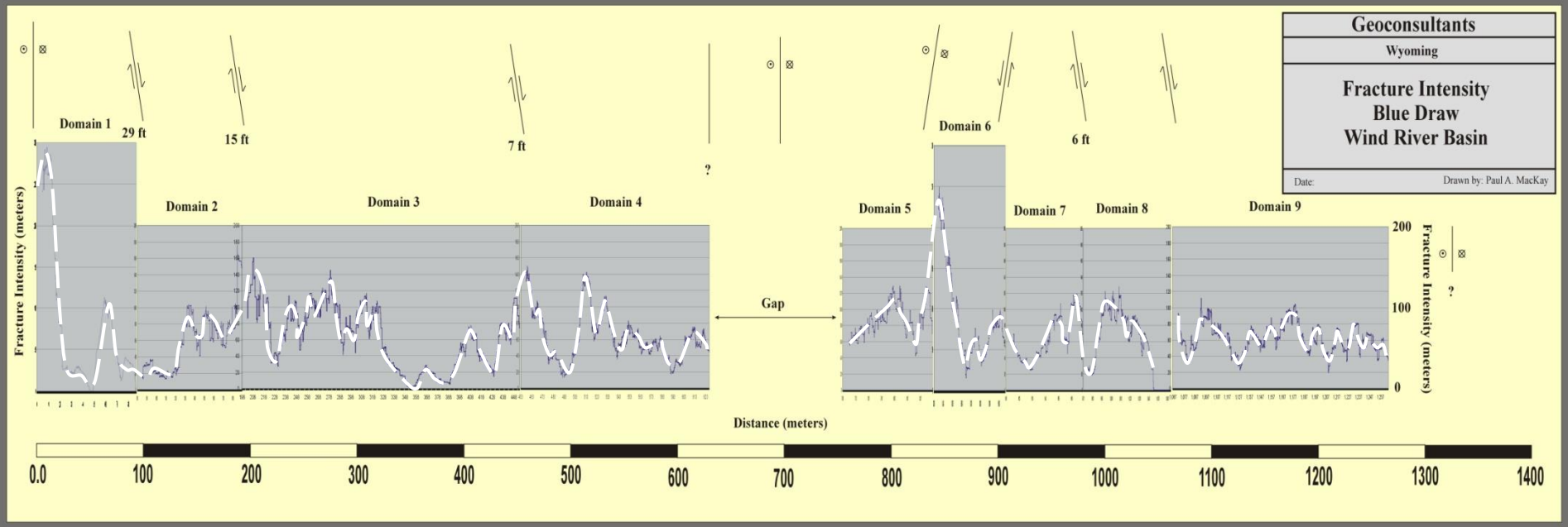
All frequencies in phase with equal amplitude

