

SFD® Case Example: Tertiary Limestone Reservoir, Balochistan Province, Pakistan

The Early Eocene to Paleocene aged Sui Main Limestone (SML) is mainly composed of porous limestone with a sequence of minor shales; the upper layer consisting of more impermeable sequences of argillaceous limestone and marls.

The thickness of the SML ranges from 625 m to 668 m and its origins are likely that of a reefal bank deposit. The SML is a closed-system reservoir likely isolated on all sides by shales or poor reservoir facies and structural barriers.

NXT was engaged by PPL for a proof of concept survey in 2012. NXT then conducted various Research and Development surveys in the area to quantify the response of the SFD® survey system. These fields were used as templates for surveys conducted in similar geological settings.

Province of Balochistan, Pakistan



Stratigraphic Column

AGE	FORMATIO	LITHOLOGY	RESERVOIRS & SOURCE ROCKS	FIELDS
MIOCENE - PLEISTOCENE	SIWALIK	[Lithology symbols]		
E O C E N E	GHAZIINDIA MB.	[Lithology symbols]		
	PIRICH MB.	[Lithology symbols]		
	ISPHIK MB.	[Lithology symbols]		
	HABIB NAKH	[Lithology symbols]		
E O C E N E	GHAZI MB.	[Lithology symbols]		
	LAKI FM.	[Lithology symbols]		
P A L E O C E N E	SUI MAIN LST. MB.	[Lithology symbols]		← Sui
	RANKHOT	[Lithology symbols]		← Sui, Uth, Zin, Karez, Qadirpur
P A L E O C E N E	PAS	[Lithology symbols]		← Pish, Lst, Sui, Ragn, Dhadak, Racho, Sui Deep, Pish
	PARSHI MB. / WACHAL FM.	[Lithology symbols]		← Janton
LOWER CRETACEOUS	LOWER GORU MB.	[Lithology symbols]		
		[Lithology symbols]		
		[Lithology symbols]		
		[Lithology symbols]		
LOWER CRETACEOUS	LOWER GORU MB.	C Lst		← Sawan
		B Lst		← Kadanwari, Mian, Man Deep
		A Lst		
SEMBAI	CHELTAN	[Lithology symbols]		
		[Lithology symbols]		

Reference:

Nusrat K. Siddiqui, 2004; pp 1007-1035

The American Association of Petroleum Geologists.

Sui Main Limestone: Regional geology and the analysis of original pressures of a closed-system reservoir in central Pakistan.

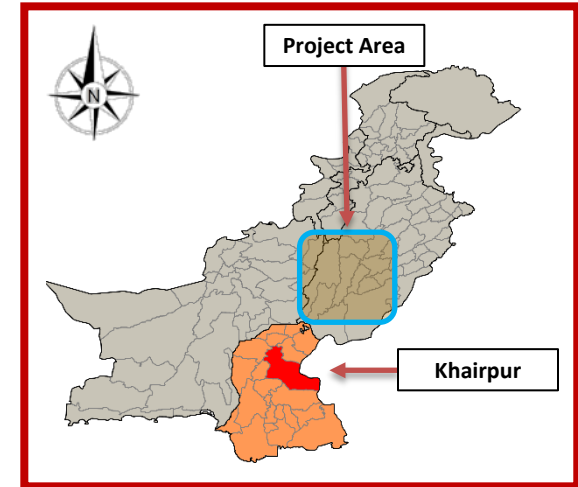
H.M. Schail, F. Sadiq, 1987 (Pakistan Petroleum Ltd.)

Exploitation of Sui Main Limestone Reservoir at Sui: The Prolific Gas Producer of Pakistan.

