



# **A Case Study of Fine History Matching Technique for Long-term Water Flooding in High Water Cut Mature Oilfields in Bohai Bay**

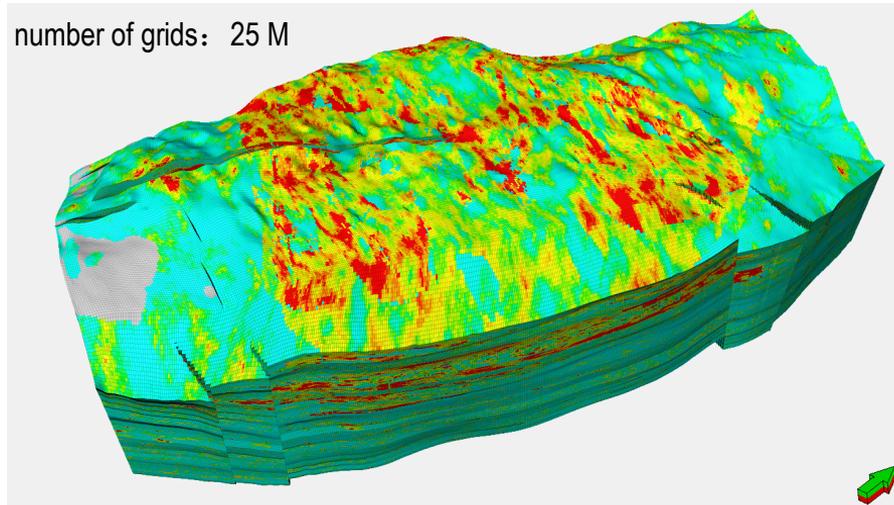
## **—— SZ Oilfield**

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**Reservoir Engineer , CNOOC**  
**2019.9**



# Reservoir profile map of SZ oilfield

**SZ oilfield is the largest self-operated offshore oilfield of China.**



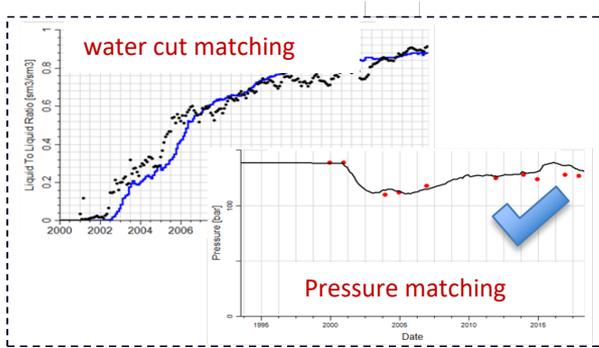
- ❑ SZ oilfield has been developed by water flooding for 25 years.
- ❑ Polymer flooding has been implemented in the south area since 2003.
- ❑ Presently, it has come into high water-cut stage (85%)

**Several wells or well groups have poor history matching which will bring an error distribution of remaining oil.**



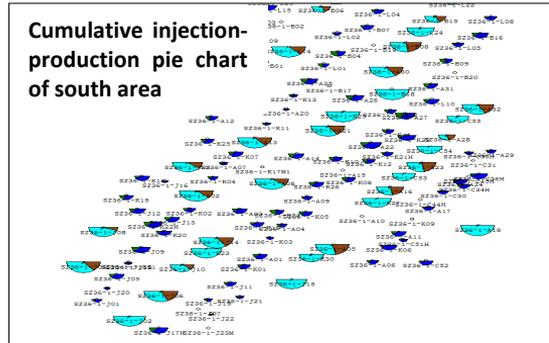
# Three challenges in history matching

- ◆ The overall matching accuracy of the block is high, but that of single well is low

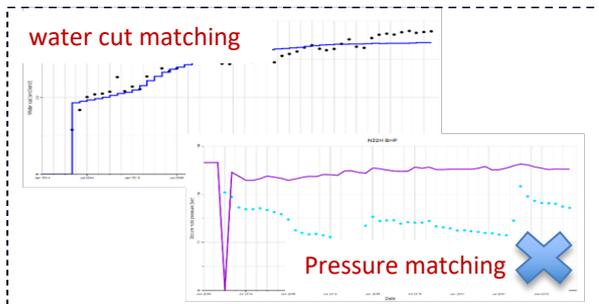
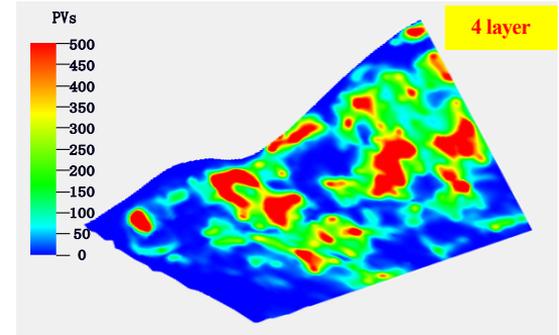