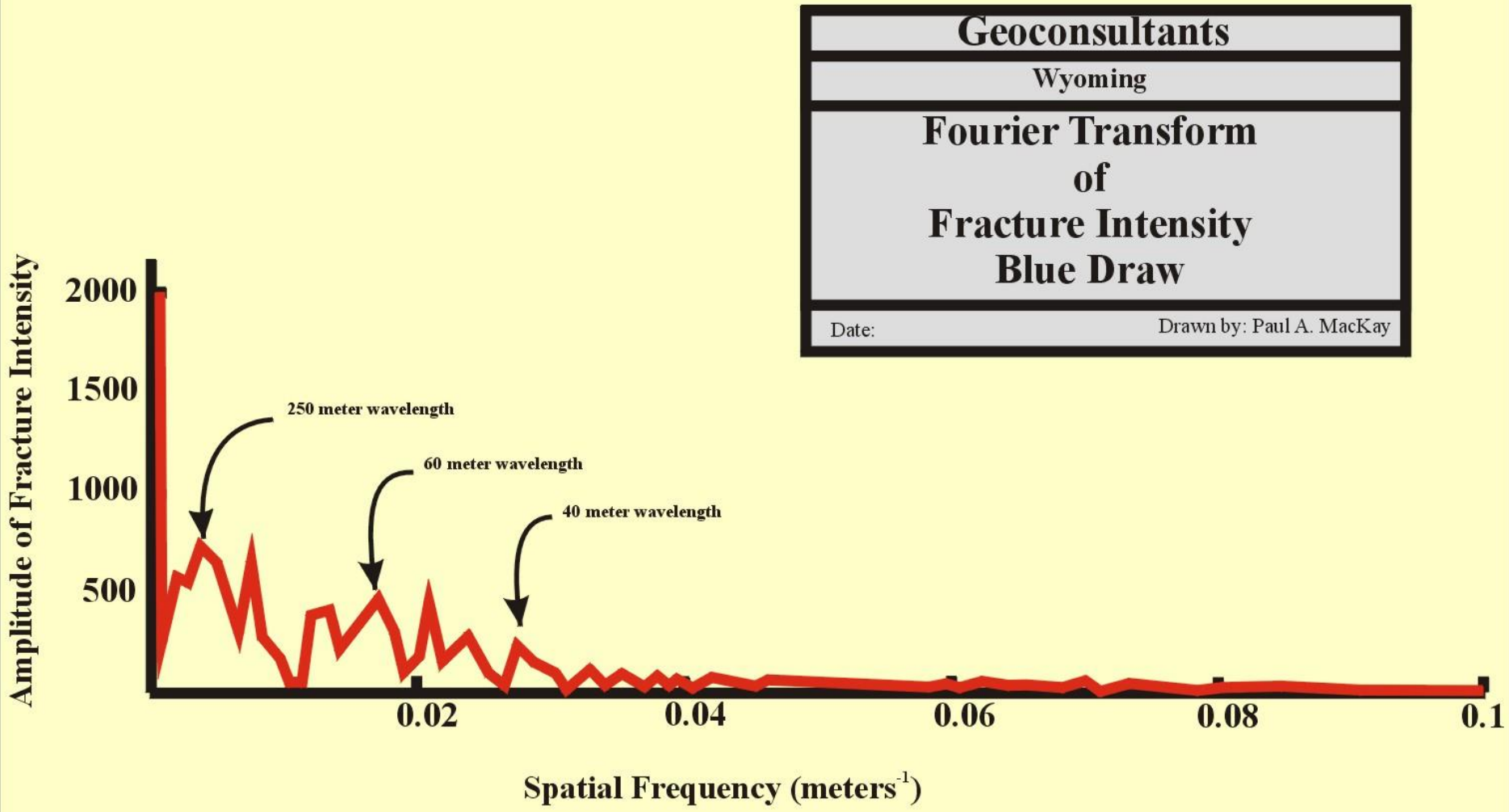


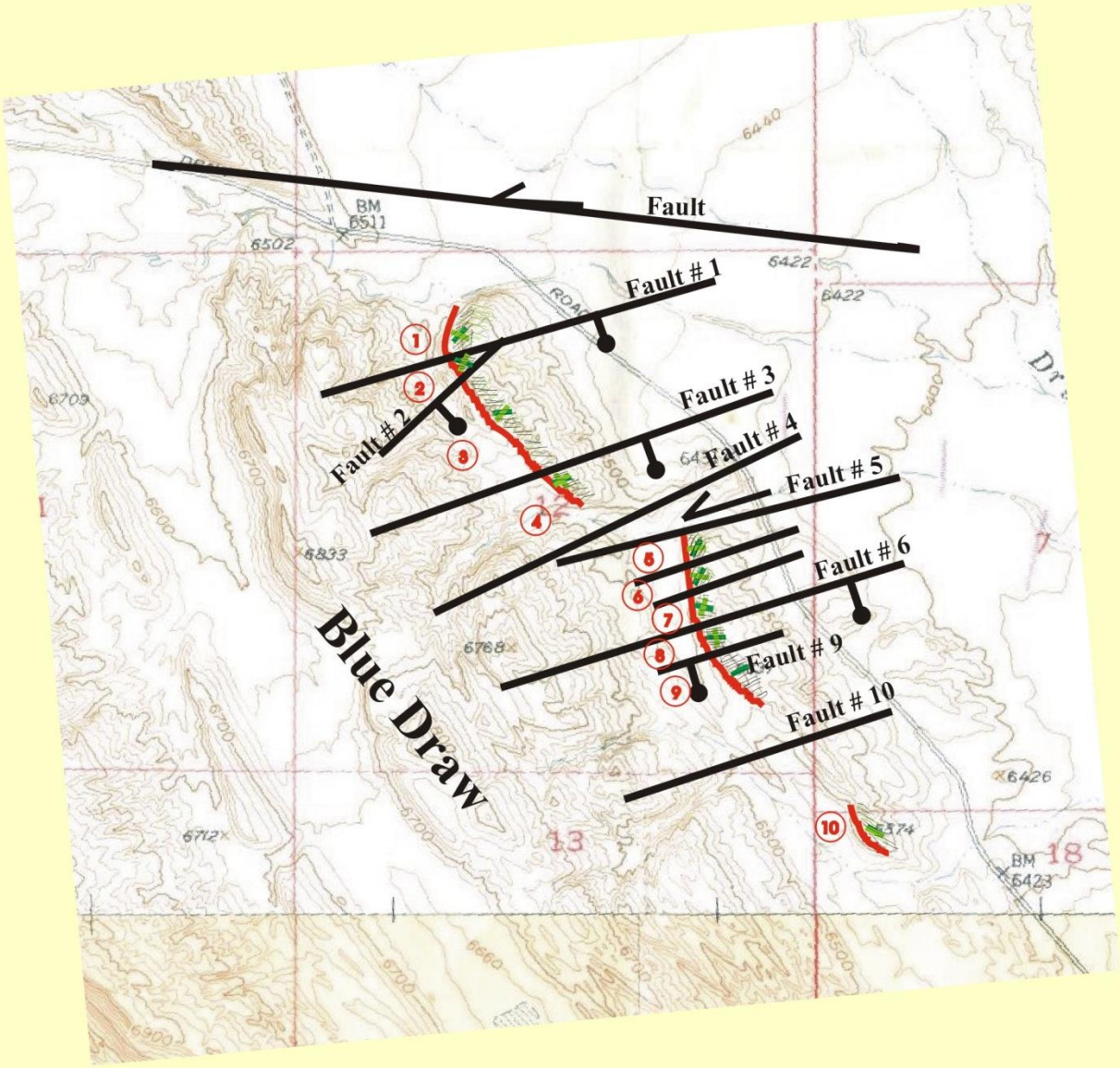
Frequency A

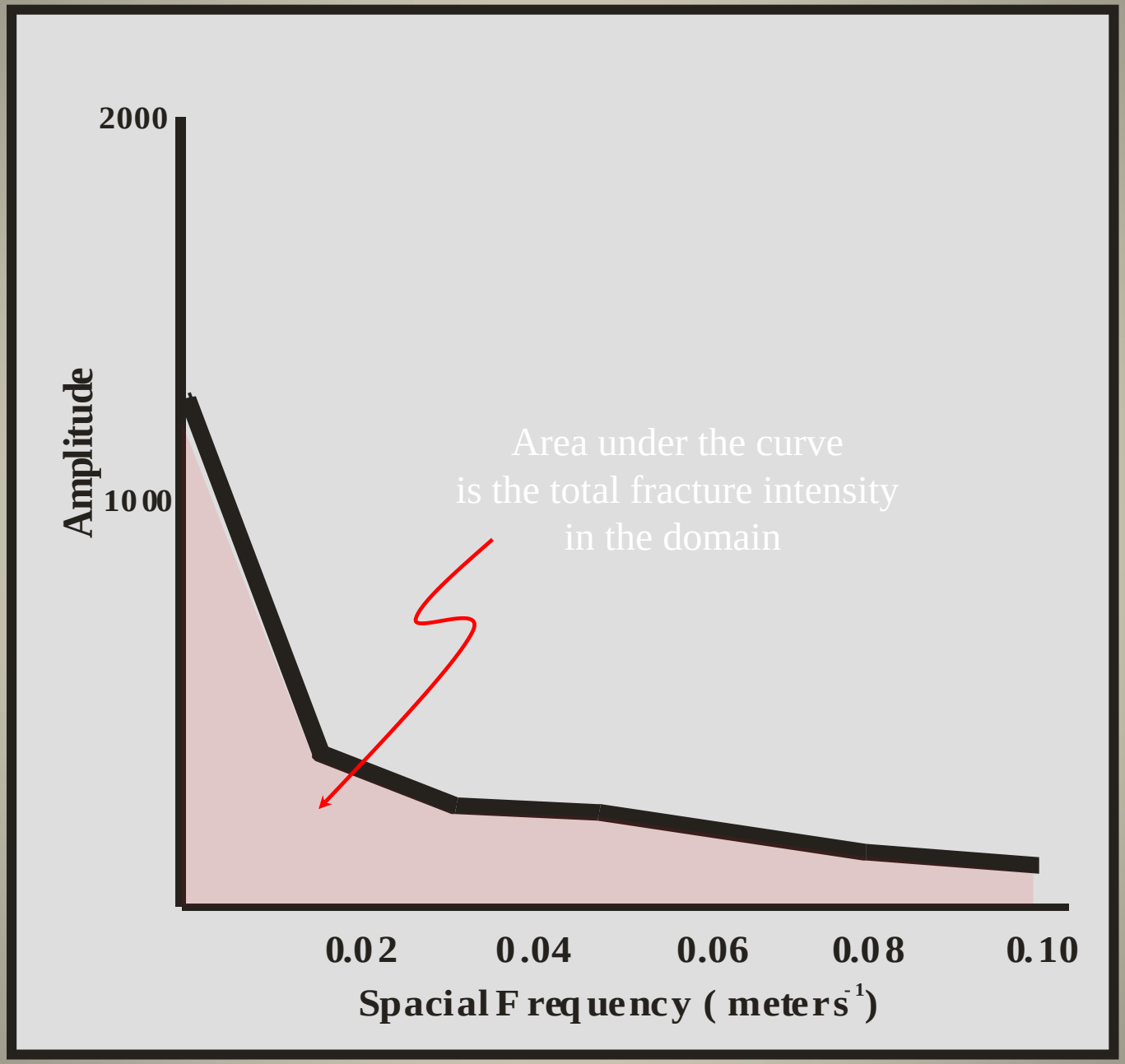
Frequency Z

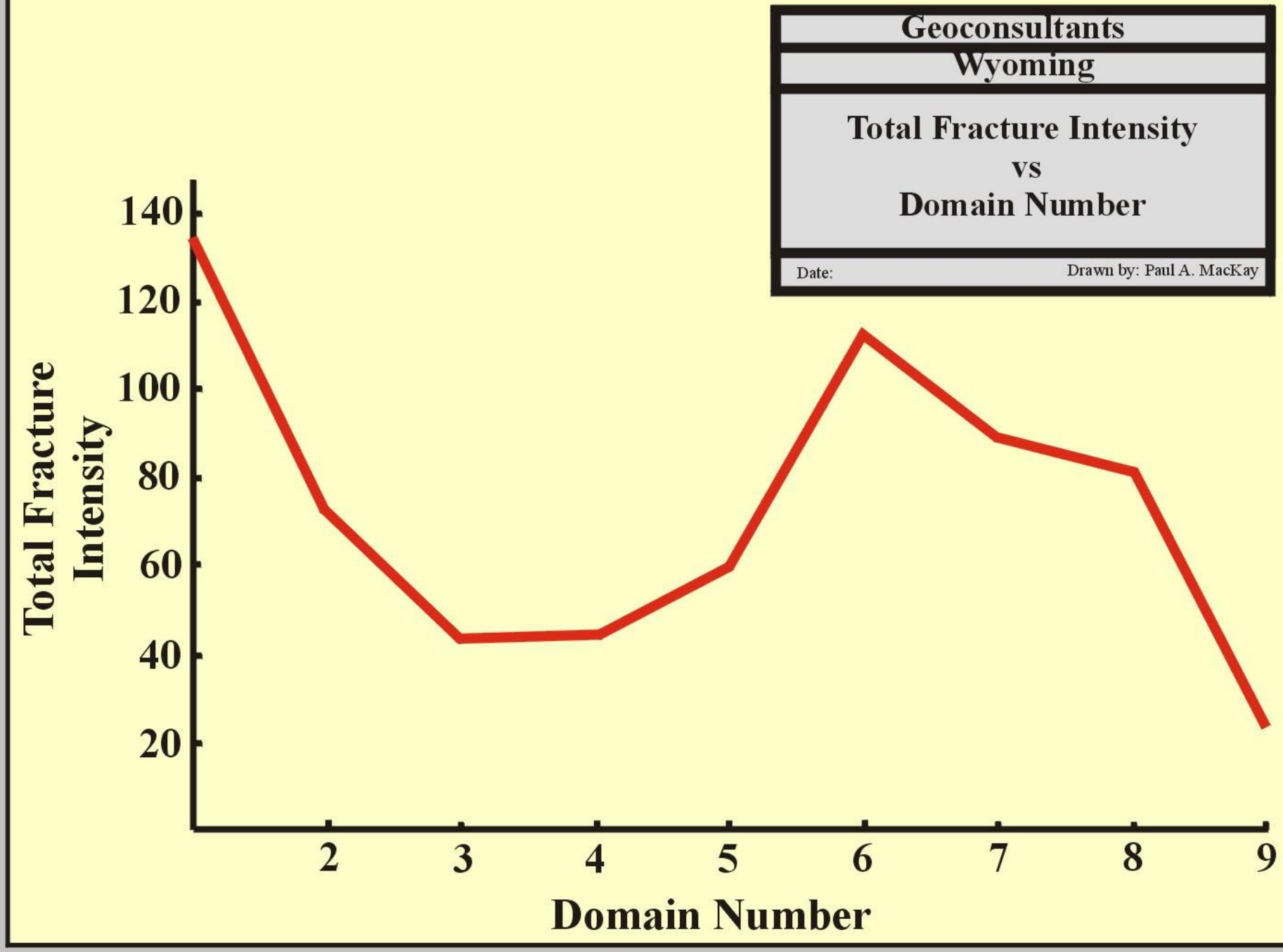


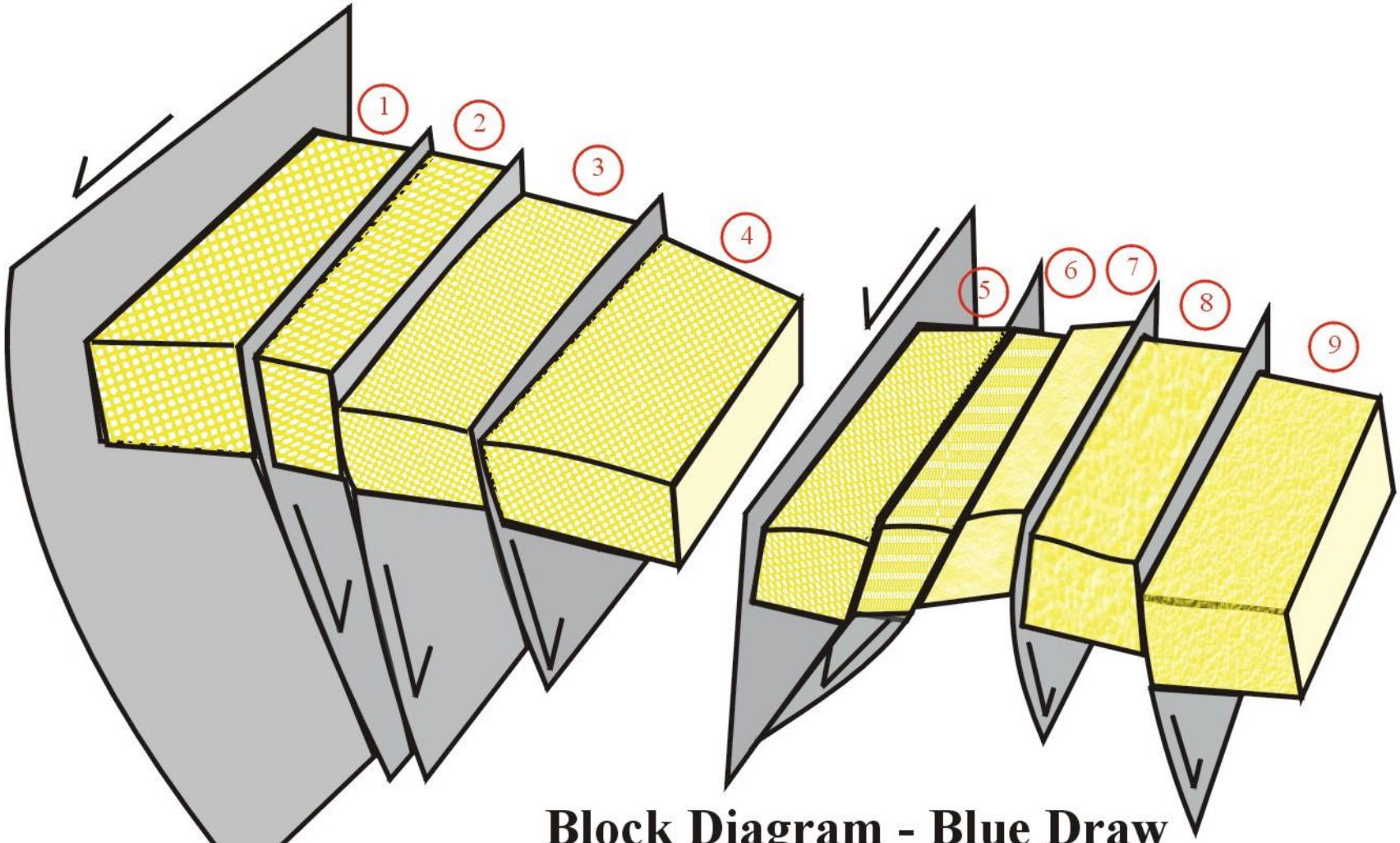

Geoconsultants
Wyoming
Fracture Intensity
Blue Draw
Wind River Basin
Date:
