

Fracture Imaging from Seismic –

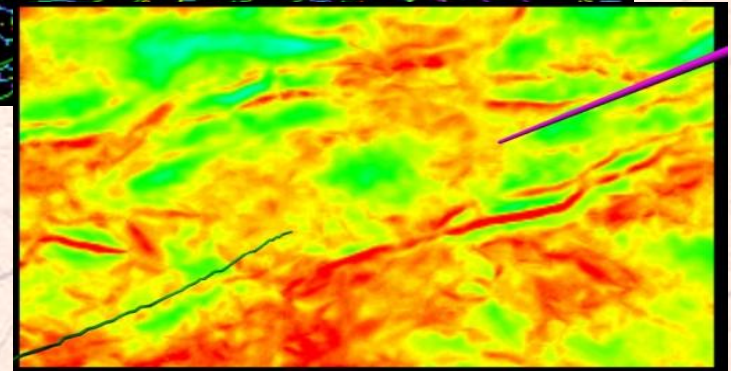
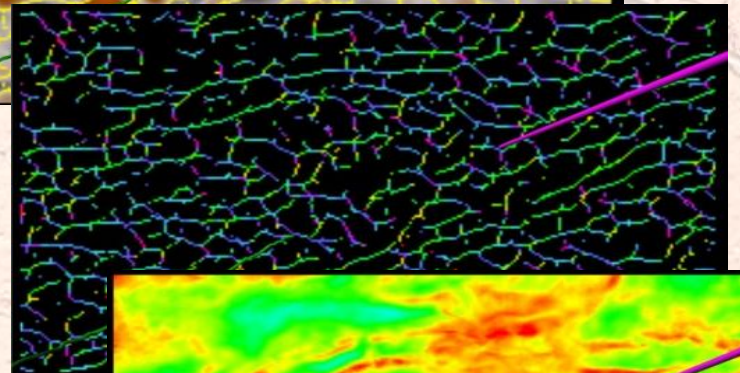
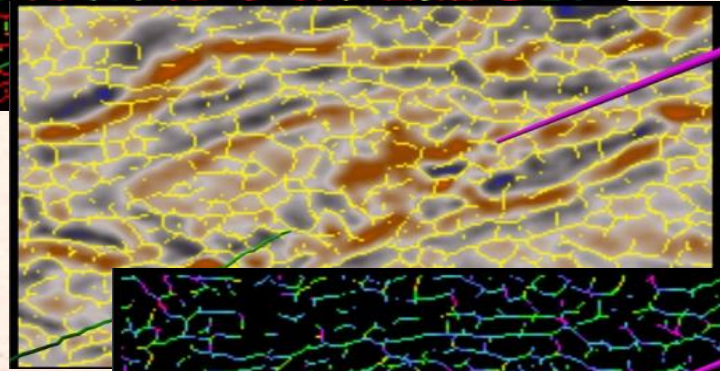
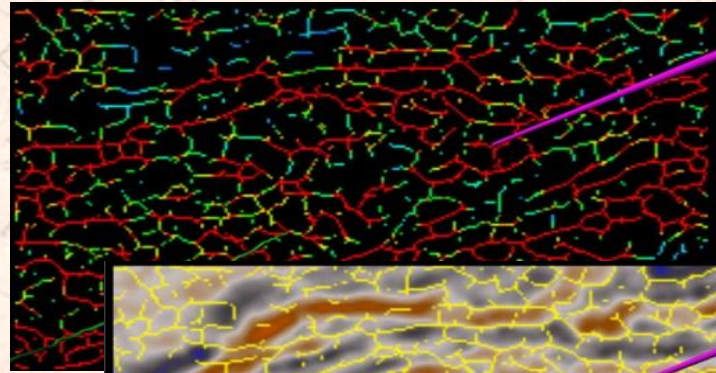
New Improved Resource Recovery Techniques

Resources & Faults

Benefits of Fracture
Extraction Workflows

Calibration

Resource Development
Optimisation / Case
Studies



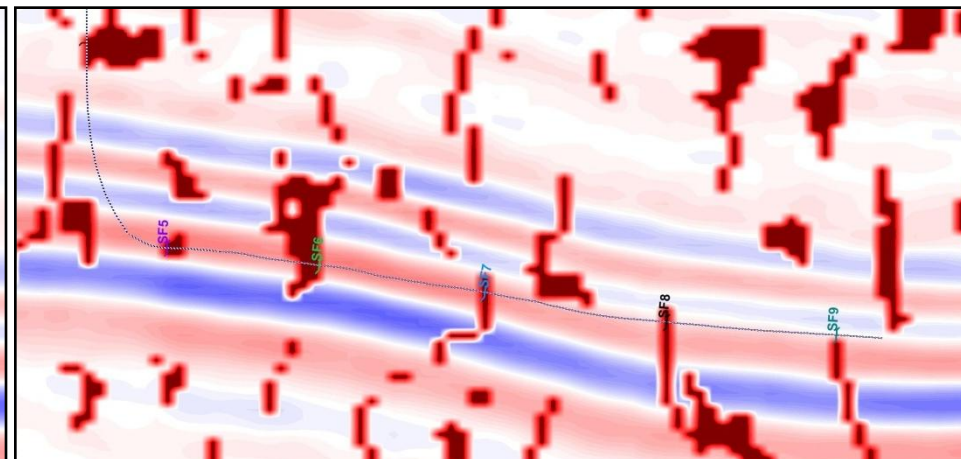
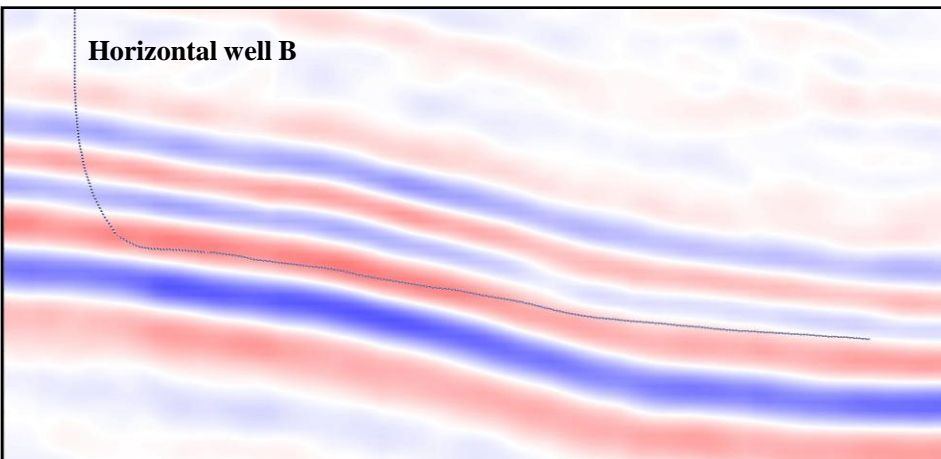
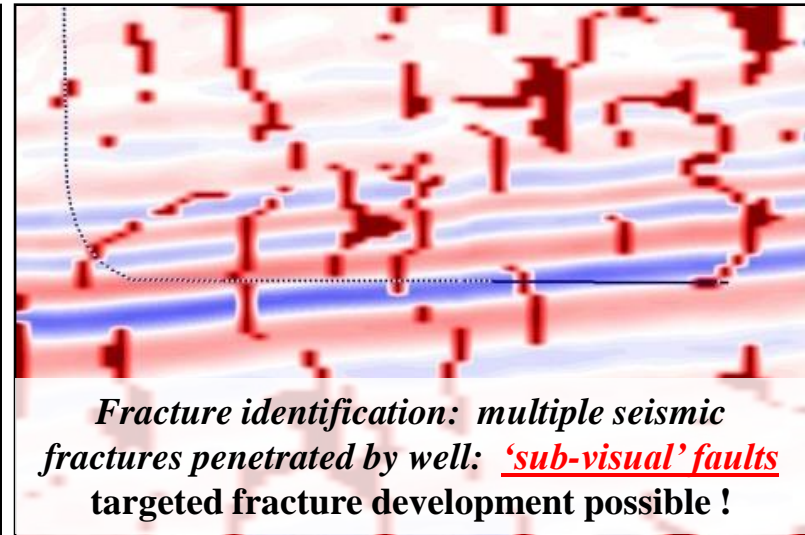
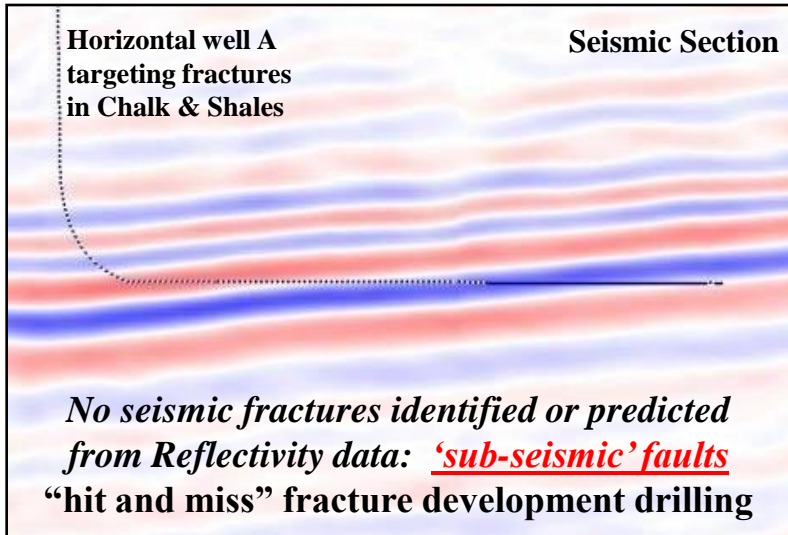
Victory comes from finding
opportunities in problems !

