WELL TEST ANALYSIS IN PRACTICE

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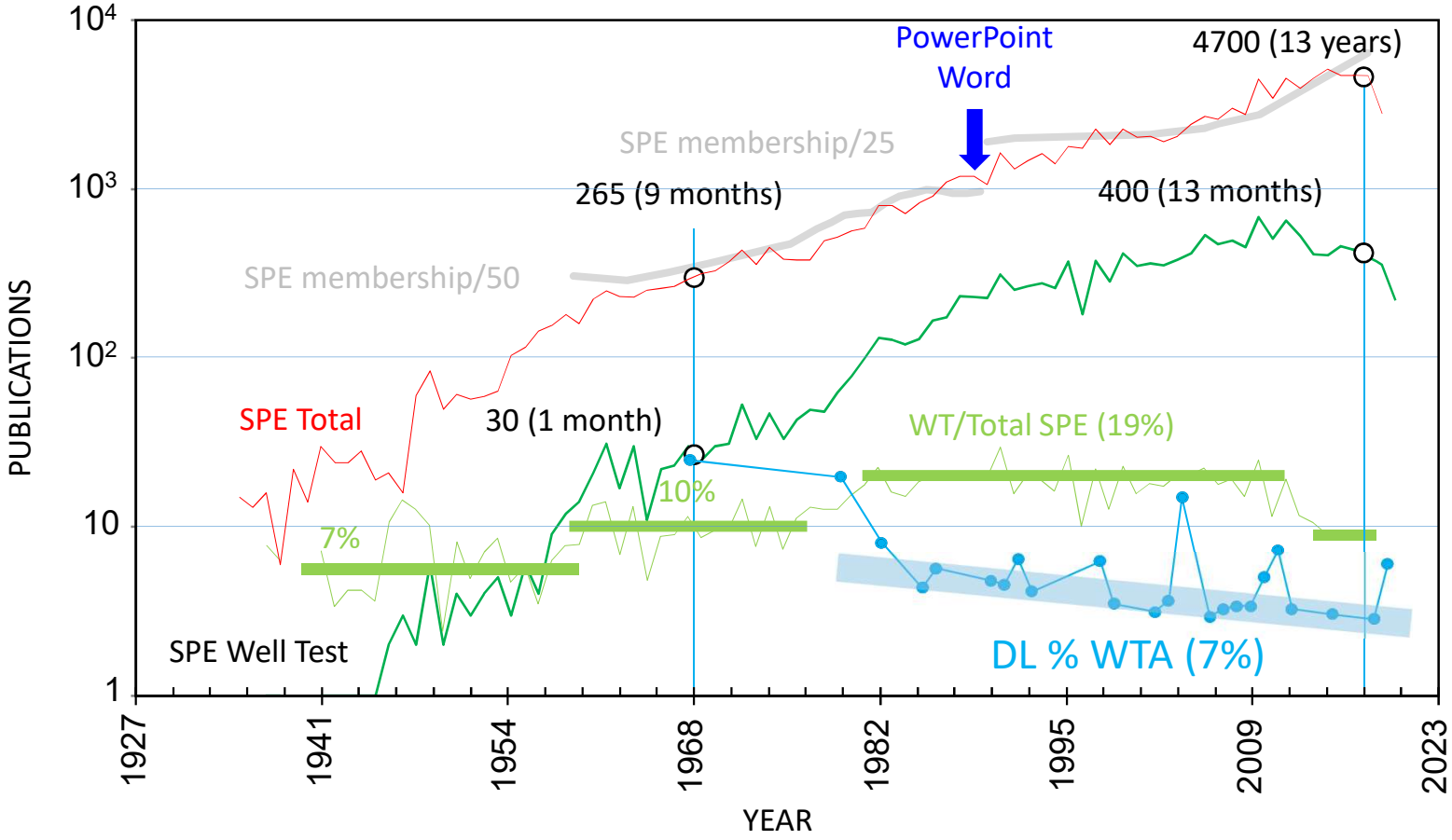
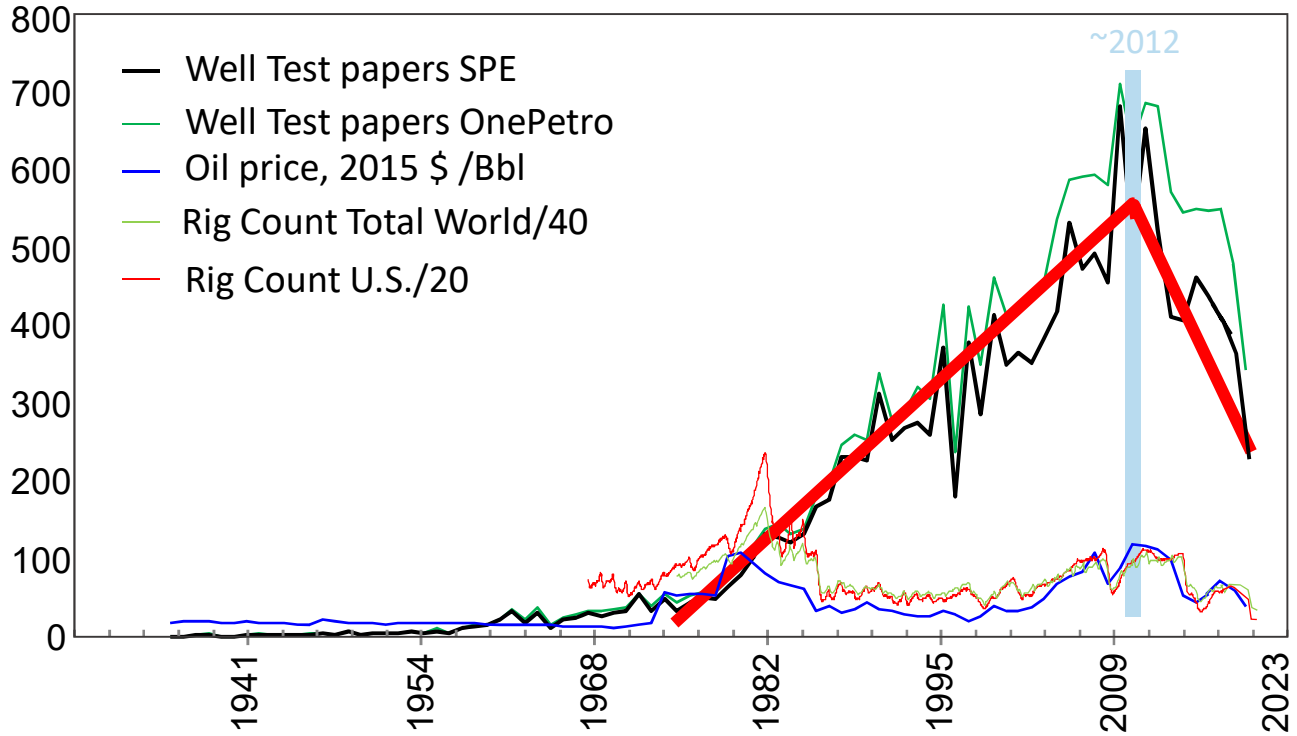
BAUERBERG KLEIN
TRAINING & CONSULTING