Drawn by: Paul A. MacKay
Domain 1
29 ft
15 ft
7 ft
?
Domain 2
Domain 3
Domain 4
Gap
Domain 5
Domain 6
6 ft
Domain 7
Domain 8
Domain 9
Fracture Intensity (meters)
Fracture Intensity (meters)
200
100
0
?
Distance (meters)
0.0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400


Geoconsultants
Wyoming
Fourier Transform
of
Fracture Intensity
Blue Draw
Date:
Drawn by: Paul A. MacKay
Amplitude of Fracture Intensity
2000
1500
1000
500
250 meter wavelength
60 meter wavelength
40 meter wavelength
0.02
0.04
0.06
0.08
0.1
Spatial Frequency (meters^{-1})

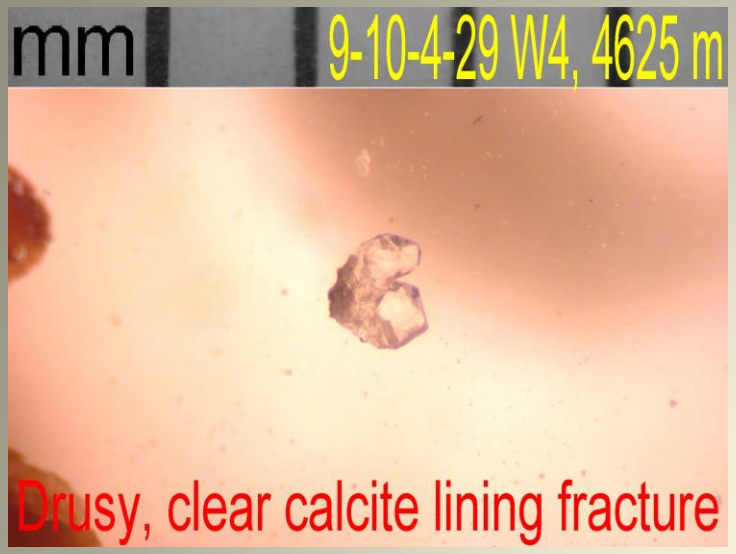

Fault
Fault # 1
Fault # 2
Fault # 3
Fault # 4
Fault # 5
Fault # 6
Fault # 9
Fault # 10
Blue Draw
1
2
3
4
5
6
7
8
9
10
BM
6511
6502
6422
6422
6440
6709
6833
6768
6712
6426
6374
BM
6423
13
18


2000
1000
Amplitude
Area under the curve
is the total fracture intensity
in the domain
0.02
0.04
0.06
0.08
0.10
Spacial Frequency (meters^{-1})

