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# Application of micro-seismic monitoring technology in fracturing and water injection development of horizontal wells with low permeability and thin layer

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**Abstract.** With the development of unconventional oil and gas reservoirs, microseismic monitoring has been developed rapidly as the key technology of hydraulic fracturing design, implementation and evaluation of this type of oil and gas reservoir. A oil field test area as a low-porosity and low permeability reservoir, the micro-seismic monitoring data were collected and processed during the development of fracturing horizontal well fracturing. The spatial development characteristics of the length, width and azimuth of the artificial fracture zone are analyzed by the method of overlooking the projection, fracturing and front edge calculation of the microseismic event point, and the later stage water injection is instructed to provide technical support for the future design of the horizontal well encryption and adjustment scheme.

**Key words:** In-filled horizontal wells; Micro-seismic monitoring technology; water injection

## 1. Introduction

Due to the poor physical properties of the reservoir and the thin production layer, the  $300 \times 300\text{m}$  anti-nine point of the network water injection development effect is quite poor for this A oil field.

Reservoir permeability  $1.01 \times 10^{-3}\mu\text{m}^2$ .

Effective thickness of 2.2m / 3.4 layer, storage abundance of  $16.01 \times 10^4\text{t} / \text{km}^2$ .

The average single well oil production 0.3t / d, the estimated recovery rate of 12.4% .

Horizontal well in-infill between the vertical wells, together with artificial cracks and well pattern matching, and achieved good results:

Single well production is high, oil production 7.4t / d, which is 5 times higher than the straight wells.

Water injection is easy to effect, stable yield of up to 2 years.

Recovery forecast to more than 30%.

But the in-filled horizontal wells face the following two issues that need to be addressed:

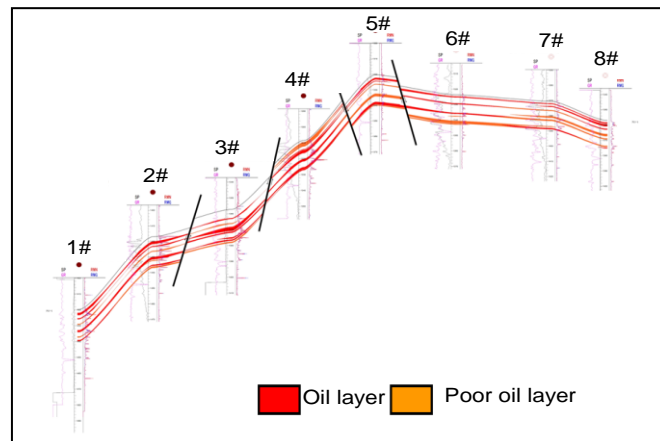
What is the actual form of artificial fractures after fracturing? Is it possible to achieve the matching of cracks and well patterns and capacity design requirements?

How can the in-filled horizontal wells be prevented from flooding during the water injection adjustment process? How to maintain horizontal wells for efficient development?