Sun Tzu

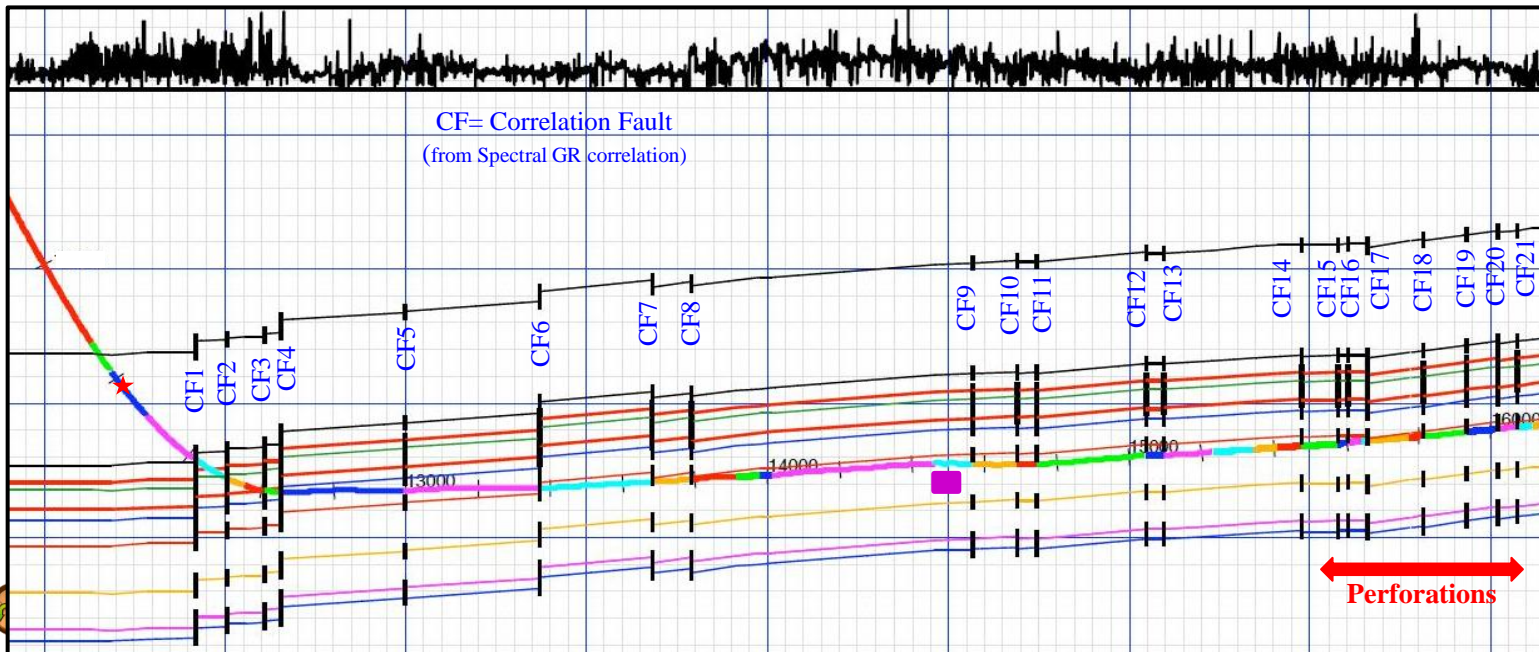
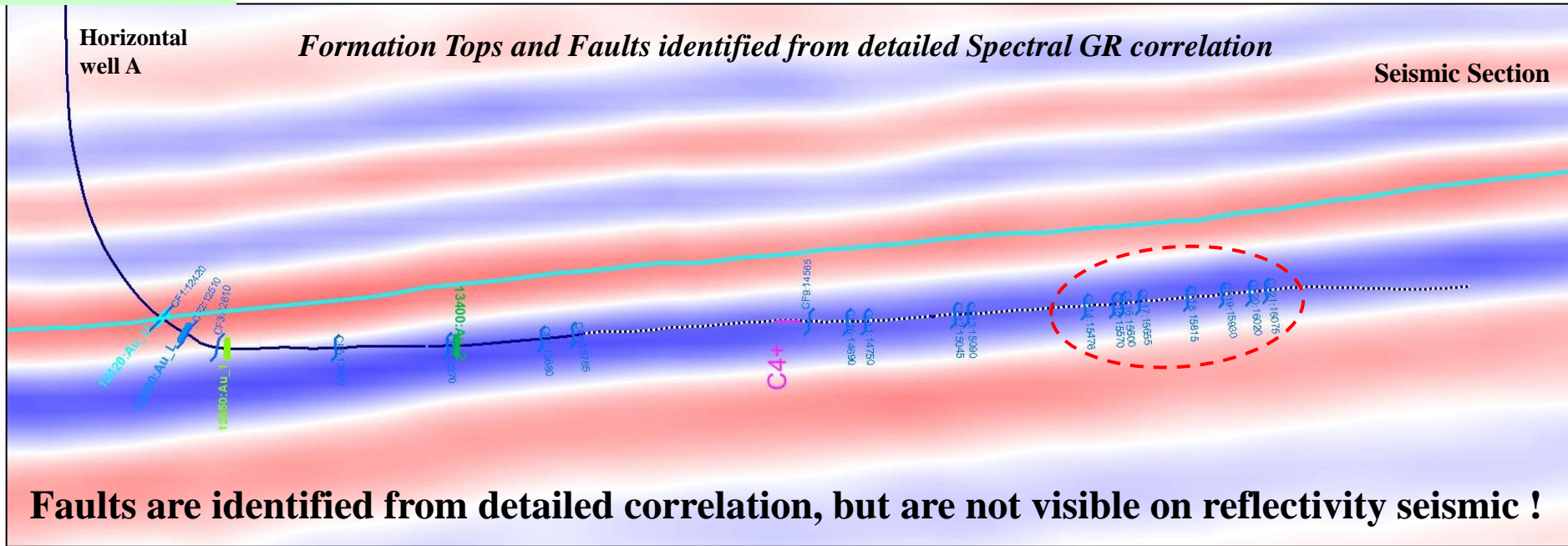
Resource Development Optimisation

1. Identification of fracture penetrations in wells:

there are way **more fractures penetrated in Oil & Gas wells than usually recognised !** Vertical wells penetrate between 5 and 25 seismic fractures, horizontal wells up to 50 fractures.