WHY A BRIEF SUMMARY:

Publication inflation

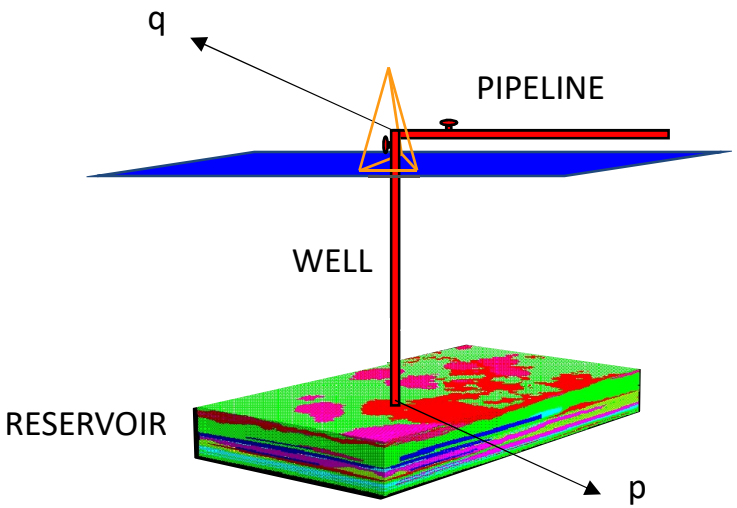


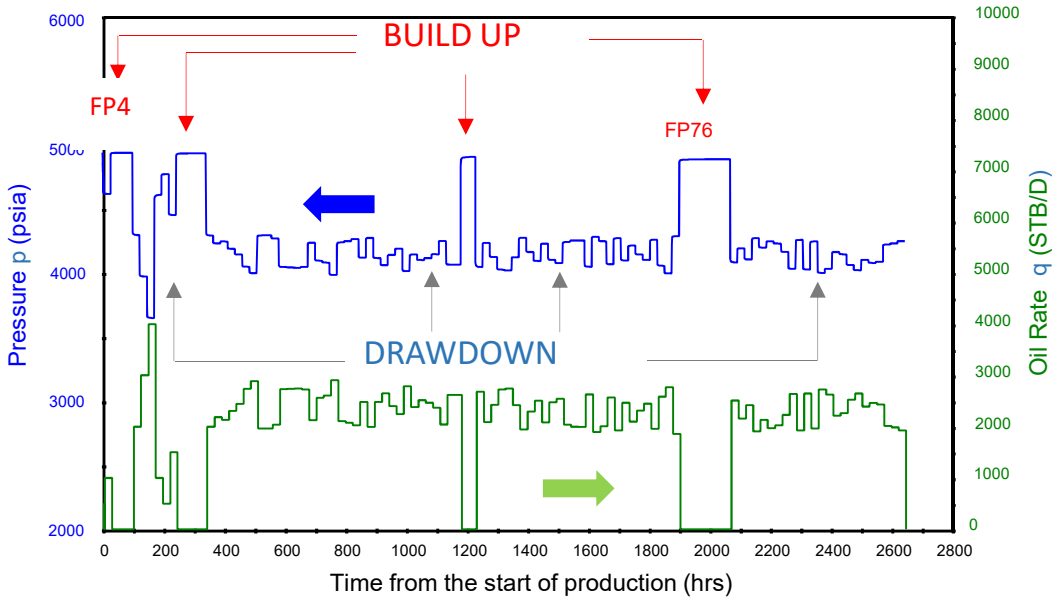
WELL TEST PUBLICATION INFLATION



WHAT IS WELL TEST ANALYSIS (WTA)?

- It is the extraction of information from pressure and rate data measured in a producing well





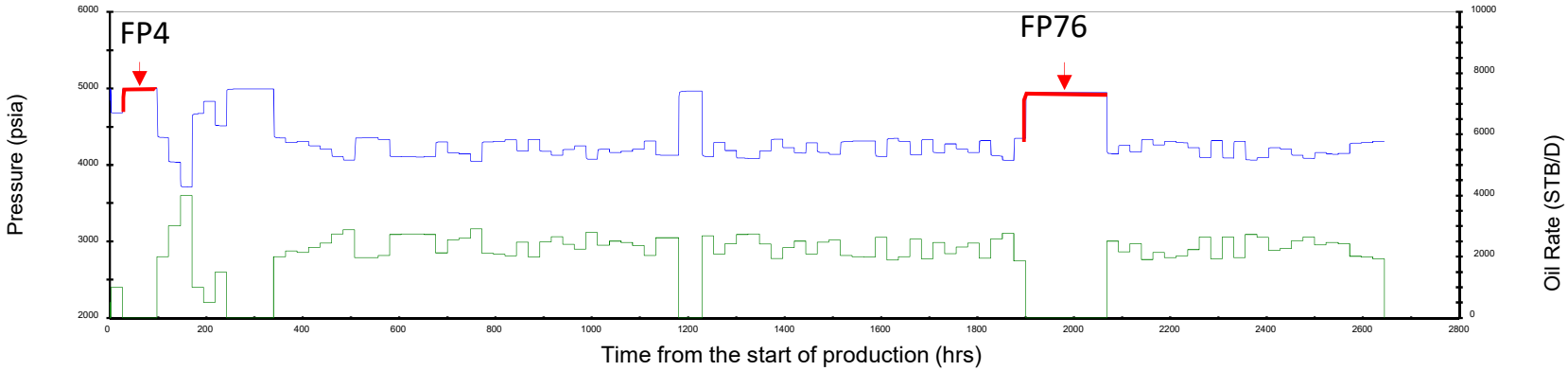
WHY DO WE DO WELL TEST ANALYSIS?

- **To obtain information on the well**
  - Permeability
  - Well damage or stimulation (skin effect)

- **To obtain information on the reservoir**
  - Fluid
  - Average reservoir pressure
  - Reservoir heterogeneities
  - Reservoir hydraulic connectivity
  - Distances to boundaries

HOW DO WE DO WELL TEST ANALYSIS?

- We select a period at constant rate (usually, a build up)



- We plot some function of pressure vs. some function of time
- We try to identify flow regimes (radial, linear, spherical,…)
- We include these flow regimes into an interpretation model which can reproduce the pressure given the rate (or vice-versa)
- We verify that the interpretation model is consistent with all other information (geology, seismic, cores, logs, completion, etc…).