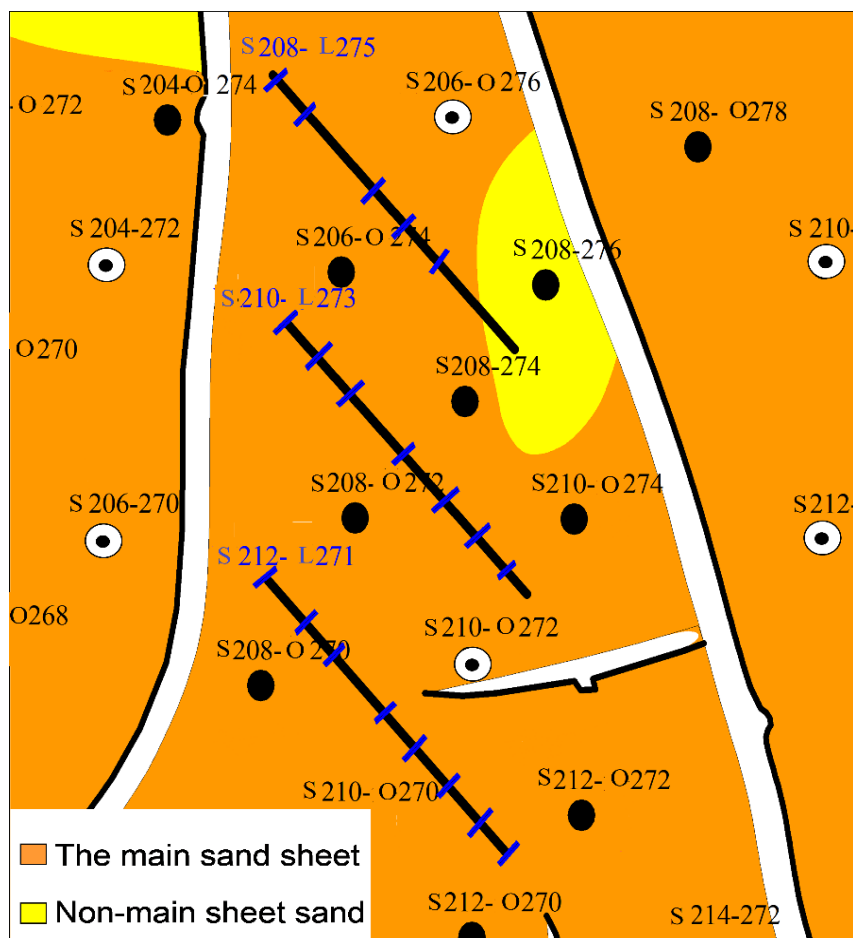


## 2. Micro-seismic monitoring of fracture distribution

In 2014, the micro-seismic monitoring technique was used to monitor the 8 sections of the H-well during the hydraulic fracturing of the horizontal wells. After the treatment, the spatial location data and the distribution characteristics of the micro-seismic events were obtained.