matching curves of the block X

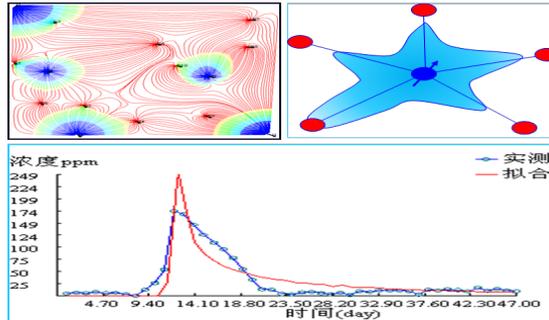
- ◆ Matching accuracy of some well groups needs to be improved in high water cut stage



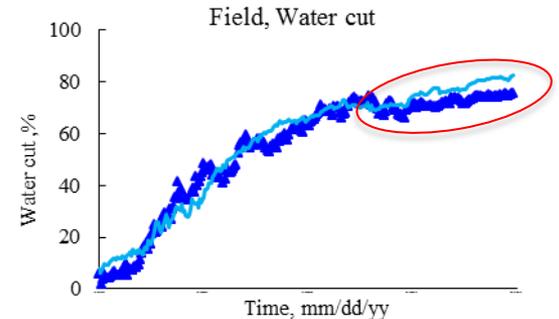
- ◆ the physical properties of water-flooding reservoirs would be altered due to the long term washing of injected water