WTA: the Good

WTA allows to assess well condition and to estimate reservoir parameters

Over the last 50 years, new WTA techniques have been developed which give **more** and **better** results, and more **confidence** in those results

Nowadays, WTA potential contribution to reservoir knowledge has never been greater

Only WTA provides reservoir **hydraulic connectivity**

Well test analysis is the technique of choice in **arbitrations**

WTA: the Bad

Interest and knowledge in WTA seems to be fading

One reason may be that the latest new techniques (deconvolution) are perceived as **too complex**

This fear of complexity is compounded by WTA being often taught, wrongly, as "basic" and "advanced" which is mistaken for "practical (for everybody)" and "esoteric (for experts only)"

Reservoir engineers tend to believe they know how to interpret well tests as a side benefit of knowing how to do simulation

The Big Crew Change: WTA experts educated by Ramey at Texas A&M and Stanford, or trained in Flopetrol/Schlumberger during the heyday of WTA have retired or are about to retire, with no obvious replacements

WTA: the Ugly

Buttonology instead of domain expertise: engineers often believe software will do the interpretation for them

Resistance to changes: commercial software vendors are often forced by their clients to include techniques which are obsolete or have been proven wrong over 40 years ago

Pressure from operators: Regular well testing is no longer mandatory in many oil provinces

Short term focus: In Unconventionals, data acquisition in general (and well testing) is considered unnecessary cost

Economic constraints: Formal WTA teams have disappeared in many oil companies following the latest oil price drop

The challenge

"The picture actually looks very gloomy.

It is not because inexperienced hands ask the same questions about the same old problems as 30 years ago,

but **because they get the same answers as 30 years ago**,

even though our industry has advanced tremendously and gotten much better answers and solutions,

but this knowledge that resides in repositories and in the heads of the experienced and knowledgeable older experts is not being transmitted effectively."

The Big Crew Change: Knowledge Loss or Management of Change? Robert Mathes http://oilpro.com/post/22284/big-crew-change-knowledge-loss-management-change

The challenge (cont'd)

"Partially, we are to be blamed for the decline of the importance of testing.

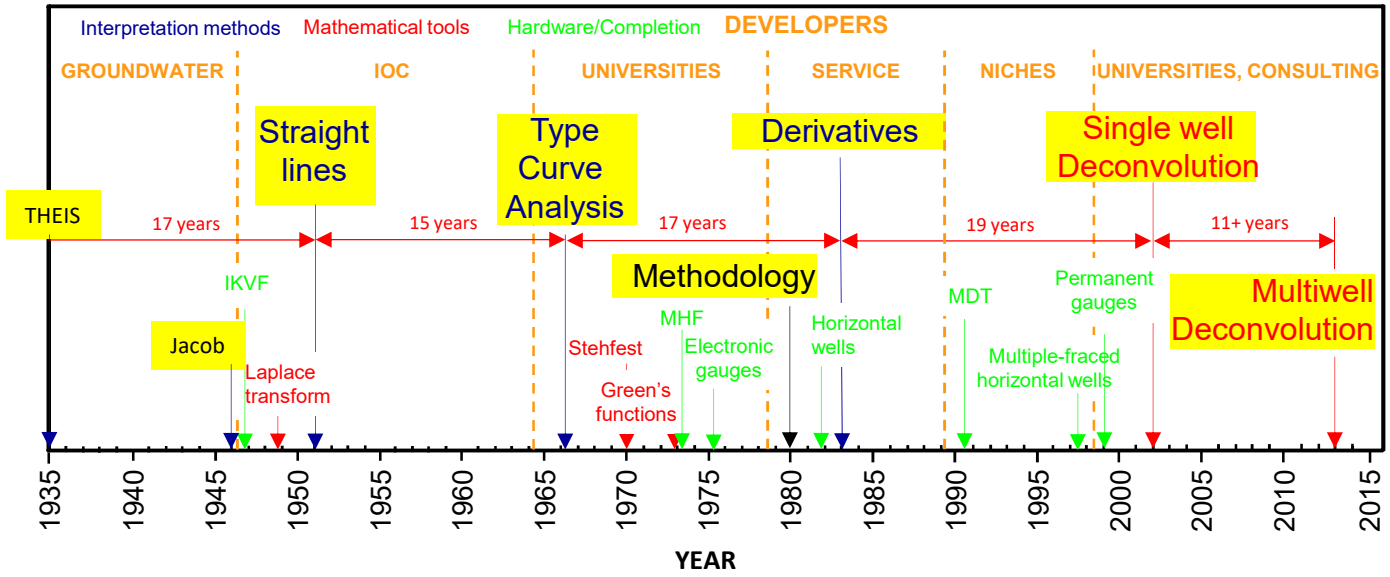
The SPE testing literature is so much polluted that it is difficult to find relevant papers.

Many interpretations (80%) even in published papers are incorrect.