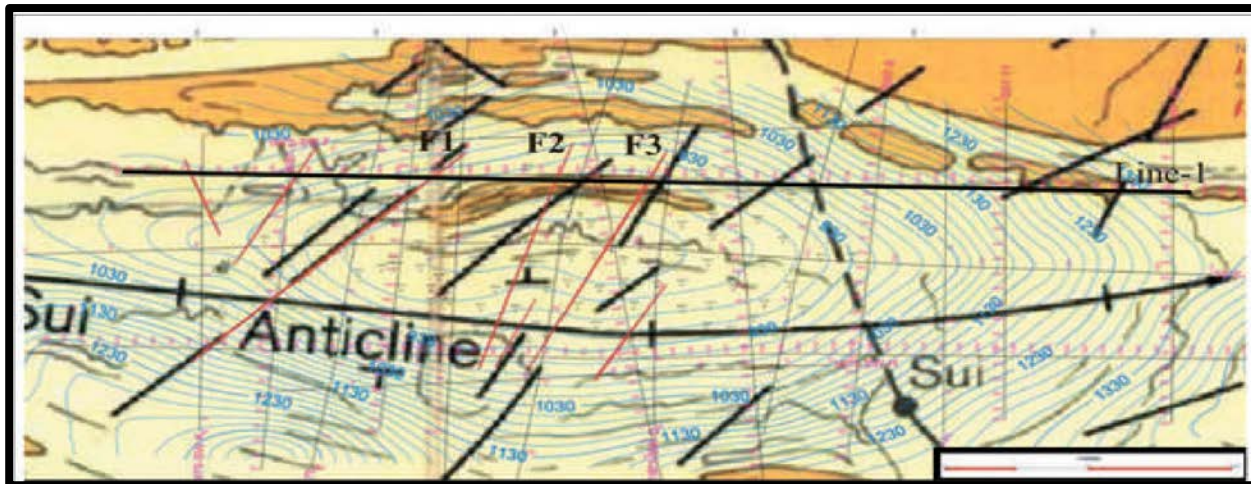
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SFD® Case Example – Pakistan Tertiary Limestone - Sui

- The Sui Gas Field is located in the Balochistan Province about 80 km north-north-east of the town of Khairpur.
- The field was discovered by Pakistan Petroleum Limited in 1952 as a result of drilling over an exposed anticline. It was the first major gas discovery in Pakistan and remains the largest with reserves over 10.0 Tcf.
- The field is producing gas from two reservoirs i.e. Sui Main Limestone (SML) and Sui Upper Limestone (SUL).
- The Sui structure is an E-W-trending double plunging anticline that developed at the southern mountain front of Sulaiman Fold Belt. It is a symmetrical anticline with limbs having gentle (8°) conjugate sets of NE - NW oriented shear fractures. These are present on the surficial outcrop and can be readily observed on satellite imagery.



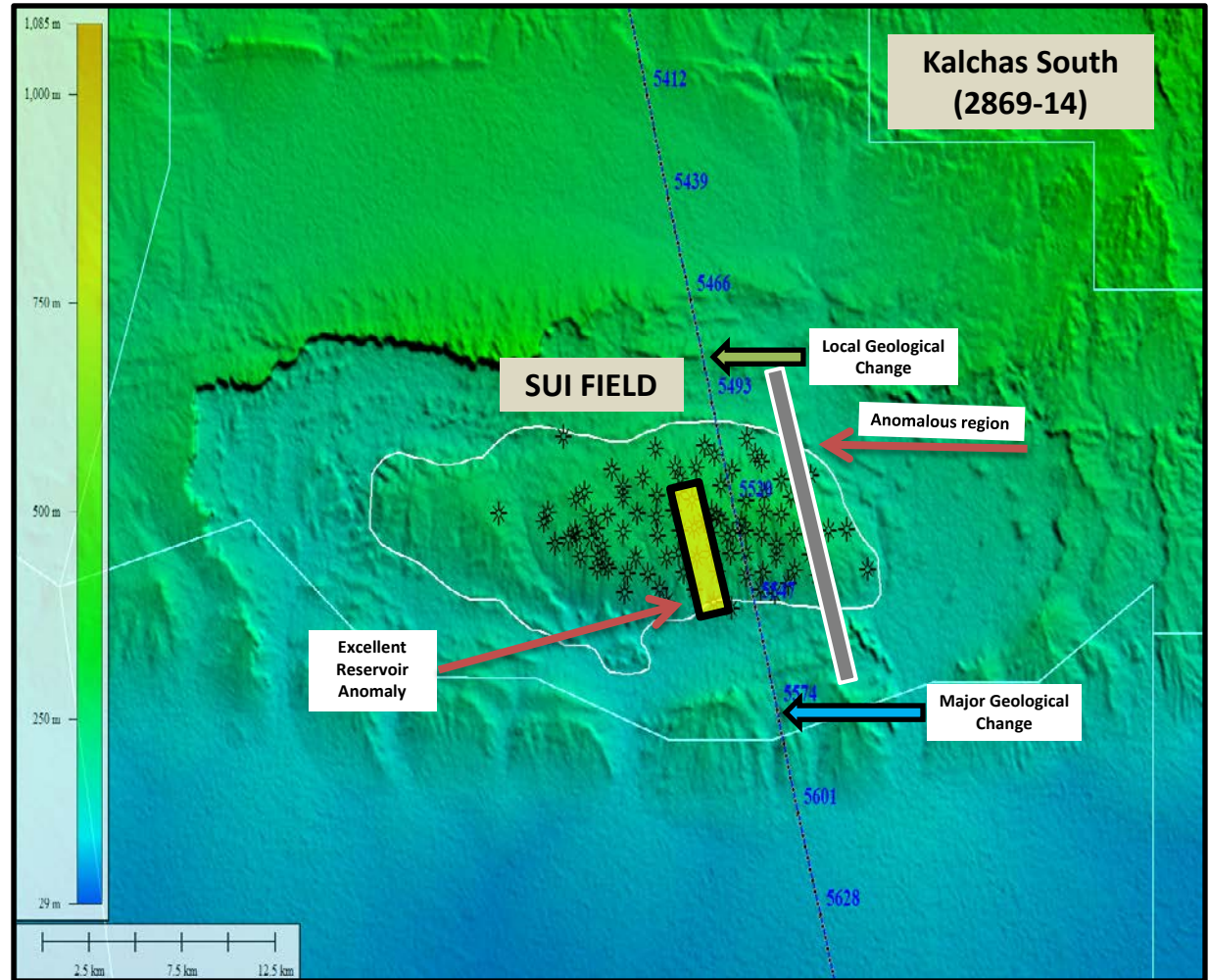
Generalized Stratigraphy and Petroleum Geology, Central Indus Basin