matching curves of the well X1

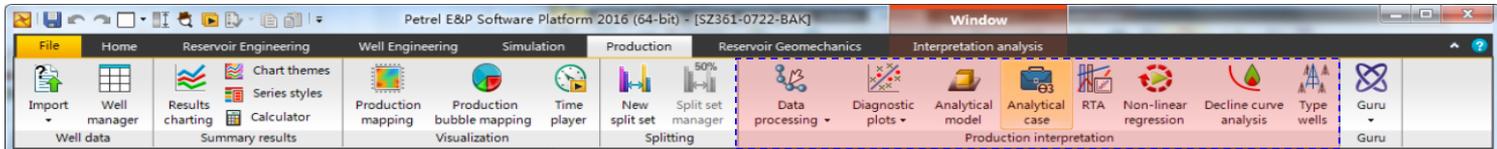


Tracer testing is expensive and time-consuming

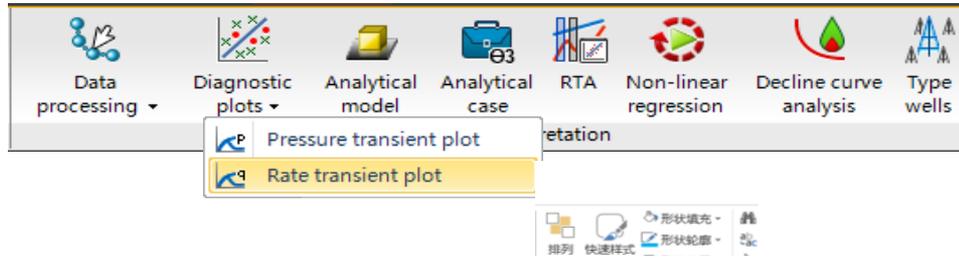




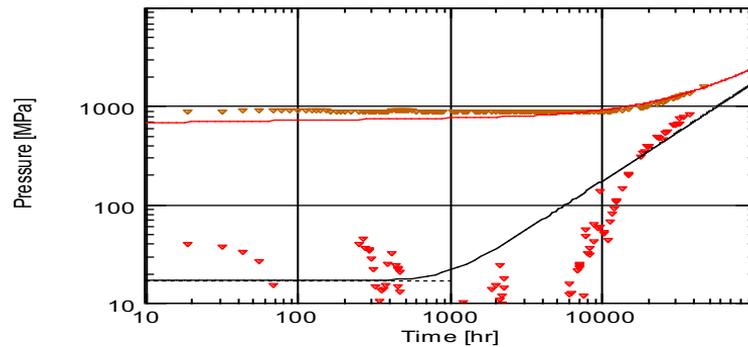
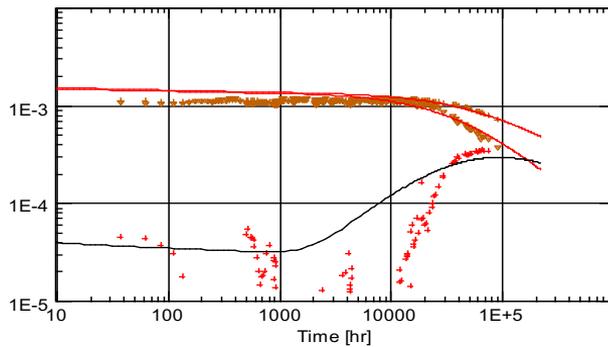
# 1、 Production transient analysis of single well



Production interpretation



◆ Saphir、Topaze





# 1、 Production transient analysis of single well

Firstly, with abundant pressure test data (nearly 500 wells for 23 years), single well pressure transient analysis (PTA) and production transient analysis (RTA) were carried out to obtain accurate reservoir parameters, such as permeability, skin factor, faults, etc.

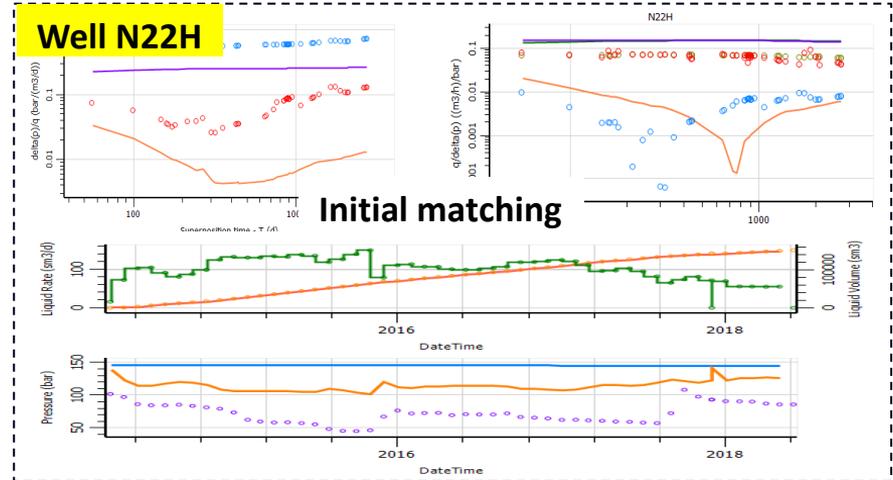
Production interpretation

- Data processing
- Diagnostic plots
- Analytical model
- Analytical case
- RTA
- Non-linear regression
- Decline curve analysis
- Type wells

Production interpretation

- Rate transient diagnostic plots
  - Rate transient diagnostic plot 1
  - Rate transient diagnostic plot 2
- RTA
  - RTA interpretations
    - RTA interpretation 1
- Non-linear regression
  - Non-linear regression 1

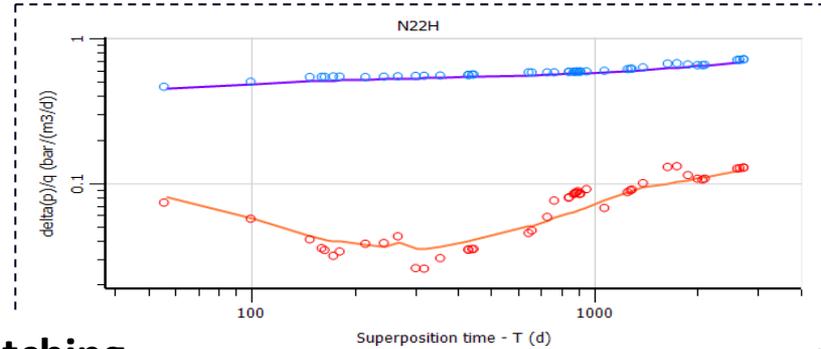
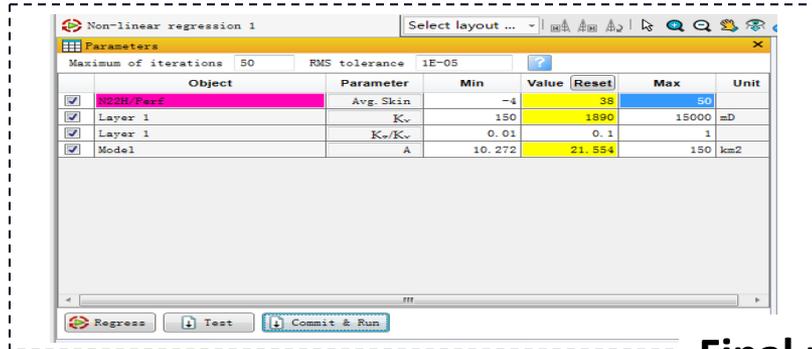
Source	Flow regime	Use	Kh (mD)	S	A (acre)	Re (m)	STOIP $10^6 \text{ sm}^3$
Model			2890	38	5447.1	2347.539	754.84