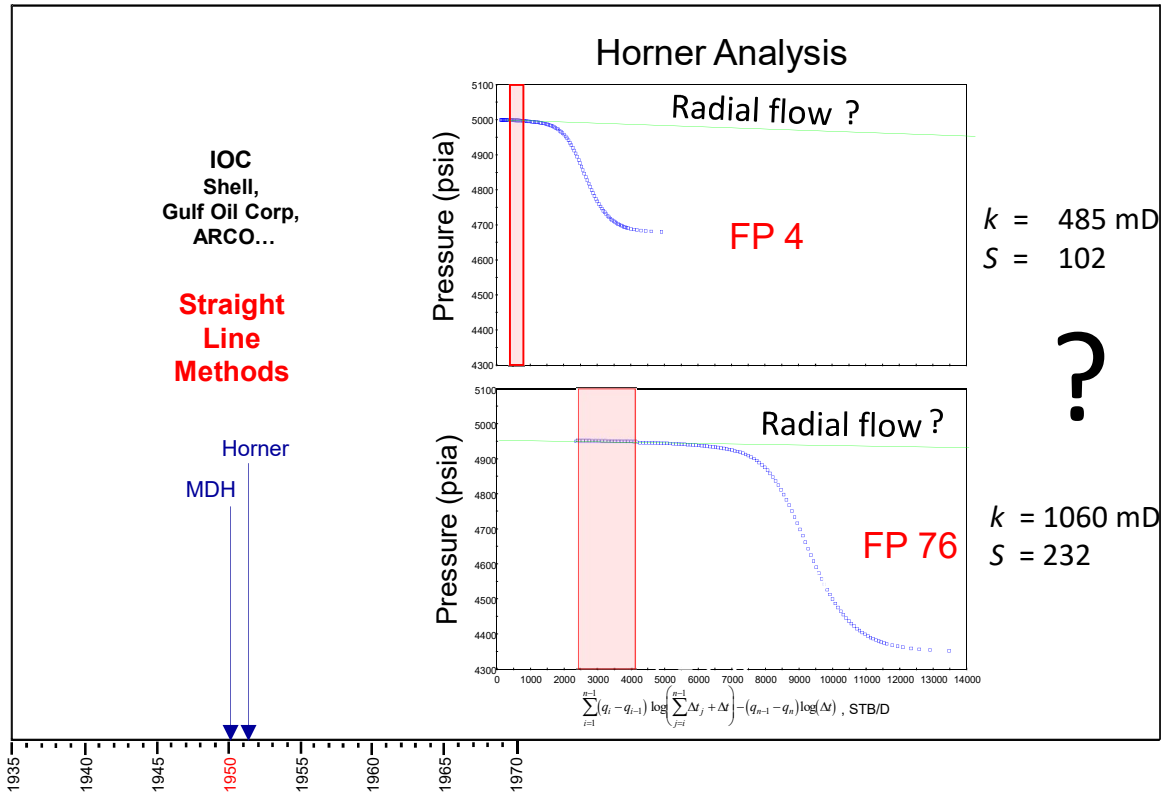
And MDT has replaced the Testing fluid sampling."*