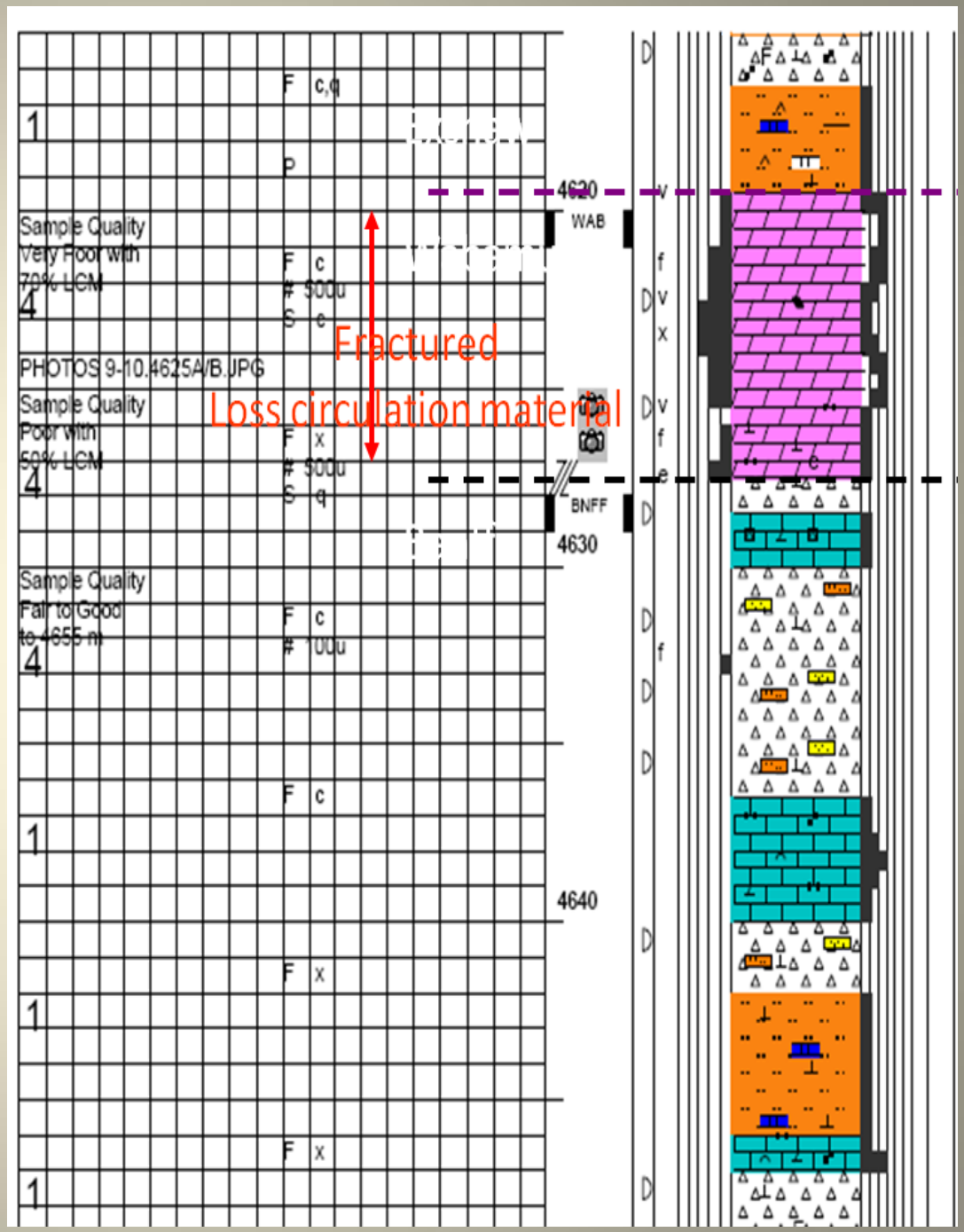

Geoconsultants
Wyoming
Total Fracture Intensity
vs
Domain Number
Date:
Drawn by: Paul A. MacKay
Total Fracture Intensity
140
120
100
80
60
40
20
2
3
4
5
6
7
8
9
Domain Number