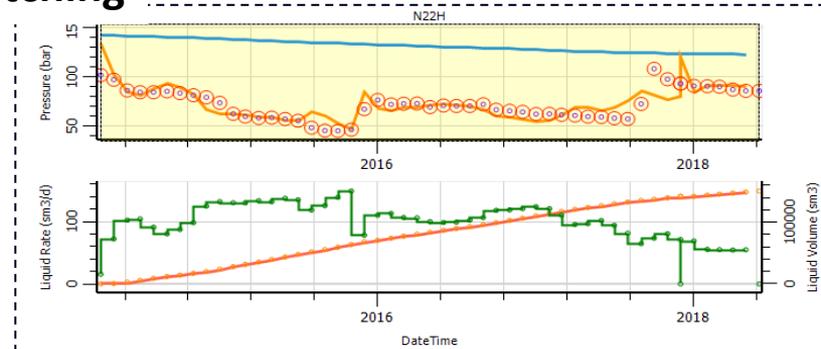
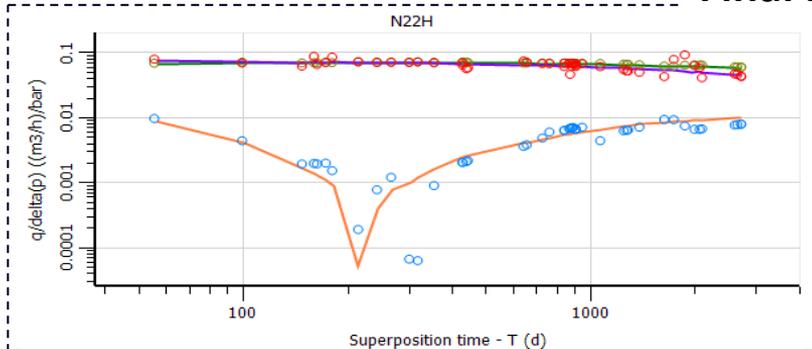


# 1、 Production transient analysis of single well

We used these interpreted parameters to modify the geological model.