Geological Map overlain by time contours at SML level showing orientation of Mega-Shear Fracture (MSF), Sui Anticline.

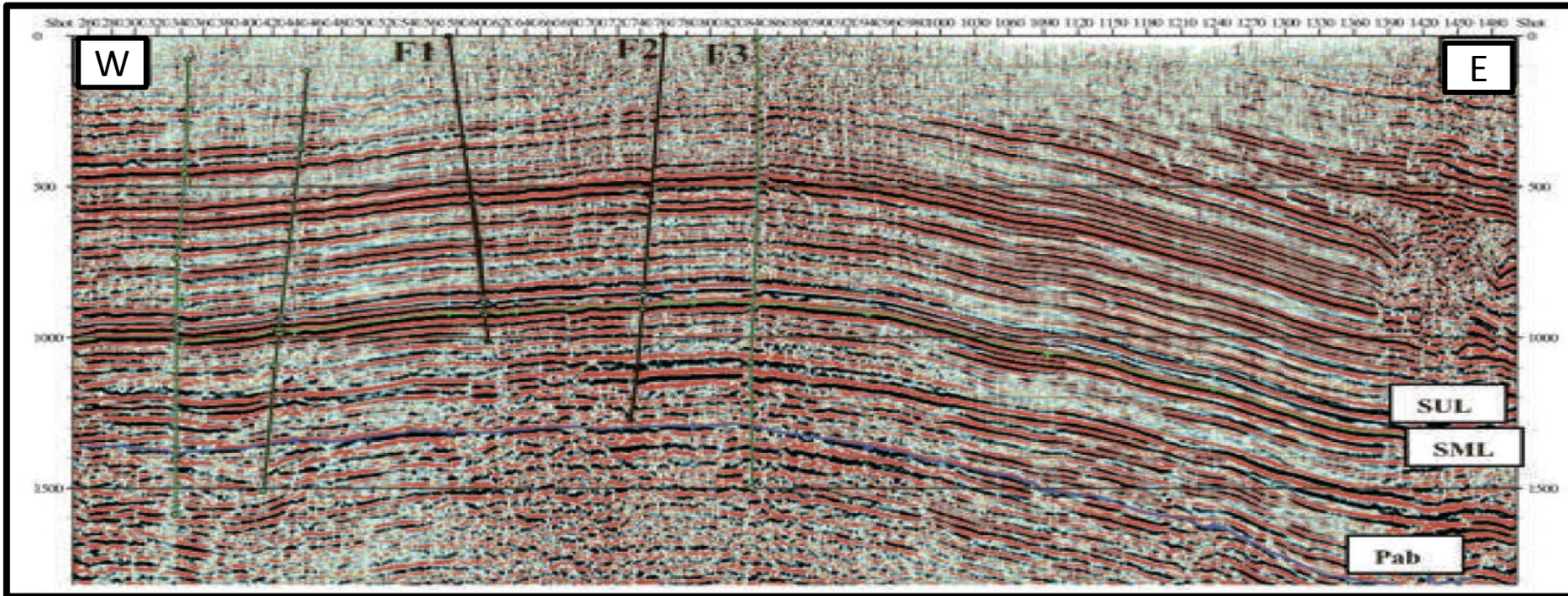
SFD® Case Example – Pakistan Tertiary Limestone - Sui