**Fig 1.** A Oilfield Reservoir Profile



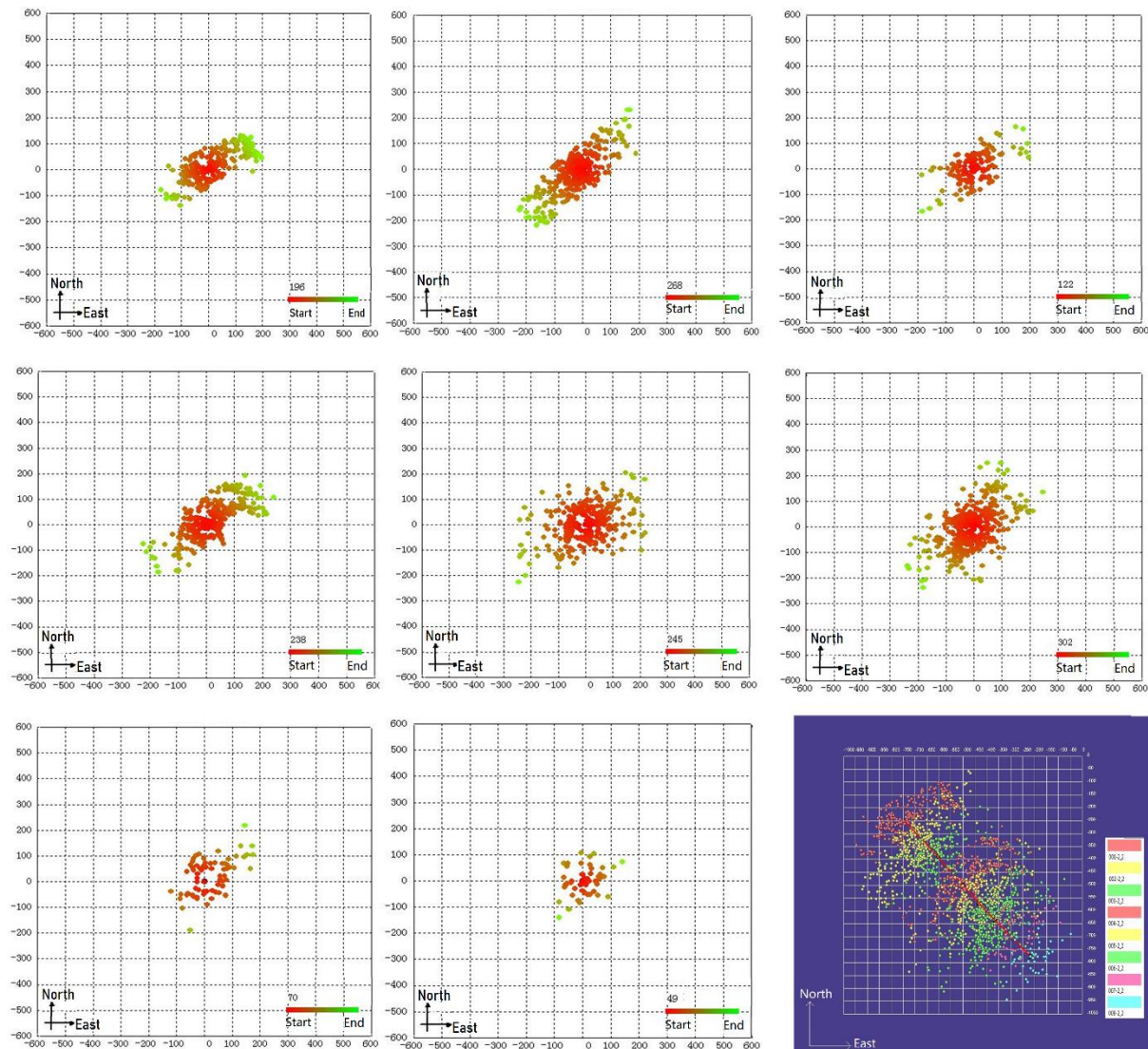
**Fig 2.** Horizontal Wells Bitmap

### 3. Guide the optimal design of horizontal well scheme

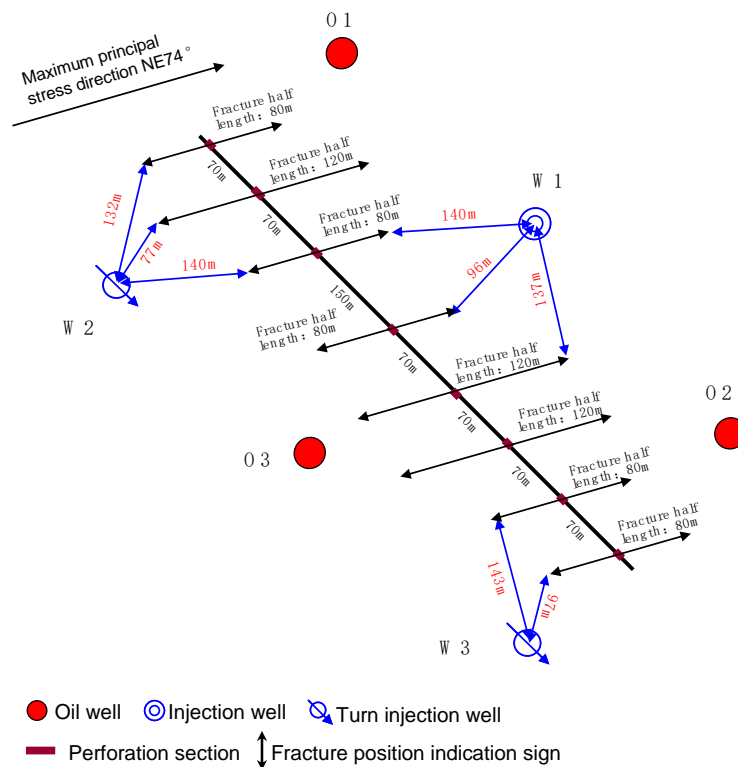
Optimal design of the in-filled horizontal well scheme:

Horizontal segment orientation to be perpendicular to the maximum horizontal stress direction NE74°, so as to obtain higher productivity.

The length of the artificial fracture should meet the requirement that the displacement distance is less than the effective displacement of 144m, in order to achieve long-term stable production purposes.



**Fig 3.** Numerical Observation and Superposition of Micro - seismic Event Points in H Fracturing Section



**Fig 4.** H well fracturing parameters design results diagram

**Table 1.** H well fractures spatial distribution characteristic parameter statistics

Fracturing section	Design of fracturing parameters			Microseismic monitoring results		
	Fracturing fluid dosage(m <sup>3</sup> )	Design the amount of sand(m <sup>3</sup> )	Design half seam length(m)	Crack orientation(NE°)	Cracks are half length(m)	
					East wing	West wing
1	180	15	80	63.8	116	85
2	250	25	120	50	104	111
3	180	15	80	63.1	94	84
4	180	15	80	58.1	117	98
5	250	25	120	73.4	115	110
6	250	25	120	60.1	111	108
7	180	15	80	68.3	99	76
8	180	15	80	72.3	69	81

Each section of artificial cracks micro-seismic monitoring results:

The direction of artificial cracks in the NE50 ° -73.4 ° between the cracks were fully modified to achieve a higher initial capacity of 7.4t / d, compared with the design capacity 6.9t / d high 0.5t / d.