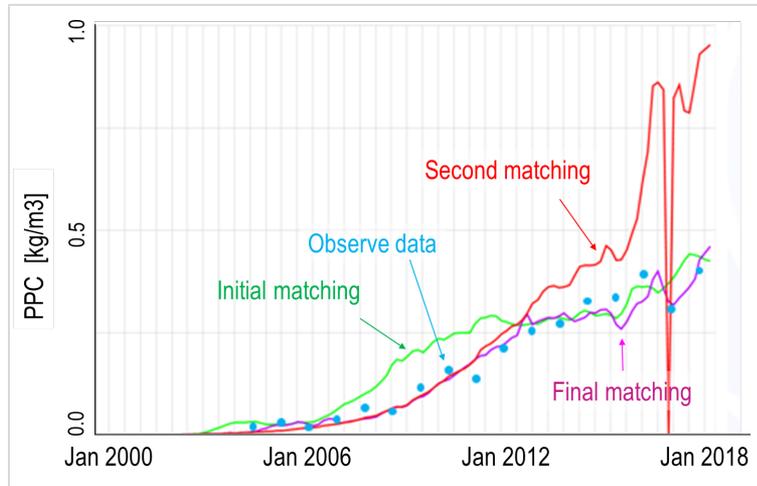
Final matching



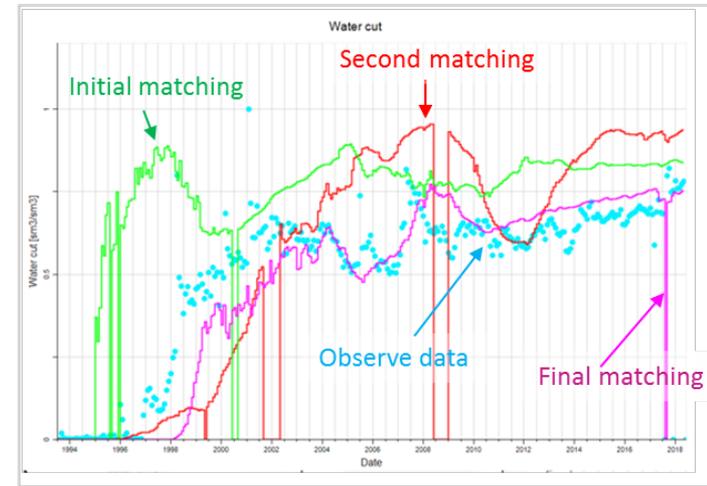


## 2、 Polymer production concentration analysis of well groups

Since there are 24 polymer injection wells in the south area, polymer concentration monitoring was carried out in 89 oil production wells. we matched the breakthrough time and concentration of polymers to help to improve the matching accuracy.



Polymer production concentration matching



water cut matching



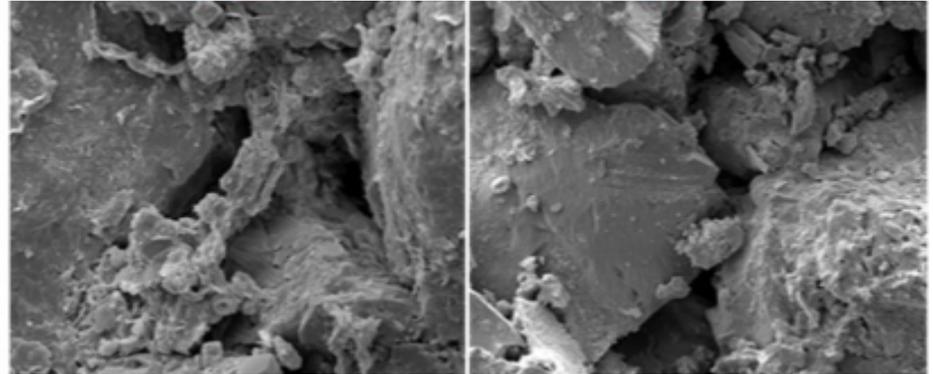


### 3、 Reservoir property time-variation

For water flooding oilfields, both the lab experiments and field practices have proved that the physical properties of water flooding reservoirs would be altered due to the washing of injected water. This condition has not aroused enough attention.



Sediment produced from underground with oil together



Microscopic pore structure changes before and after water flooding  
(by Electron Microscopic Scanning)