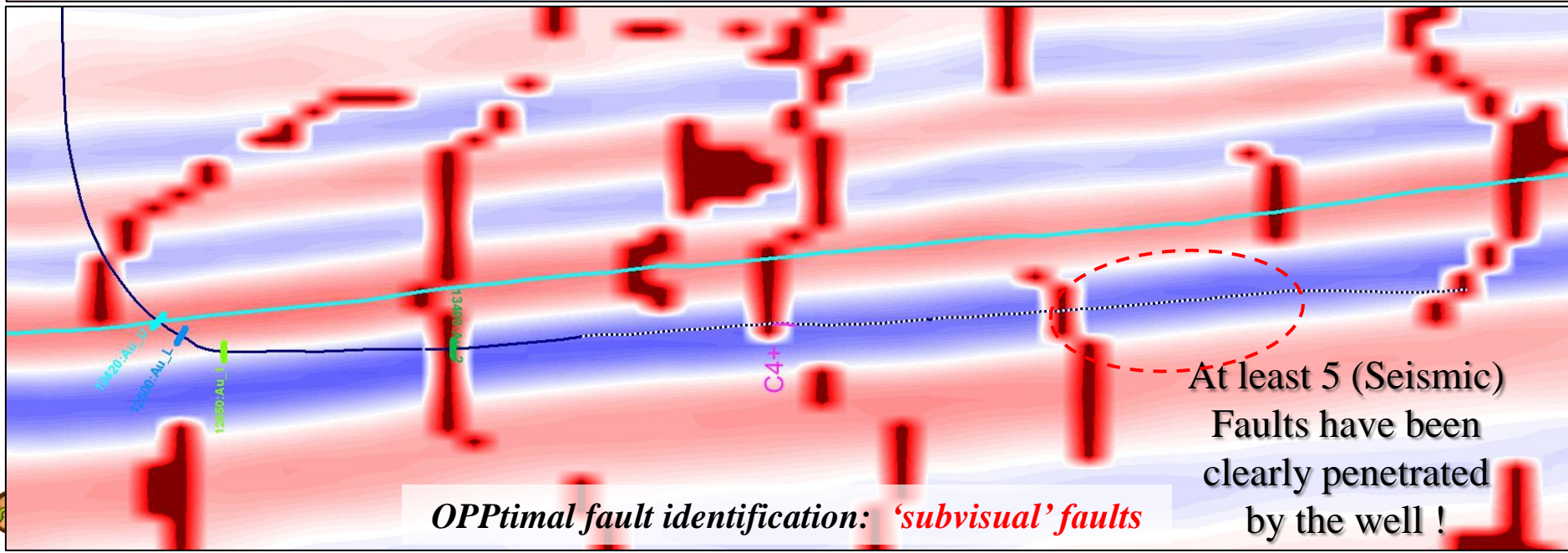
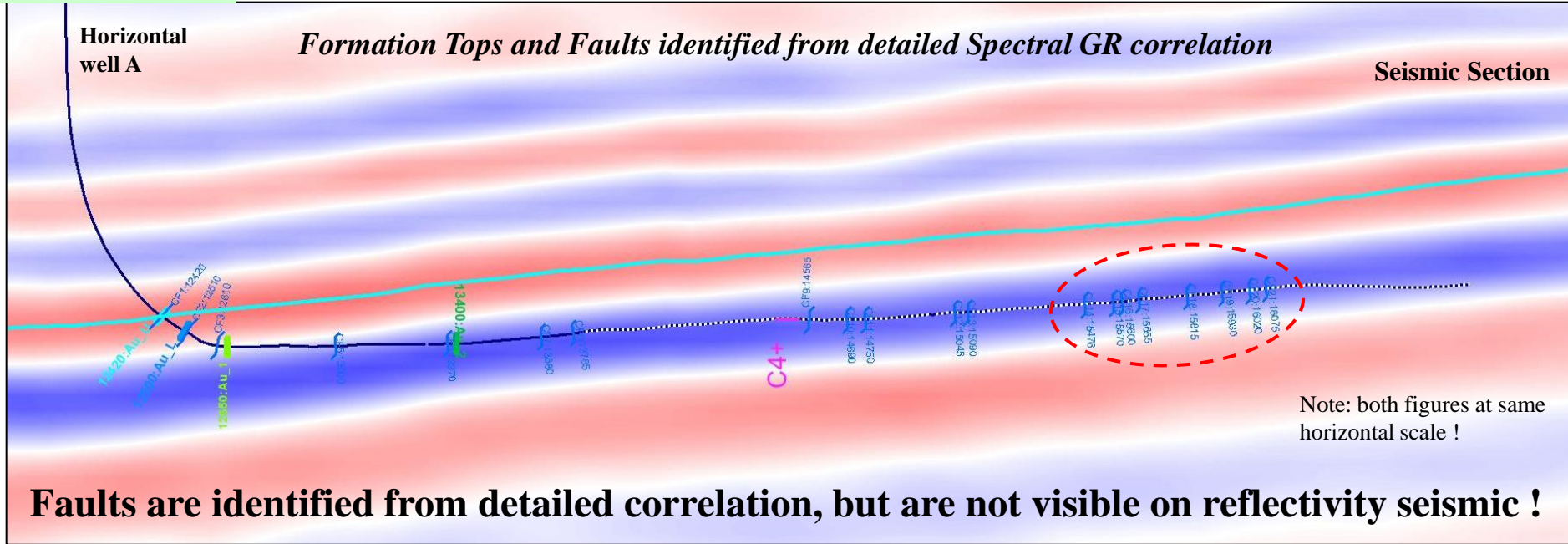
Resource Development Optimisation



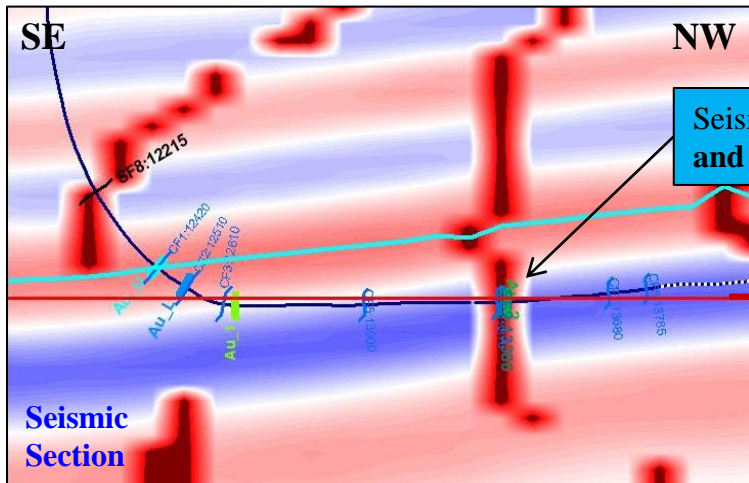
Note: both figures at same horizontal scale !