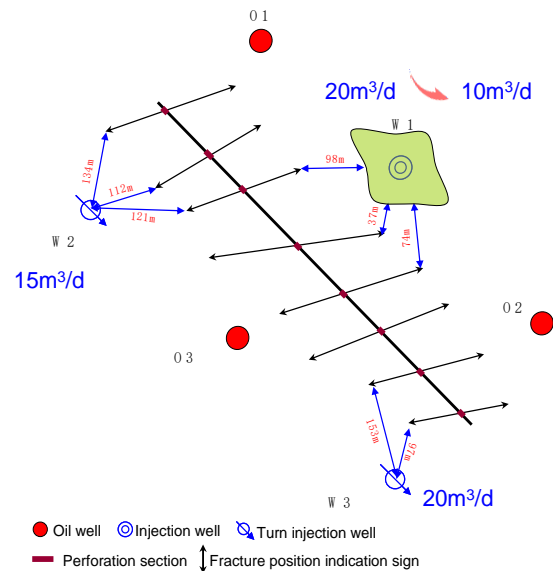
The fracture half-length is between 69 and 117 m, and the distance after the fracturing is less than the effective distance, and the reasonable match between the fracture and the well pattern is achieved. After 18 months of water injection, the formation pressure was restored from 8.8 MPa to 10.4 MPa

#### 4. Guide the horizontal well block water injection adjustment

Through micro-seismic monitoring it obtained the fracture orientation, half-length and other information for the injection wells, which could be used for dynamic adjustments:

Quantify the distance from the leading edge of the water-flooding to the fracture, and provide the basis for judging the dynamic adjustment.

Reduce the amount of water injection for wells having risk of water flooding, prevent the horizontal wells from flooding prematurely. Increased water injection in the safe range of flooding wells to promote horizontal wells production.

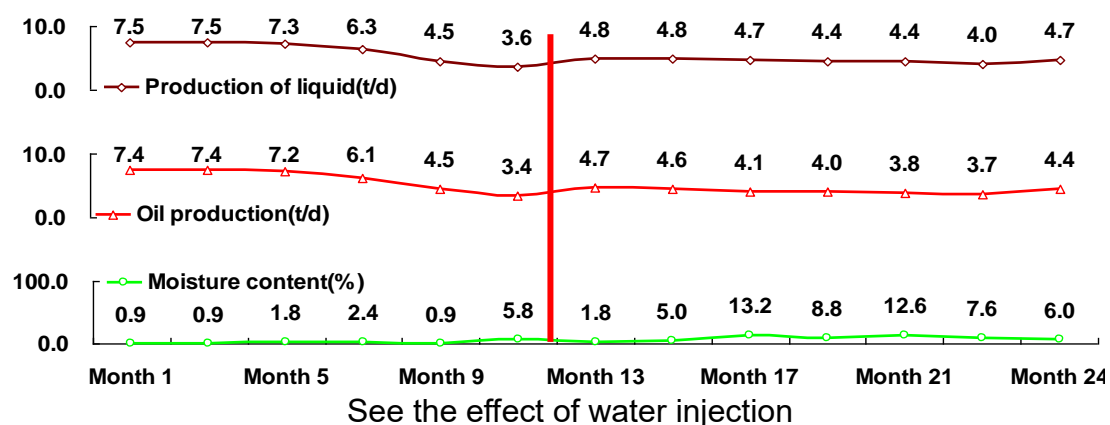


**Fig 5.** Micro-seismic monitoring results and water injection adjustment diagram

After adjustment, the horizontal wells have achieved good developmental effects:

The direction of the H well is W1 well and the targeted adjustment is carried out. The low water cut period lasts as long as 31 months.

Horizontal wells are subject to significant water injection, and the oil production is kept above 4.0 t / d.



**Fig 6.** The Curve of Water Injection Adjustment after H Fracturing

## 5. Conclusion

The design of artificial crack distribution is the key to the success of horizontal well in-fill. The micro-seismic monitoring technology can be used to describe the distribution pattern of artificial fractures well,

guide the design of horizontal wells and adjust the water injection, and above all, to provide the basis for the future development and adjustment of the same type of oil field.

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