Fikri Kuchuk (Emeritus Fellow Geoscientist, Slb), personal communication

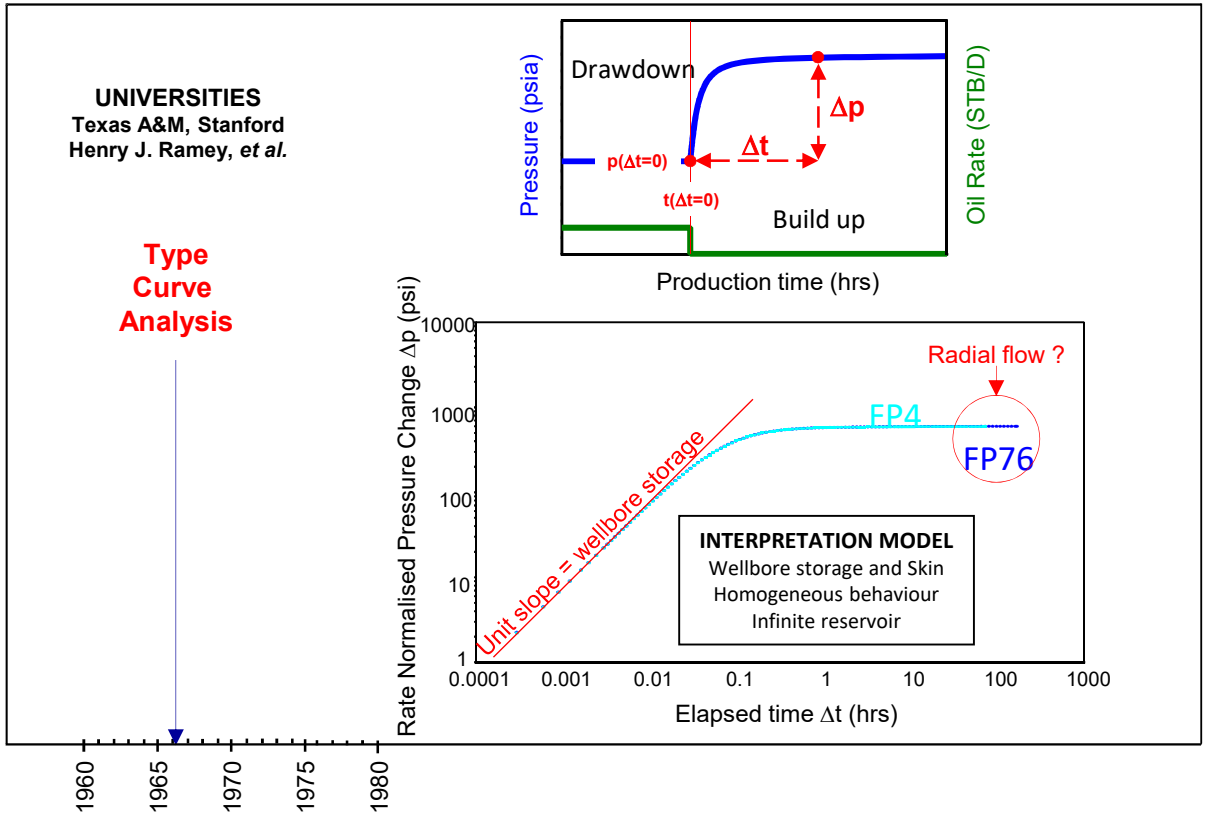
WELL TEST ANALYSIS MILESTONES



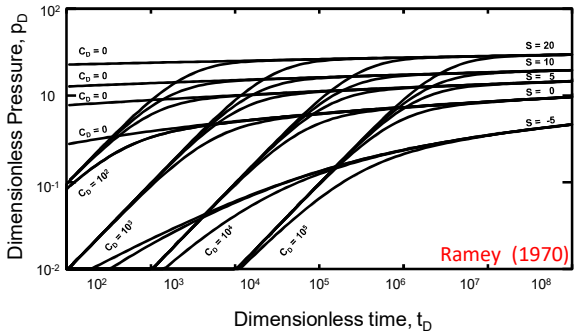
STRAIGHT LINE METHODS

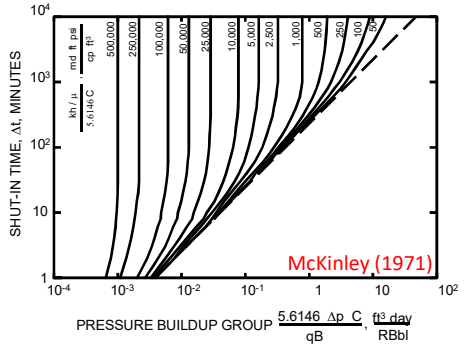


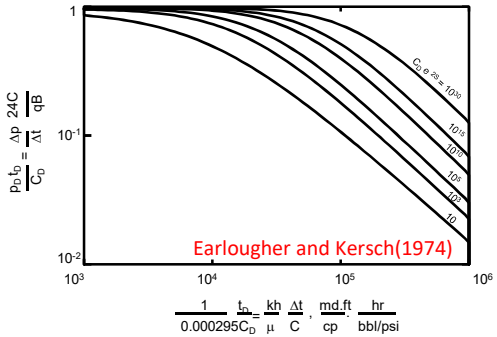
PRESSURE TYPE CURVE ANALYSIS