Geological Cross-section

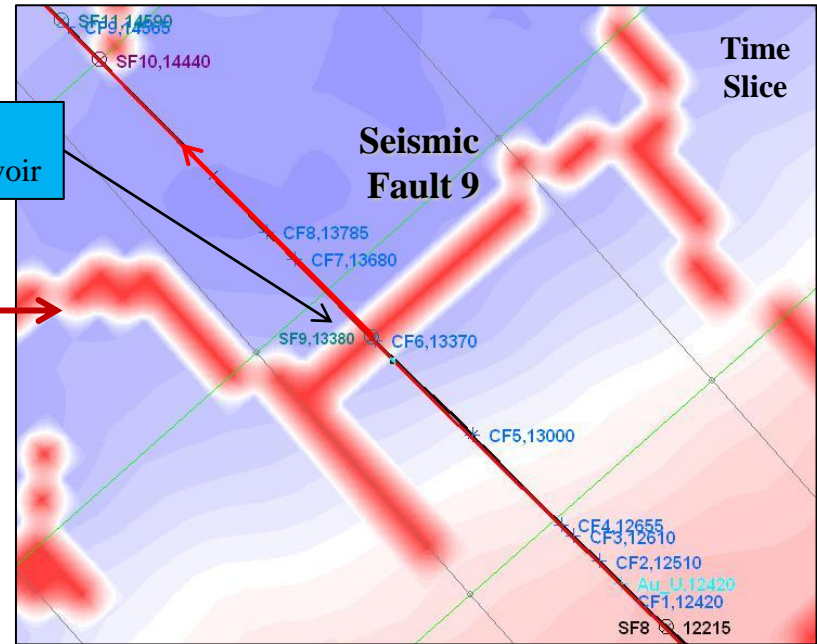
Resource Development Optimisation



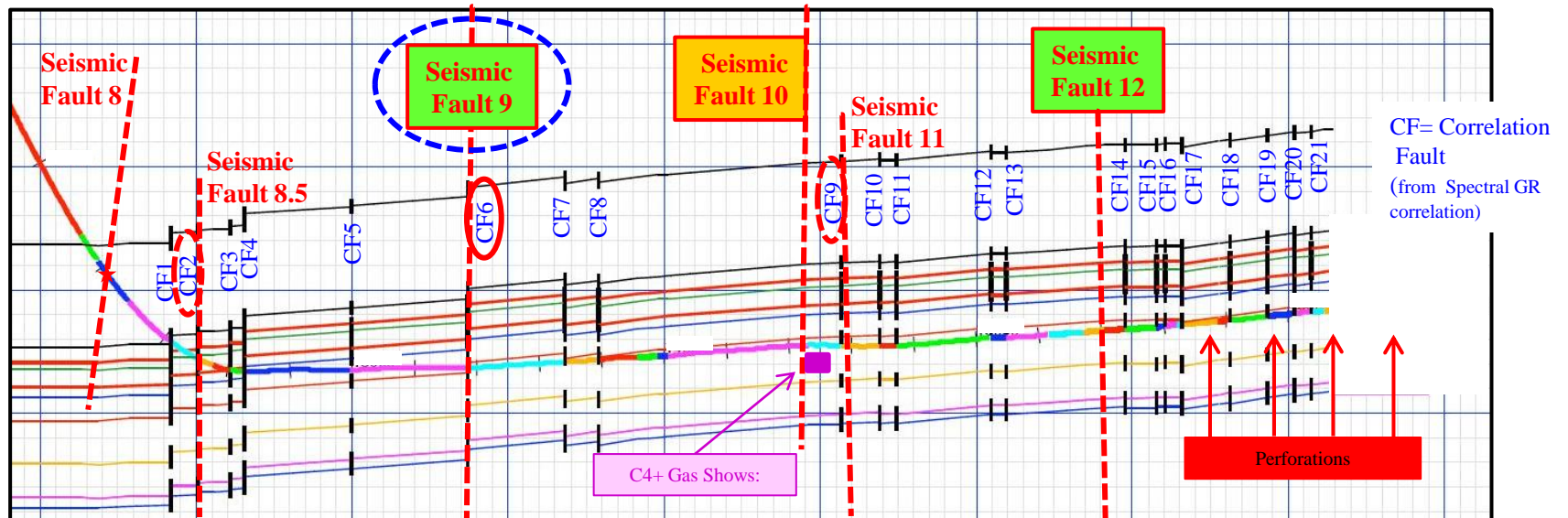
Resource Development Optimisation



Seismic Fault 9 and Top Reservoir



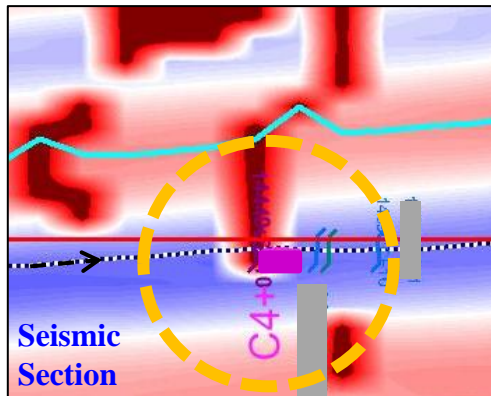
Seismic Fault 9: coincides with fault identified from Client's detailed Spectral GR correlation ! Well enters reservoir after intersecting a (seismically visible) fault.



Resource Development Optimisation

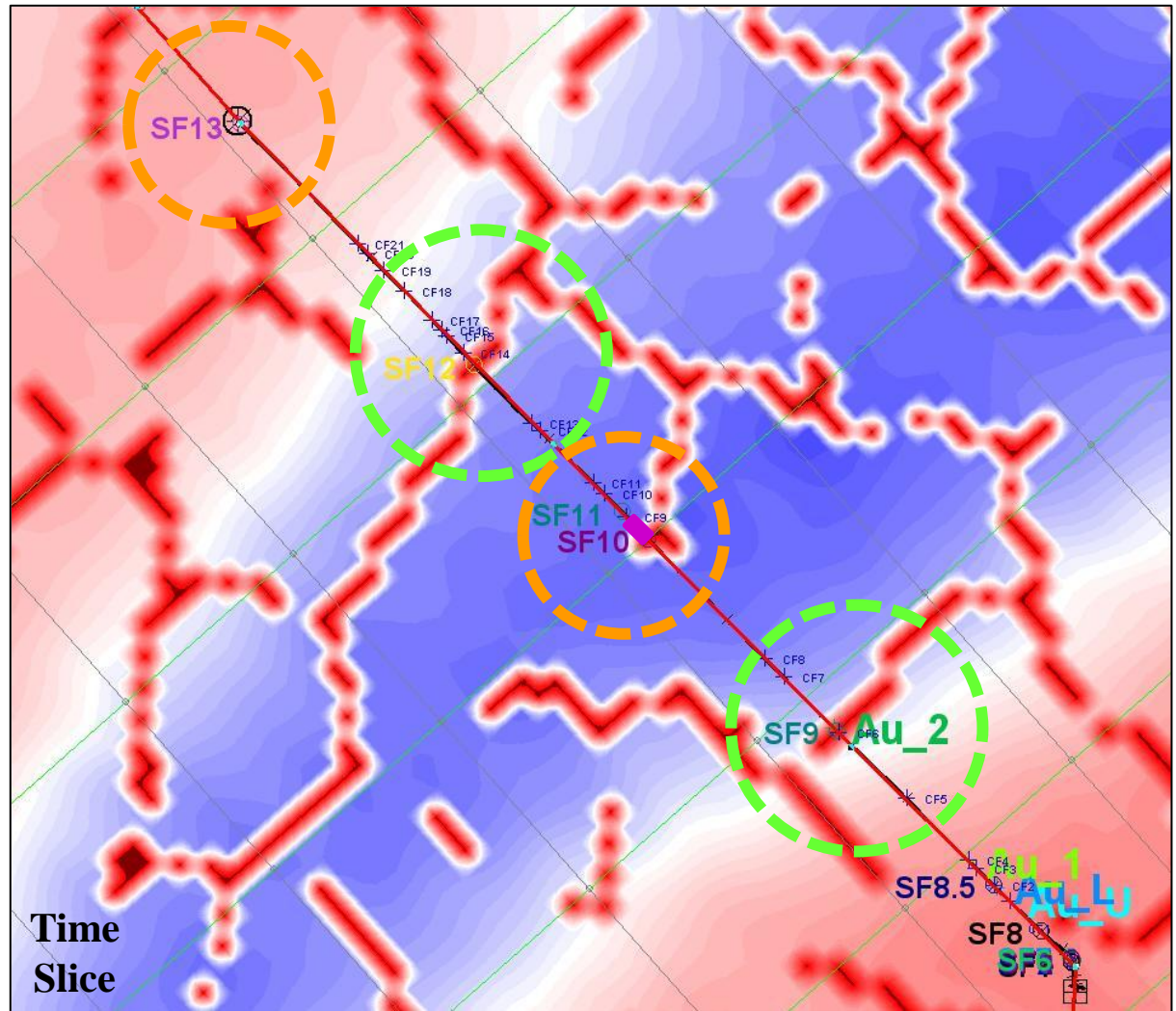
Challenge: Location and prediction of sweet spots / productivity.

Outcome: Visualisation of fault & fracture networks at very high resolution. Found **direct links between fault penetrations in wells and hydrocarbon shows/productivity**. Proper 3D fault imaging allows **evaluation of reservoir connectivity (lat./vert.) and productivity**.