Block Diagram - Blue Draw
Frontier Sandstaone

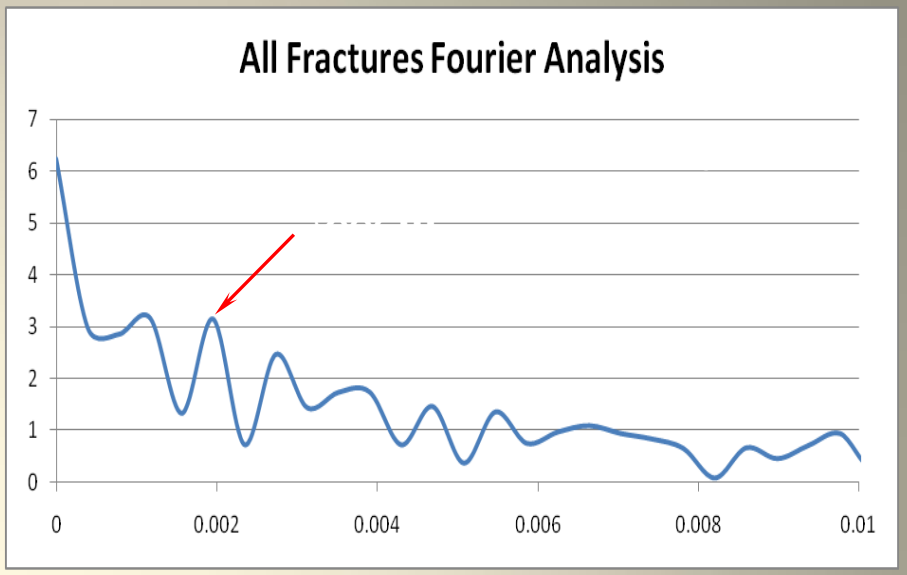

mm
9-10-4-29 W4, 4625 m
Drusy, clear calcite lining fracture

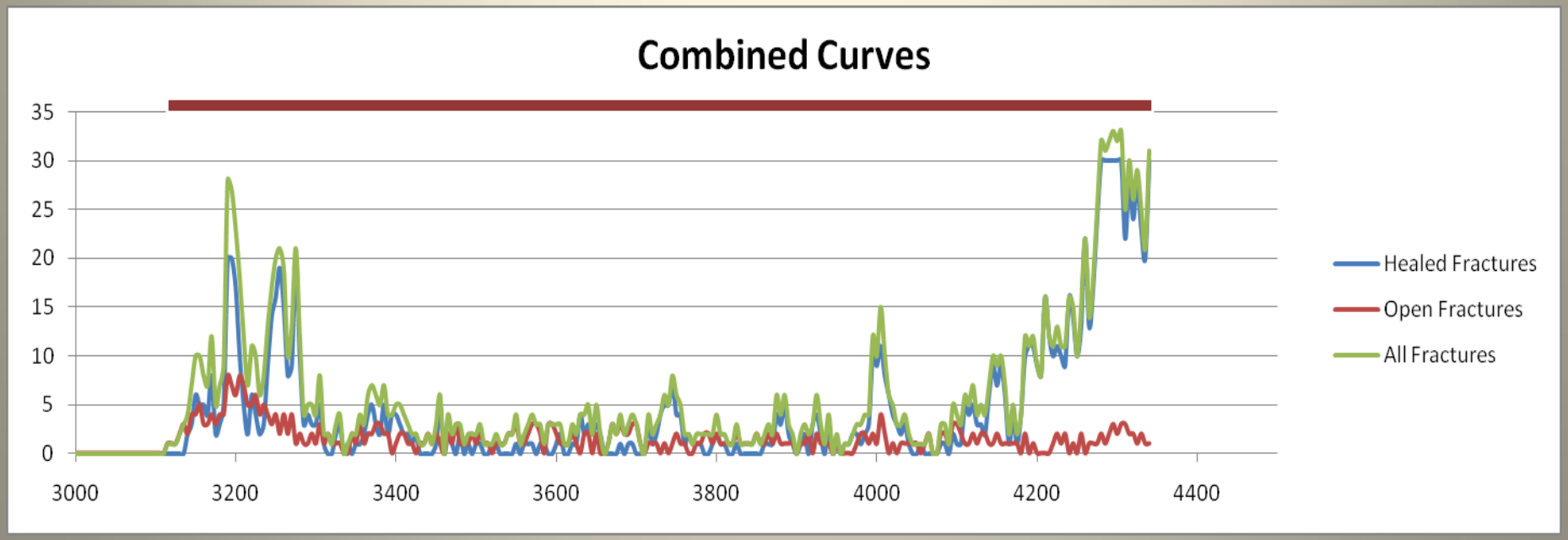
mm
9-10-4-29 W4, 4625 m
Vuggy + ix porosity in dolomite


Sample Quality
Very Poor with
70% LCM
PHOTOS 9-10.4625A/B.JPG
Sample Quality
Poor with
50% LCM
Sample Quality
Fair to Good
to 4655 m
4620
WAB
Fractured
Loss circulation material
BNFF
4630
4640