- Commercial production from Sui commenced in 1955 at a rate of about 35 MMcf/day.
- A total of 86 wells have been drilled on the structure.
- SFD® Survey Conducted in 2012.
- Surface Area: 187.5 km², with maximum gas column of 245 meters.
- Net Pay: 250 meters to 33 meters at the flank above main producing zone (1250 meters).



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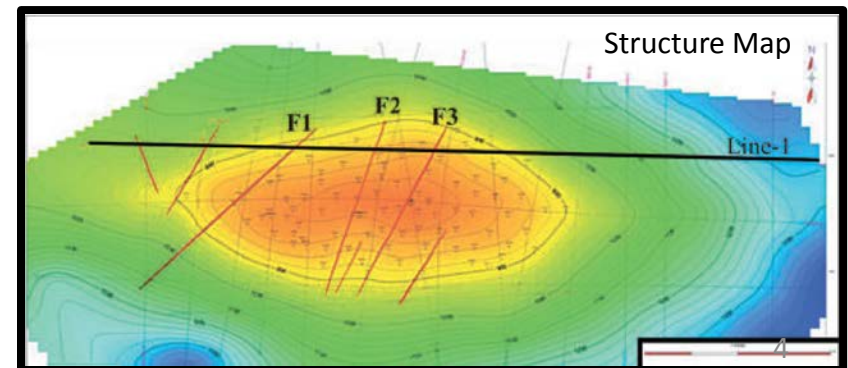
*SFD® Case Example – Pakistan
Tertiary Limestone - Sui
3D Seismic Inline – TWT Structure Map*