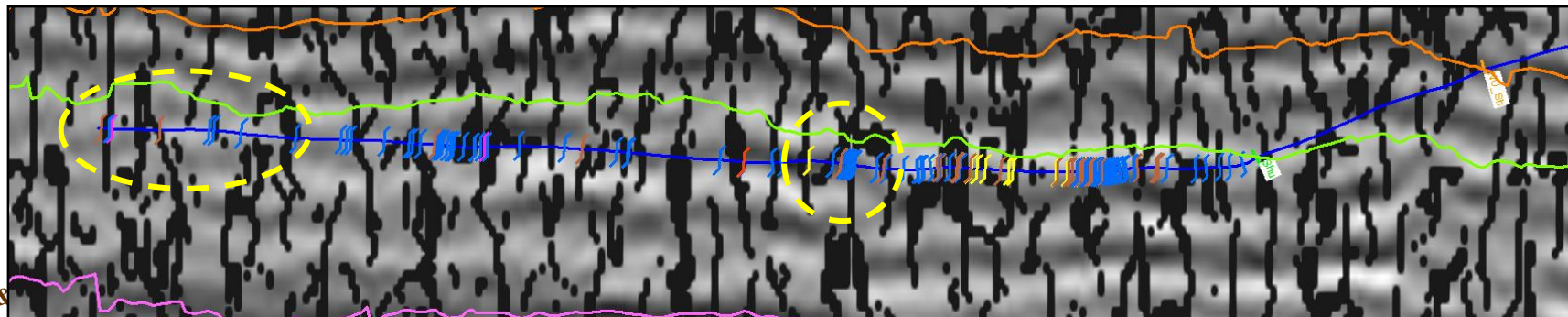
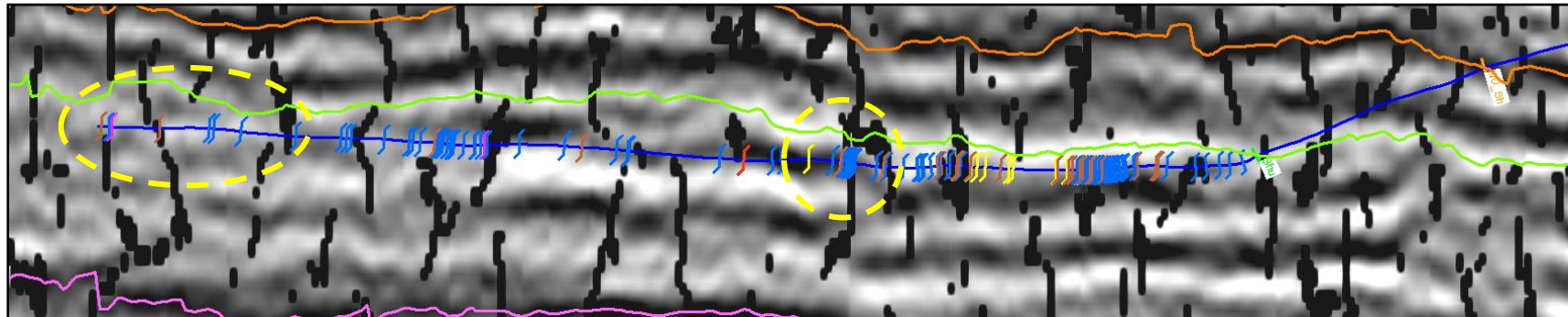
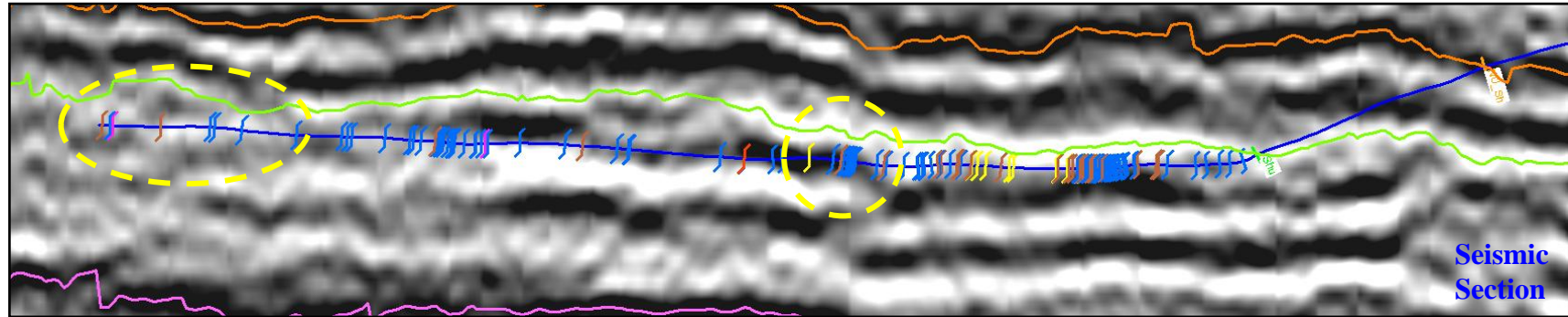
Gas show onset at exact location where horizontal well drills through fault

Seismic faults penetrated by horizontal well are often interconnected. Tracer data has shown that horizontal wells are in communication along fracture networks visualised by OPPtimal methods.



Resource Development Optimisation

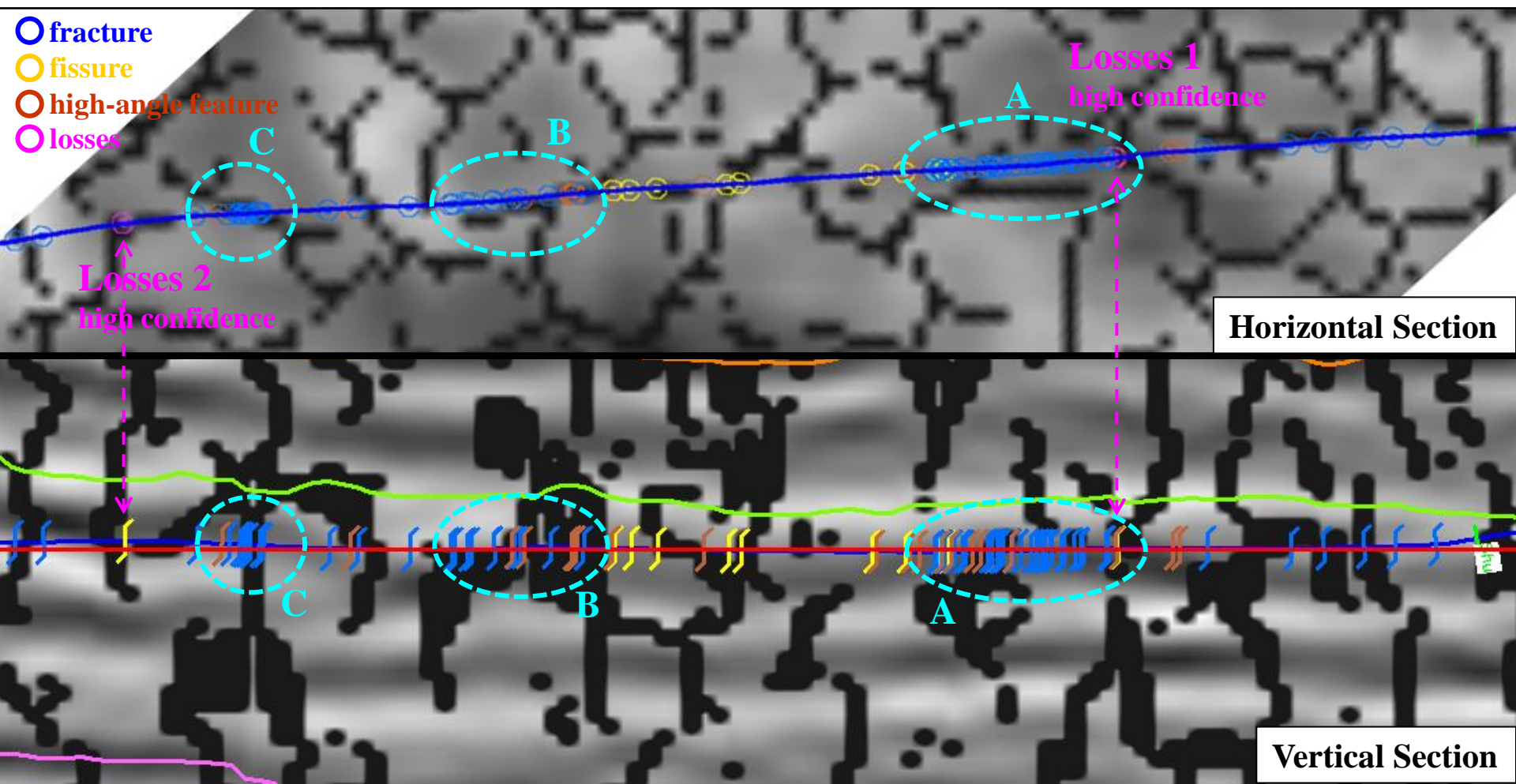
1. Identification of fracture penetrations in wells (contd.): **seismic fractures often show good to excellent matches with borehole image fractures, fluid losses and well productivity.**