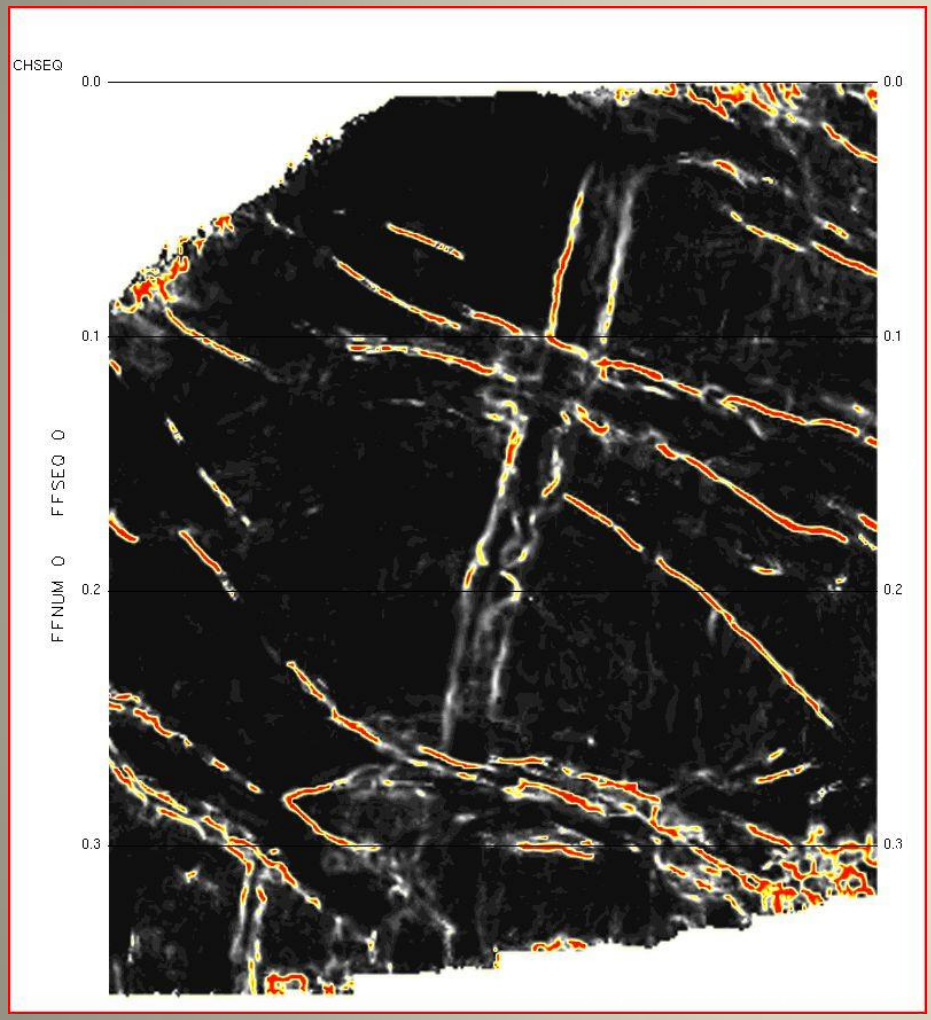
EOG Maxhamish a-001-L/94-O-15

fractures defined by cuttings

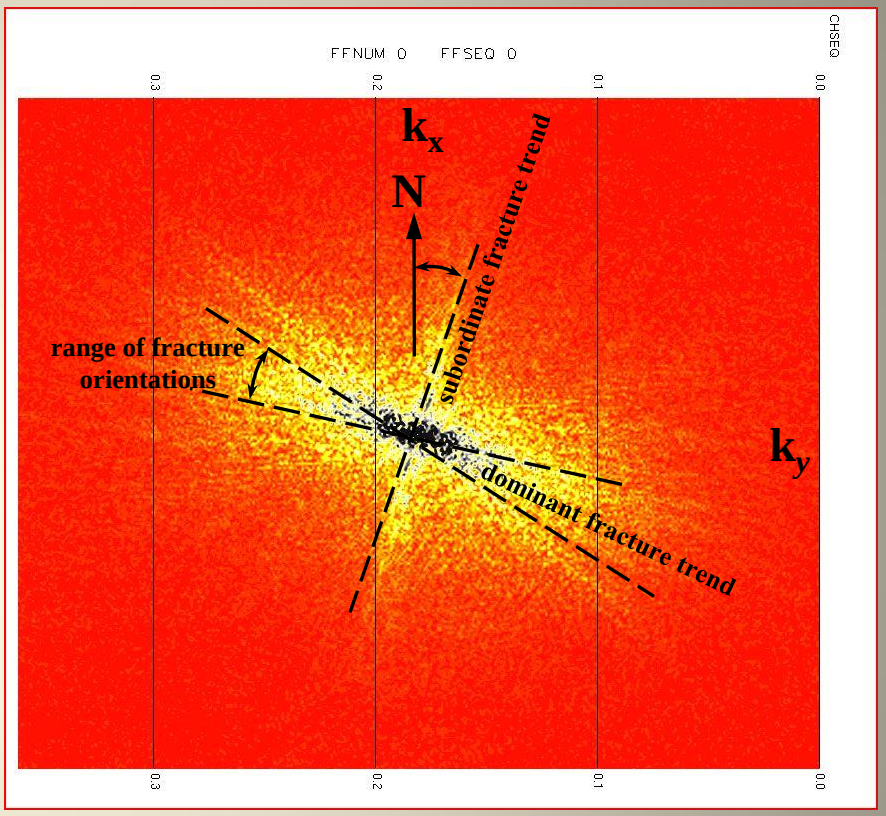




Fracture Analysis on Surfaces



Curvature Data – 3D seismic data



k_x vs. k_y transform of Curvature image

- Amplitude gives relative intensity
- Orientation gives bearing
- Range gives connectivity