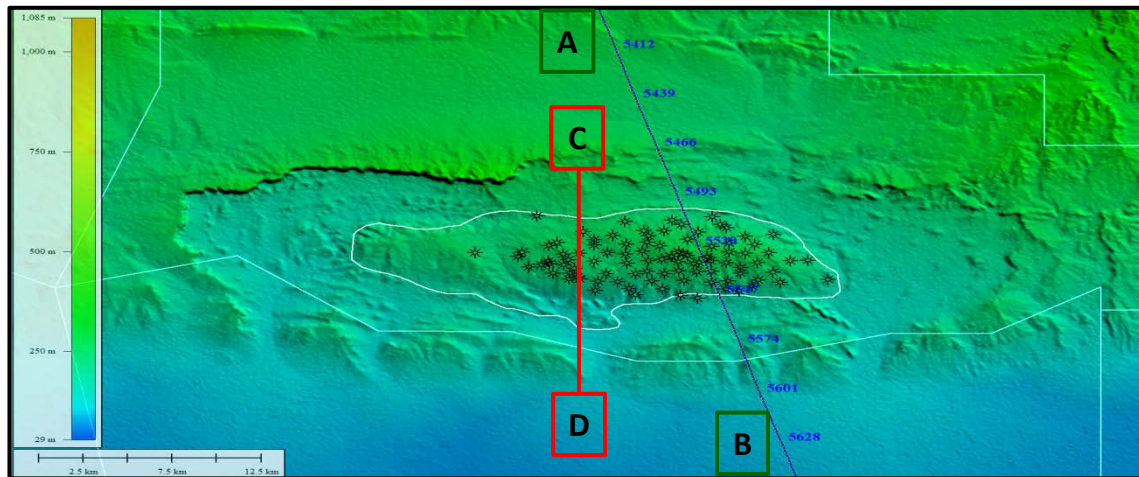
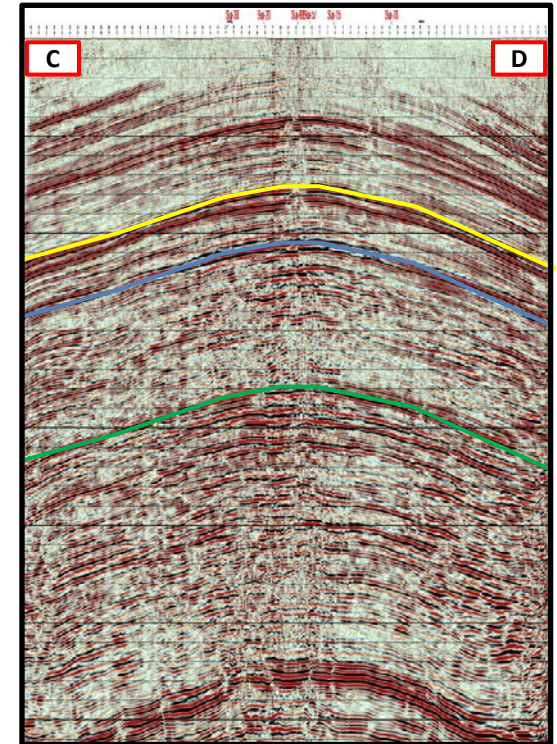
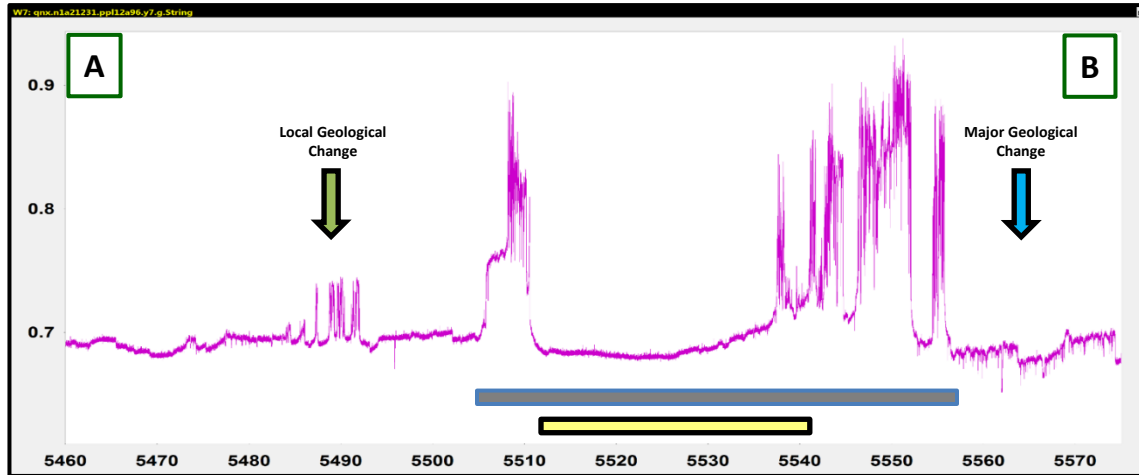
The Mega-Shear fractures observed in the Sui anticline are formed as a result of lateral displacement and extend to considerable depths.

These conjugate sets of NE/NW strike fractures are related to folding and regional strike-slip movement associated with the plate boundary conditions.

These mega-shear fractures, interpreted on 2D seismic sections, have penetrated the Cretaceous level that might have provided the conduits for gas migration from Sembar (source rock) to Sui Main Limestone (reservoir).