Resource Development Optimisation

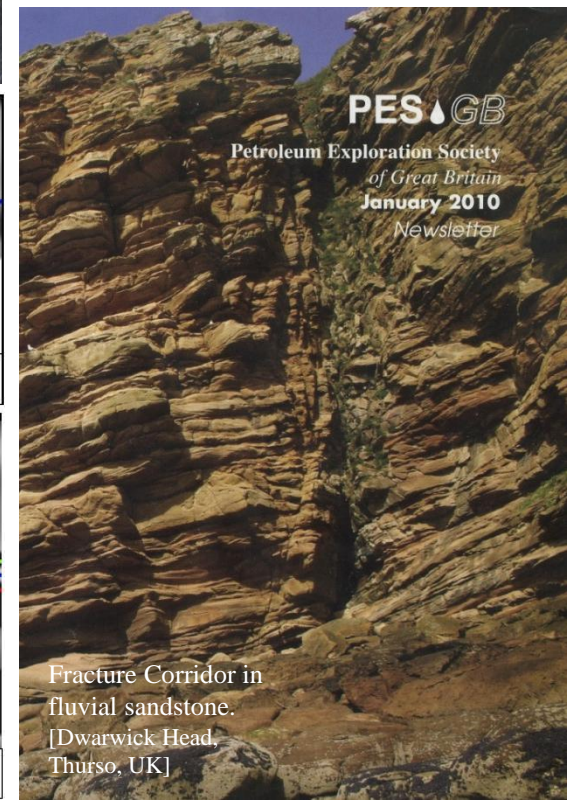
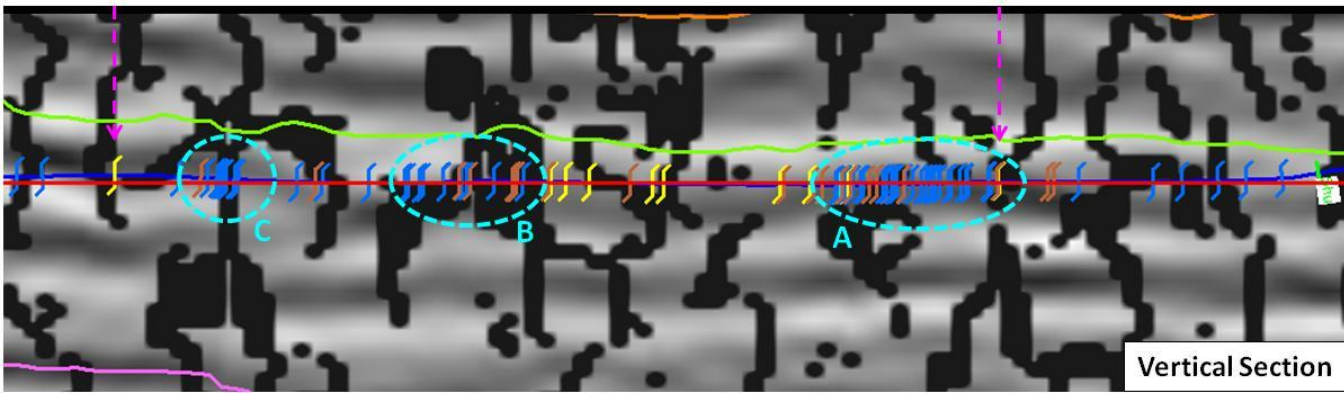
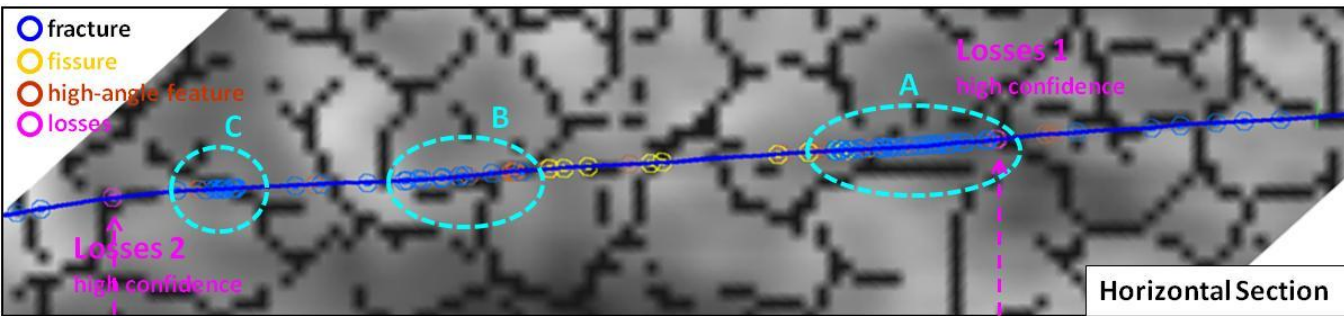
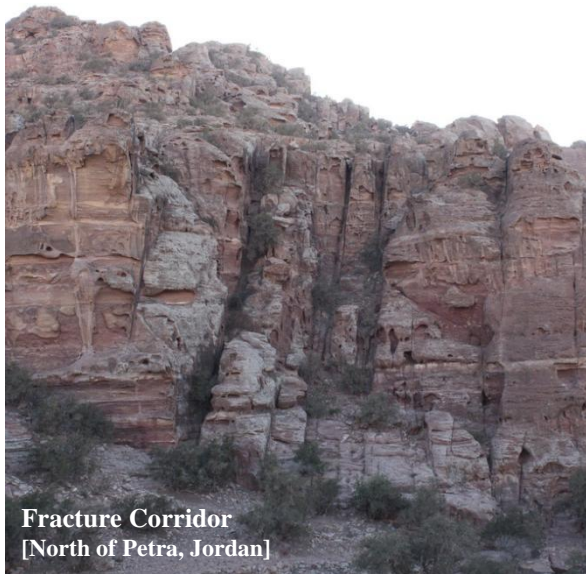
Challenge: Location and prediction of fault & fracture networks from seismic – where are ‘sweet spots’ in the reservoir ?

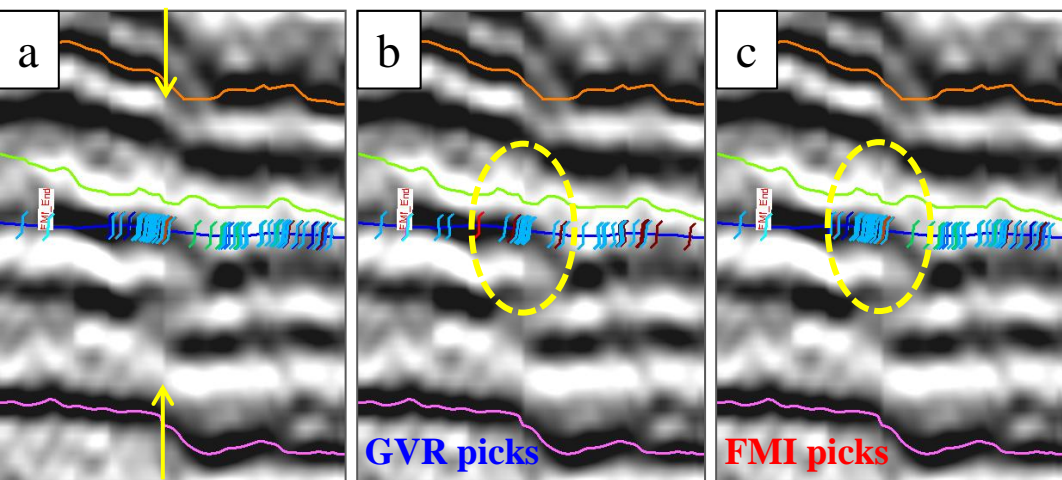
Outcome: Image log fracture density appears related to relative orientation of wellbore to seismic fracture zones – **higher image log fracture density when drilling parallel or sub-parallel to seismic fractures ! Detailed well planning can increase fracture intersections !**



Fracture clusters/swarms observed on image logs (A, B, C) are interpreted to be related to **fracture corridors**.