# 3、 Reservoir property time-variation

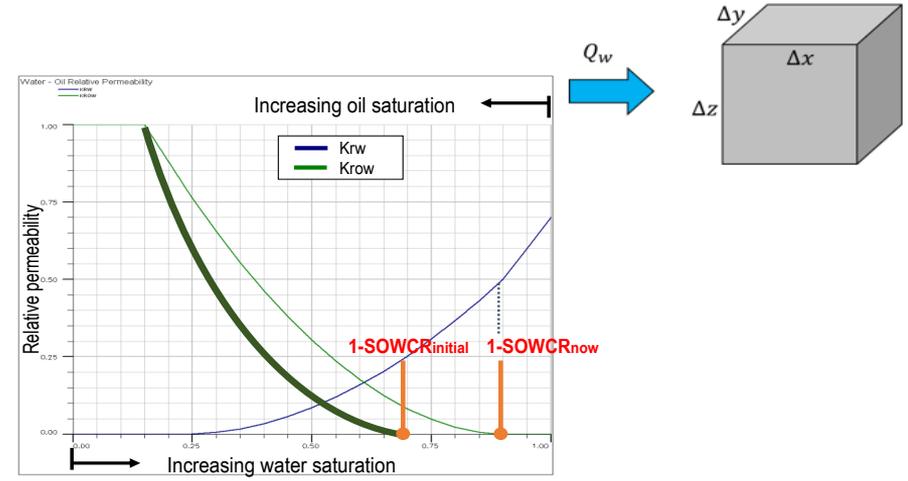
The screenshot shows a Python script in an IDE. The script defines a custom variable 'Revenue' and uses Depogrid to access well properties. A context menu is open over the script, showing methods for property measurement.

```

### This is the processing part where the script parses the cells in the grid ###
### Includes these as part of a Cell selection family on which properties can be read ###
time=FieldManagement().currentTime.set(0, days)
new_MT=time/1000
if new_MTold==None:
    nameCellEid+SOWCR="CellEid+SOWCR" *str(i)
    CellPropertyEid+(nameCellEid+SOWCR).family.set(["ROCK_COMPACTON_REGION"])
    CellPropertyEid+(nameCellEid+SOWCR).Name.set(["ROCKNUM_1"])
    CellPropertyEid+(nameCellEid+SOWCR).Property.set(["RESIDUAL_OIL_SATURATION_TO_WATER"])
    CellPropertyEid+(nameCellEid+SOWCR).Expression.set(("MAX(0, 0.6, 0.152-0.08*WATER_FLOW_DENSITY_THROUGH_CML/(150*WATER_FLOW_DENSITY_THROUGH_CML)"))
    CellPropertyEid+(nameCellEid+SOWCR).ProcessingOrder.set("PROCESS_IN_ORDER")
    CellPropertyEid+(nameCellEid+SOWCR).TargetCell@filter.set("ALL")
    CellPropertyEid+(nameCellEid+SOWCR).InsetValueBehaviour.set("COPY")
    nameCellEid+SOWCR="CellEid+KRW" *str(i)
    CellPropertyEid+(nameCellEid+SOWCR).family.set(["ROCK_COMPACTON_REGION"])
    CellPropertyEid+(nameCellEid+SOWCR).Name.set(["ROCKNUM_1"])
    CellPropertyEid+(nameCellEid+SOWCR).Property.set(["MAX_WATER_RELATIVE_PERM"])
    CellPropertyEid+(nameCellEid+SOWCR).Expression.set(("MAX(0, 0.7, 1-0.08*WATER_FLOW_DENSITY_THROUGH_CML/(50*WATER_FLOW_DENSITY_THROUGH_CML)"))
    CellPropertyEid+(nameCellEid+SOWCR).ProcessingOrder.set("PROCESS_IN_ORDER")
    CellPropertyEid+(nameCellEid+SOWCR).TargetCell@filter.set("ALL")
    CellPropertyEid+(nameCellEid+SOWCR).InsetValueBehaviour.set("COPY")
    print("Days:", time, "Modified Time:", j)
    j+=1
old_MT=new_MT

```

**EPS\_fm\_edits.ixf**



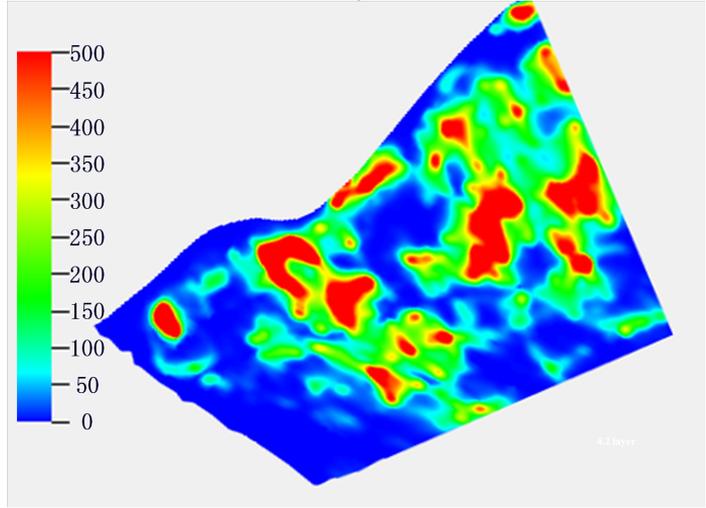
- $S_{or}$   $S_{or}$  (Residual oil to water) (SOWCR)
- $W_{c}$  Water flow cumulative through cell per pore volume (FLWPVT)
- $W_{r}$  Water flow rate through cell per pore volume (FLWPVR)
- $W_{d}$  Water flow density cumulative through cell (FLWATT)
- $V_{w}$  Water flow density rate through cell (FLWATR)