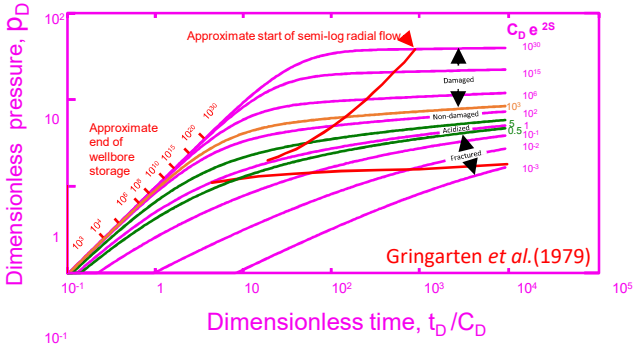


PUBLISHED TYPE CURVES









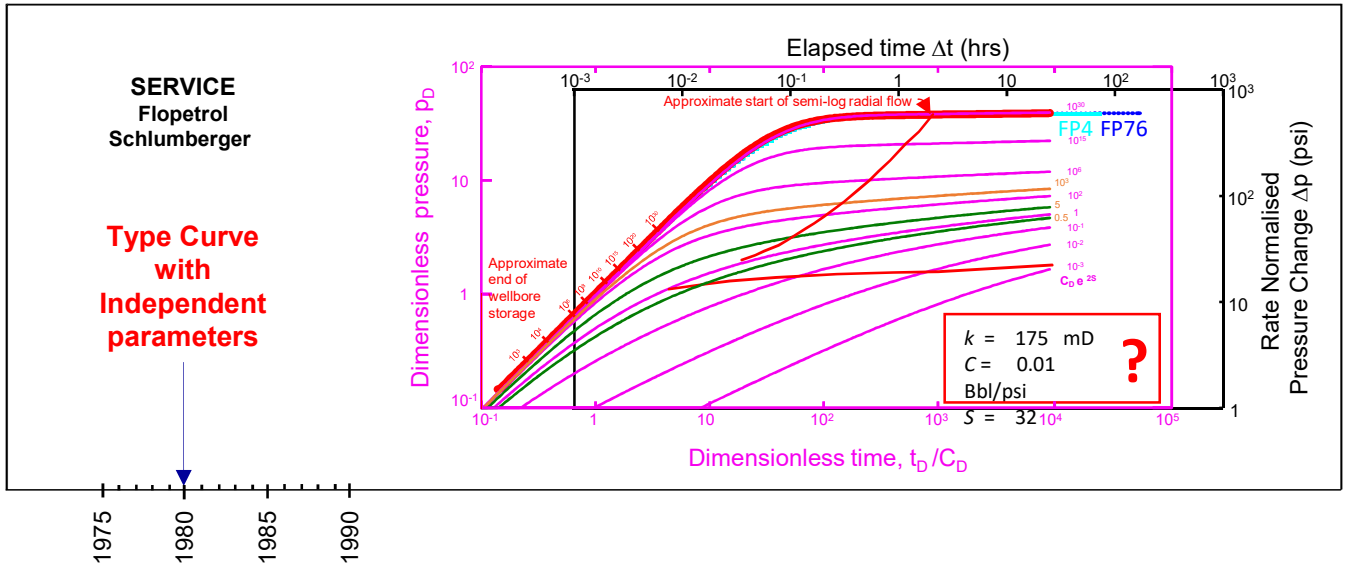
Same interpretation model

Different type curves

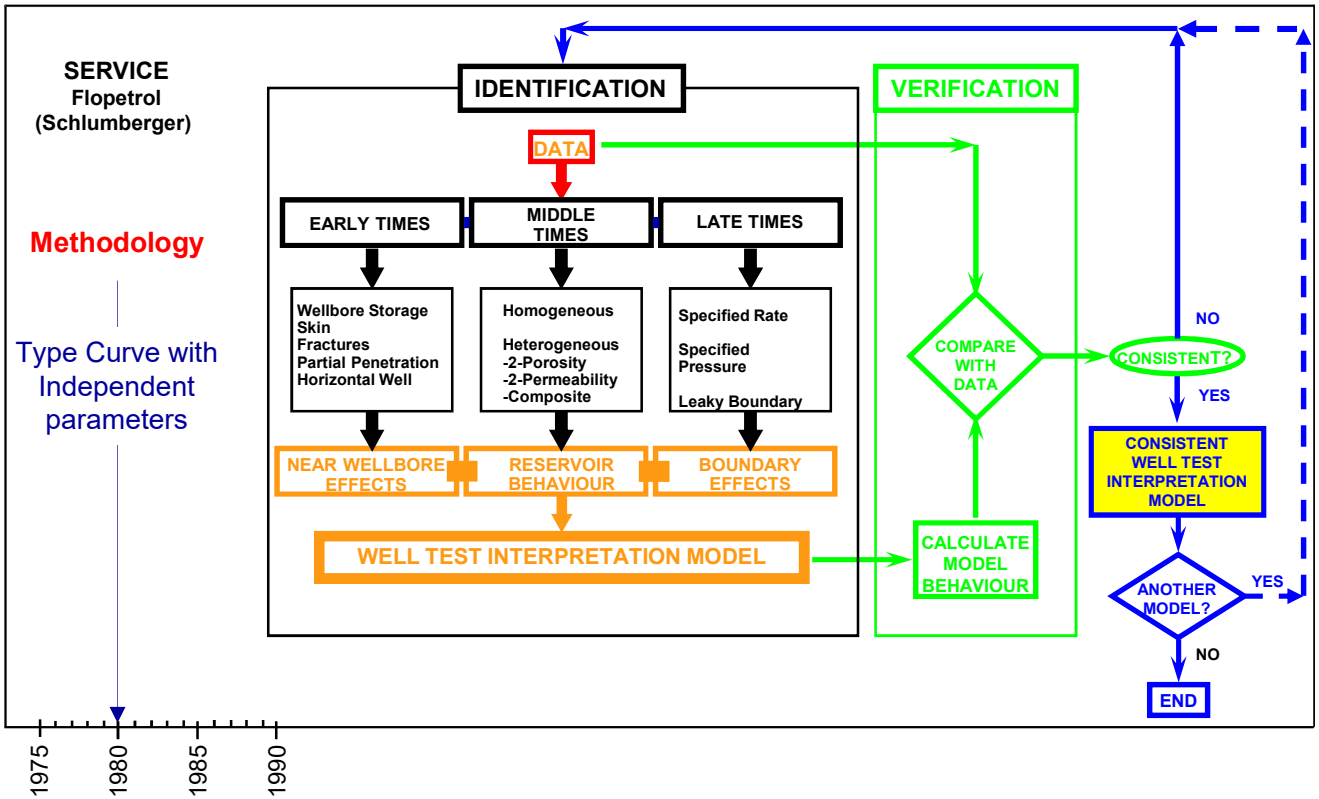
Different results

SPE 209629 • A short summary of seventy years of well test analysis • Alain C. Gringarten