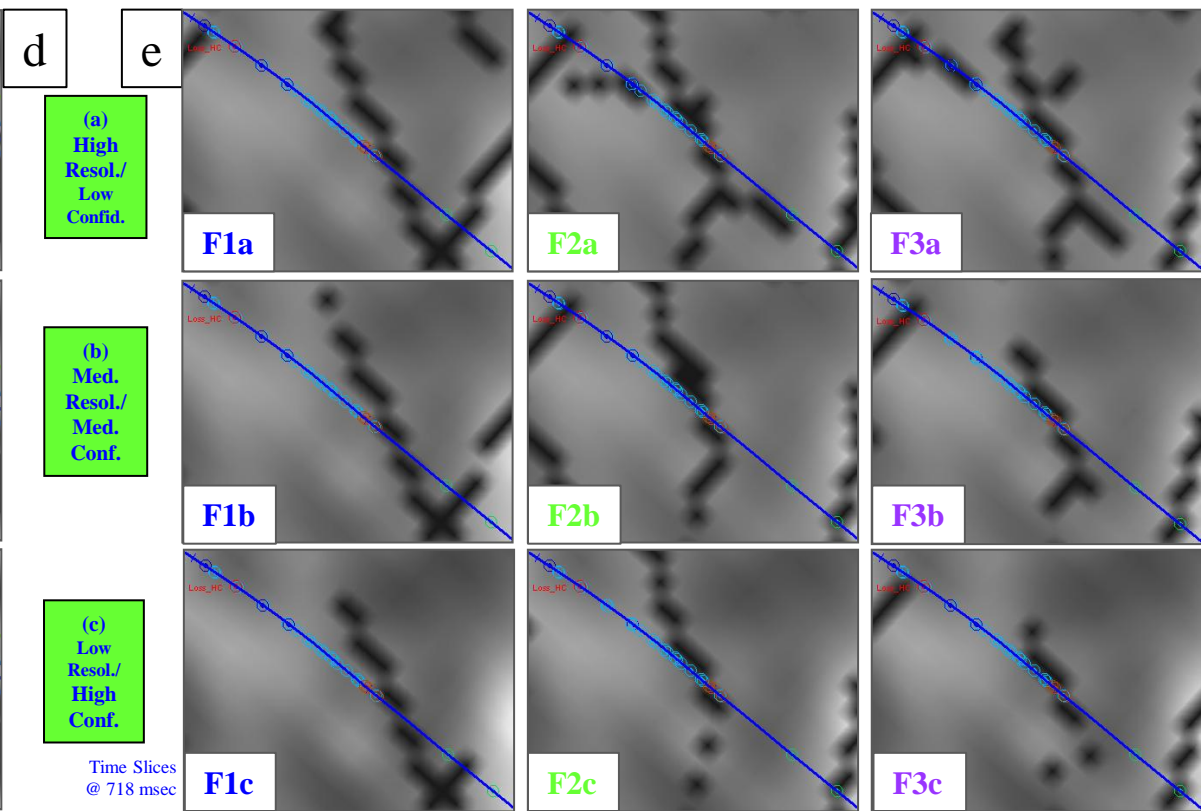
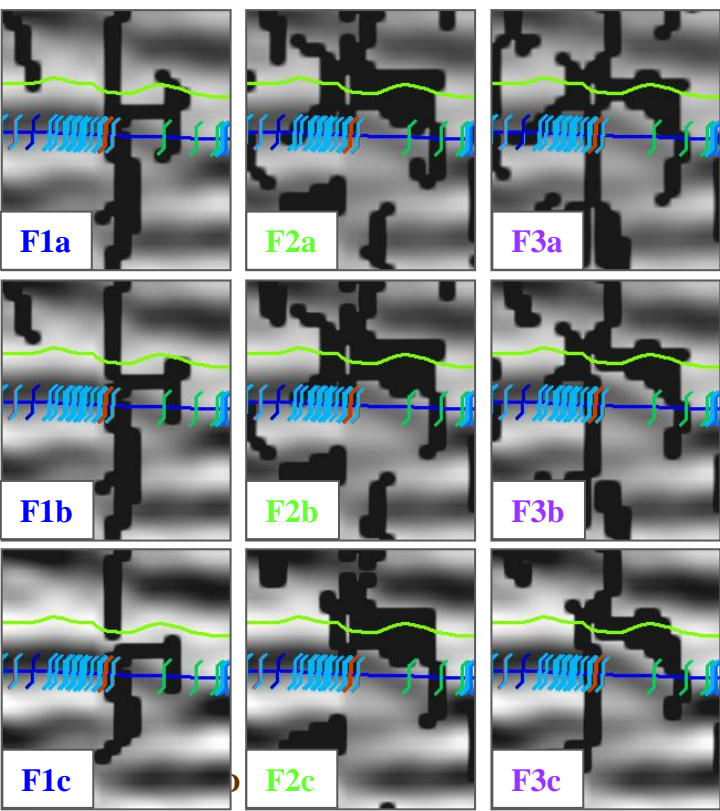
Fracture extractions indicate that image log fracture density is primarily related to the relative orientation of a wellbore to seismic fractures. Higher image log fracture densities are encountered when drilling parallel or sub-parallel to seismic fractures ! This means that **detailed well planning can increase fracture intersections !**

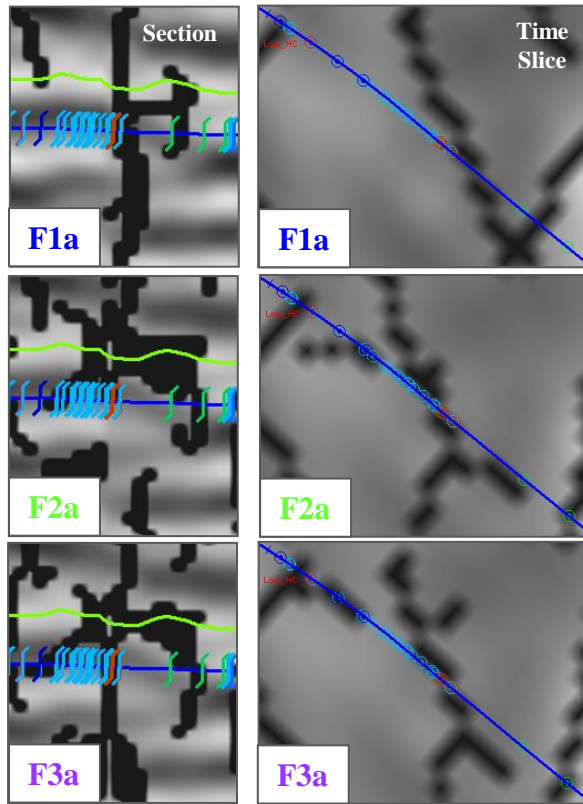




Seismic Fracture Corridor Example:

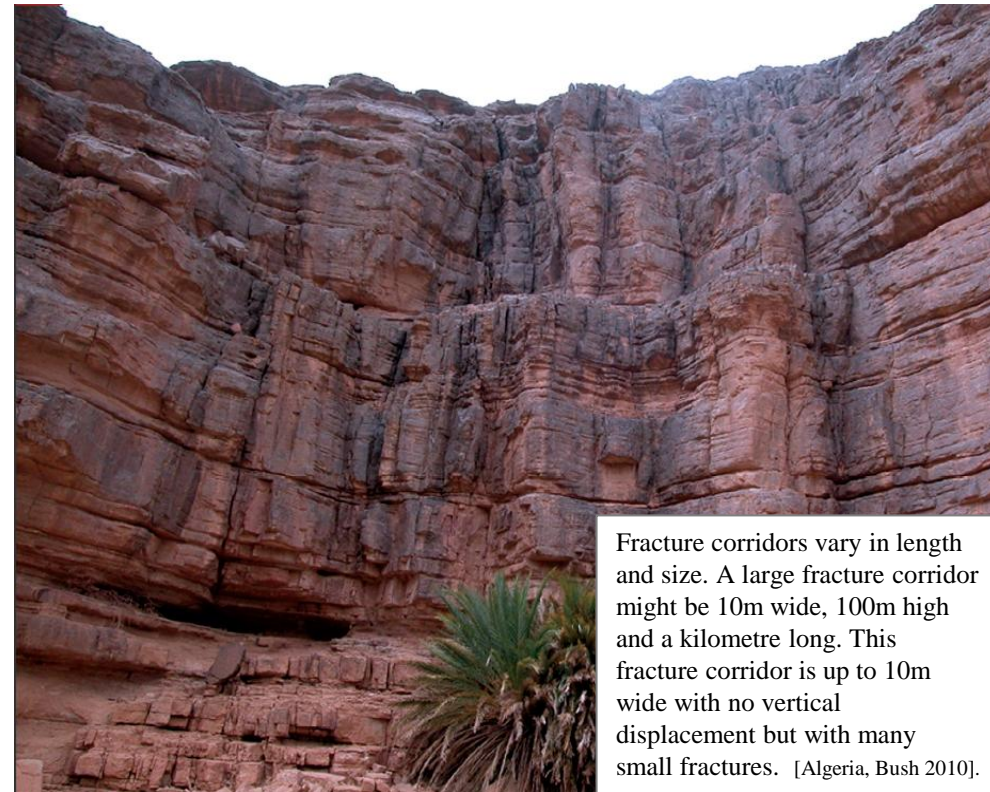
- a) obvious **visual seismic fault** was intersected by well. This fault was also mapped by the client.
- b) fracture cluster at this location interpreted from **GVR**
- c) fracture cluster at this location also interpreted from **FMI**
- d) clear **high confidence seismic fracture** identified by all 3 extraction methods (**F1c**, **F2c**, **F3c**)
- e) high fracture density appears related to the orientation of the well - well was drilled **sub-parallel to a high confidence, NNW-SSE oriented seismic fracture**, and also **parallel to a lower confidence, NW-SE oriented seismic fracture** (imaged by **F2a**, **F3a**)





(a)
High Resolution / High+Medium +Low Confidence

All three methods pick up a NNW-SSE striking seismic fracture !