SFD® Case Example – Pakistan Tertiary Limestone - Sui

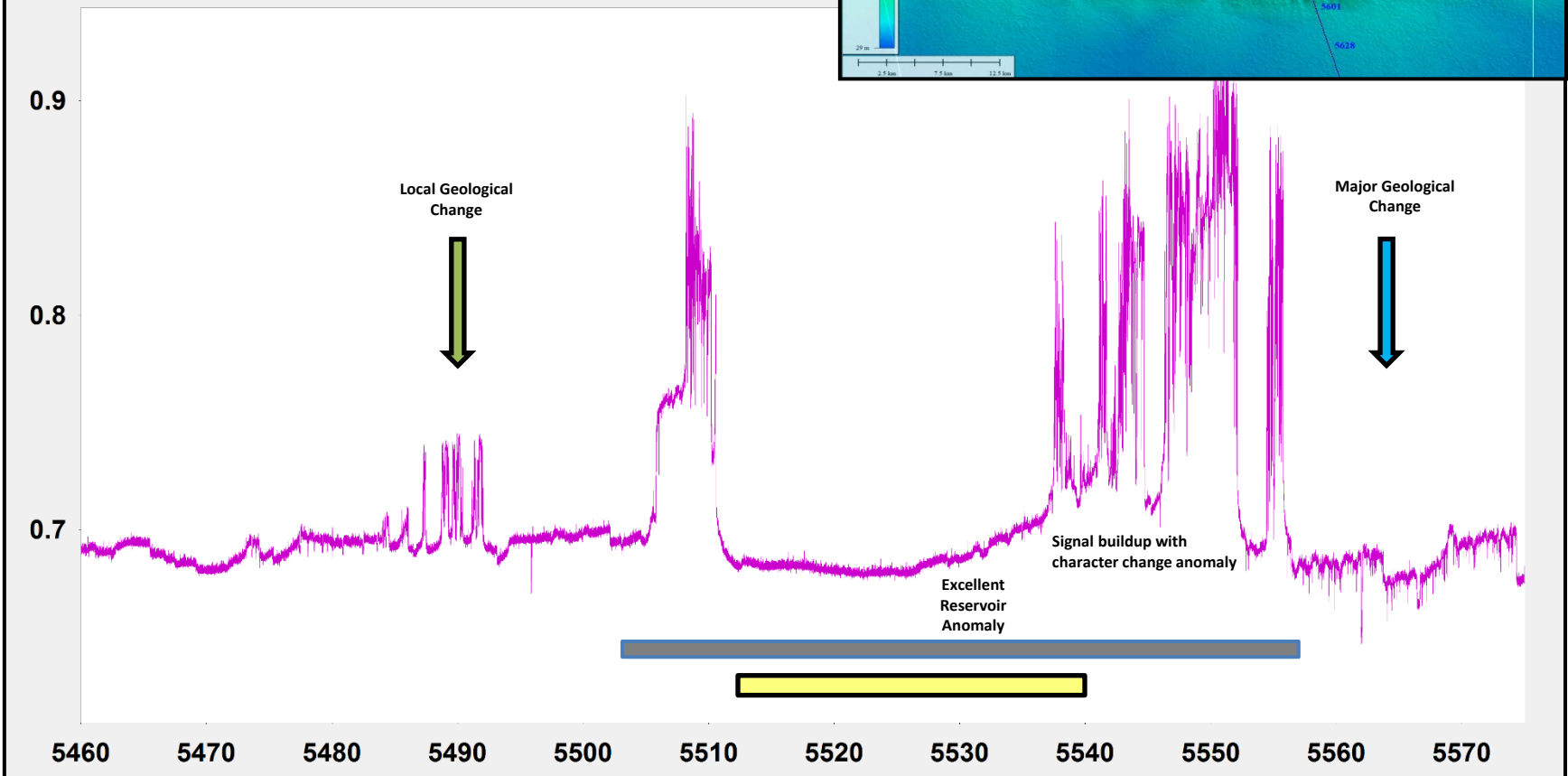
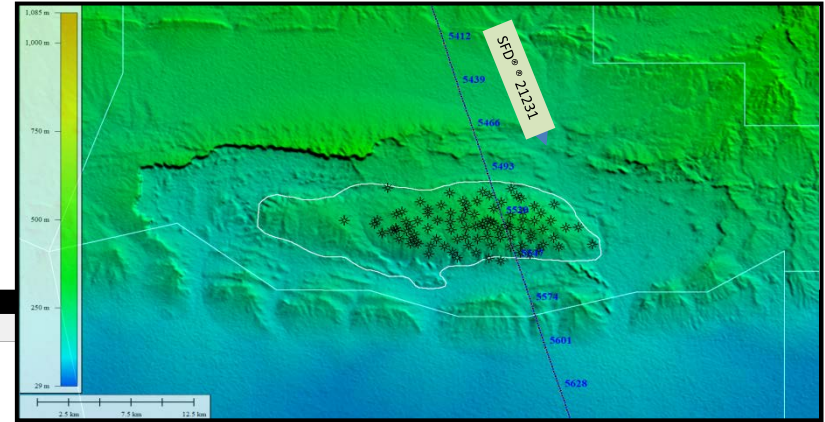


➤ Field has strong reservoir indicators as demonstrated by the frequency responses on primary SFD® sensors

SFD® Case Example – Pakistan
Tertiary Limestone - Sui

SFD® 21231 Tertiary Limestone - Sui

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SFD® Case Example – Pakistan
Tertiary Limestone - Sui

SFD® 21231 Tertiary Limestone - Sui

Summary

- SFD® flight 21231 detected an excellent reservoir anomaly over the main SUI gas pool.
- SFD® showed an anomalous region starting with a local geological change at 5490 and finishing with a major geological change at 5575.
- Within the anomalous region the signal attributes are used to further delineate the core reservoir anomaly between 5515 and 5560.