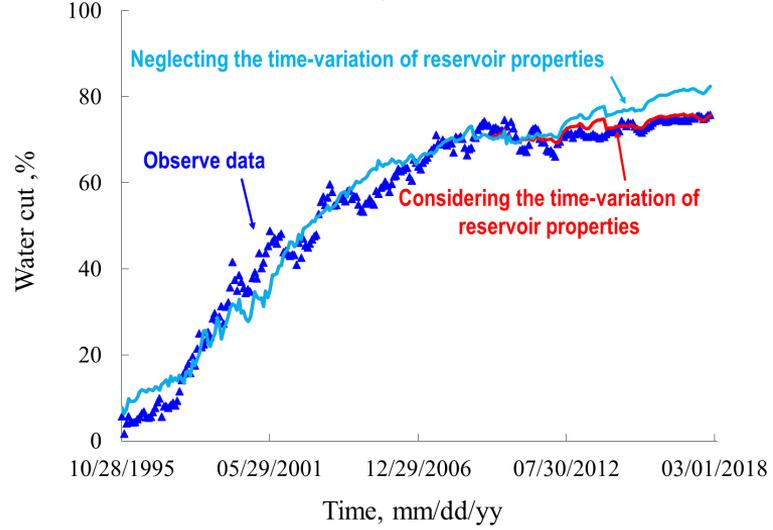
### 3、 Reservoir property time-variation

Petrel RE & INTERSECT are applied to help improve the full field model history matching quality with the compatibility to simulate the time-varying reservoir properties. As a result, the field water cut history matching accuracy was improved by 10%.

Pore volume of injected water



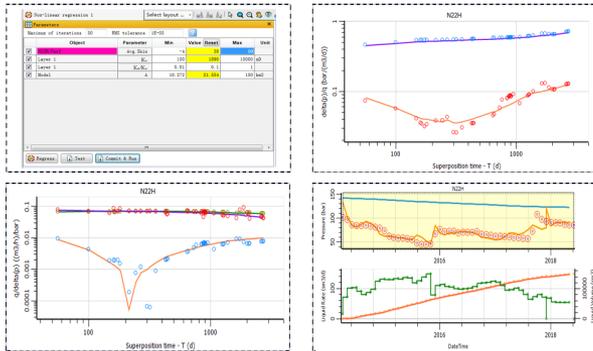
Field, Water cut



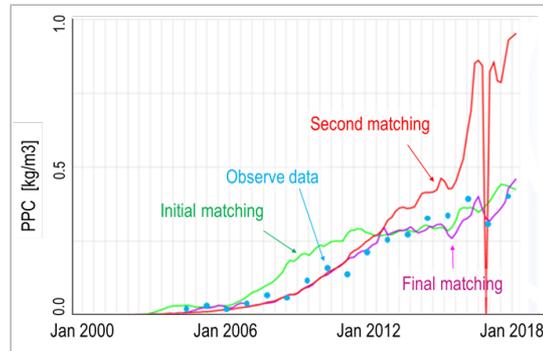


# Summary

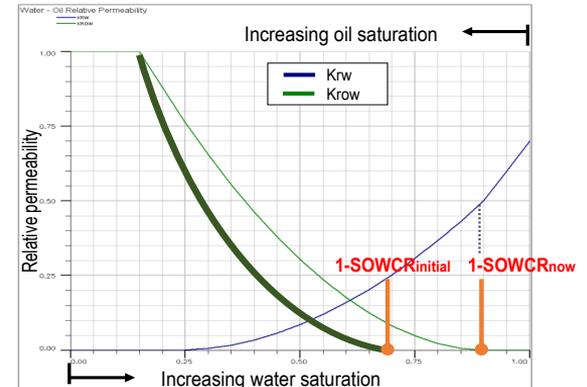
The new technologies can provide reference for the history matching of other high water cut oilfields in Bohai Bay. With the help of such techniques, the accuracy of the full field simulation model was greatly improved and the remaining oil was more accurately described, which helps reservoir engineers make more reasonable decisions on waterflood management such as injection-production parameters adjustment and high potential adjustment wells placement in high water cut stage.



Production transient analysis of single well



Polymer production concentration matching



# Acknowledgements



**To Schlumberger & CNOOC:**

Thank you for this precious opportunity!

**To Schlumberger:**

Thank you for your rapid, comprehensive and detailed technical guidance over years!

**To you:**

Thank you for your listening!

**Thank you !**



**CNOOC LTD TIANJIN**