Fracture corridors vary in length and size. A large fracture corridor might be 10m wide, 100m high and a kilometre long. This fracture corridor is up to 10m wide with no vertical displacement but with many small fractures. [Algeria, Bush 2010].

MD (ft)	Origin	Surface	Azimuth_True	Dip_True
12464	GVR-inFMlarea	CFRAC_M	48	74
12467	GVR-inFMlarea	CFRAC_M	50	88
12473	FMI	CDITF	19	86
12475	GVR-inFMlarea	CFRAC_M	29	74
12476	FMI	CFRAC_M	78	85
12479	GVR-inFMlarea	CFRAC_M	64	75
12504	FMI	CDITF	233	76
12506	GVR-inFMlarea	CFRAC_M	231	89
12509	FMI	CDITF	200	74
12512	GVR-inFMlarea	CFRAC_M	209	85
12520	GVR-inFMlarea	CFRAC_M	202	86
12528	FMI	CFRAC_M	85	80
12530	GVR-inFMlarea	CFRAC_M	264	71
12534	FMI	CFRAC_M	93	86
12537	GVR-inFMlarea	CFRAC_M	84	79
12565	FMI	CFRAC_M	148	75
12568	GVR-inFMlarea	CFRAC_M	355	79
12591	FMI	CFRAC_M	330	69
12593	GVR-inFMlarea	CHAF_REAL	342	68
12606	FMI	CFRAC_M	149	76
12610	FMI	CFRAC_M	104	79
12632	FMI	CFRAC_M	19	79
12641	FMI	CFRAC_M	141	83
12665	FMI	CFRAC_M	182	80
12666	GVR-inFMlarea	CFRAC_M	355	77
12675	FMI	CFRAC_M	155	76
12711	FMI	CFRAC_M	109	81

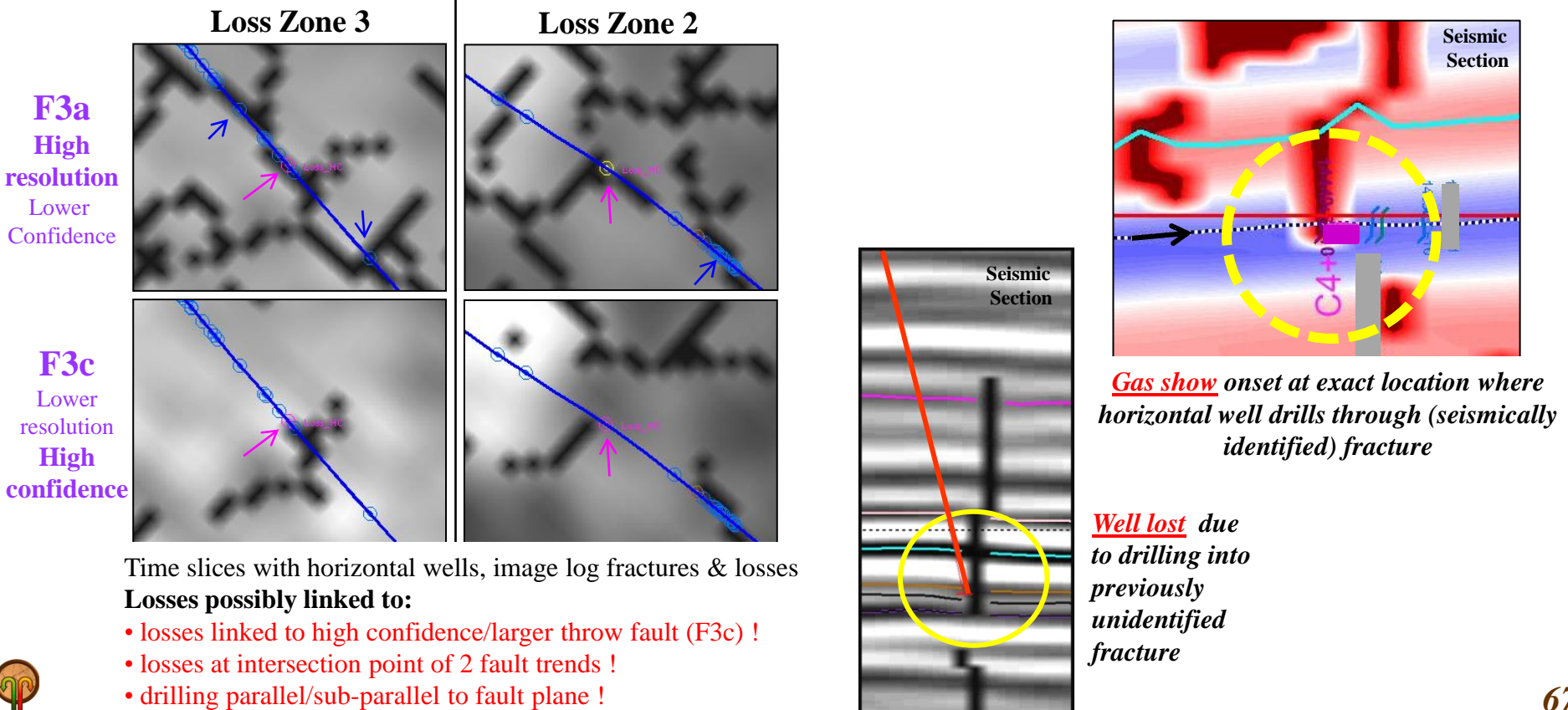
Match between strike of image log fracture and seismic fracture !

Well	Data	Type	Confidence	Method F1 Confidence	Method F2 Confidence	Method F3 Confidence	Aggregated Confidence	MD [ft]	Azimuth	Strike	Dip Dir
Well D	GVR	CFRAC_M	Medium Conductive Fracture	3				12,479	64	334 154	75
	FMI	CFRAC_M	Medium Conductive Fracture	8				12,476	78	348 168	85
	Seismic	SF_HC	High Confidence Seismic Fracture		3	3	3	9	12,475		NNW SSE

Resource Development Optimisation

2. Better understanding of links between fracture penetrations and previous drilling, mining and/or production issues:

- links between **fractures and drilling/mining observations or Non-Productive Time:**
 - ☹ wellbore stability/integrity, break outs, **total well losses**, mine roof collapse, **lost circulation**, gas kicks, outbursts, local stress variation, geomechanics
- links between **fractures and HC shows** (boundaries/baffles, fluid conduits, productivity)

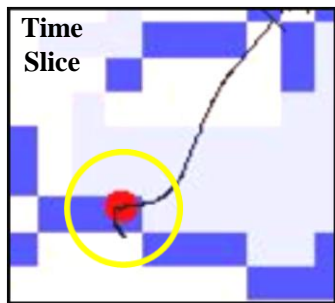


Resource Development Optimisation

2. Better understanding of links between fracture penetrations and previous drilling, mining and/or production issues (contd.):

➤ links between **fractures and production behaviors:**

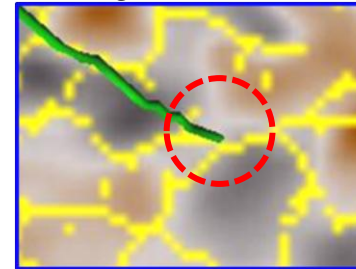
- ☺ **flow enhancement**, natural fracture networks, mine gas drainage, present-day stress influence on productivity
- ☹ **water/gas channelling**, boundaries/baffles, **compartmentalization**, seam offsets



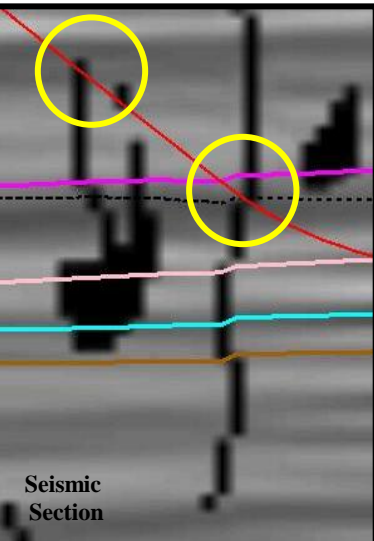
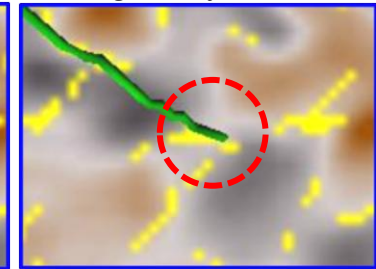
Water channelling in wells explained

Well drilled into previously unidentified (karstified) fault = oil-filled cavity

High resolution



High confidence



Visualising compartments in fields