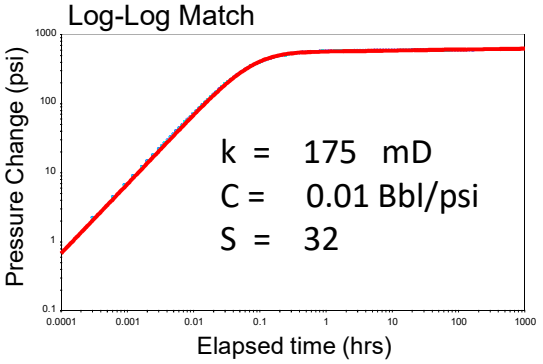
PRESSURE TYPE CURVE ANALYSIS

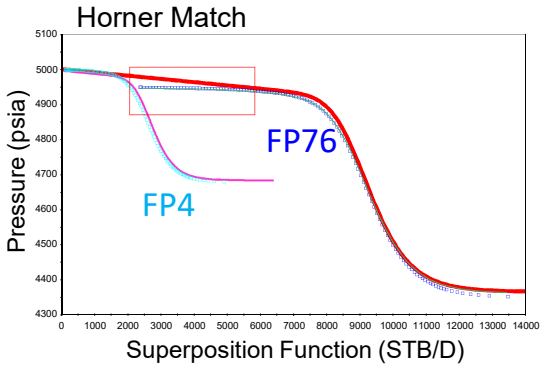


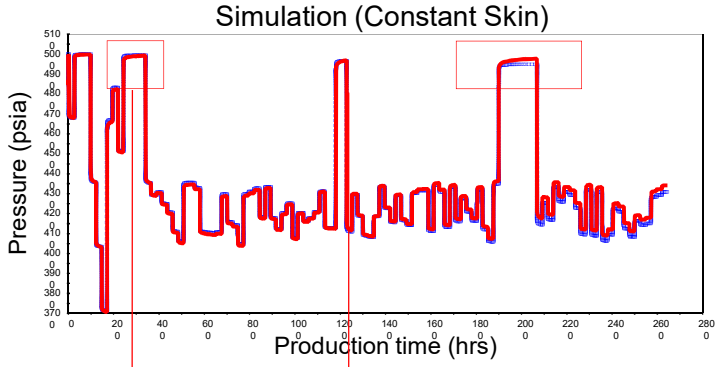
METHODOLOGIE (WORKFLOW)

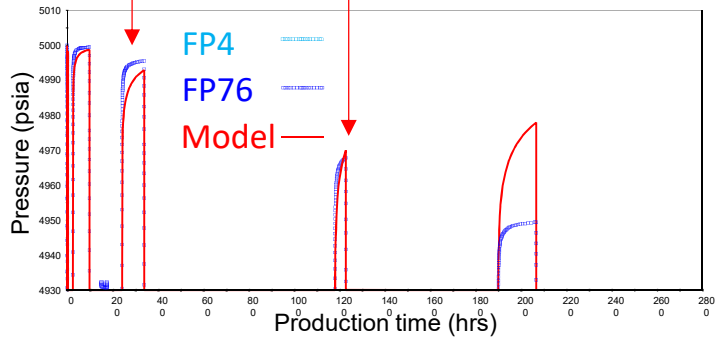


VERIFICATION: ~~Wellbore storage and Skin, Heterogeneous behaviour, Infinite reservoir~~

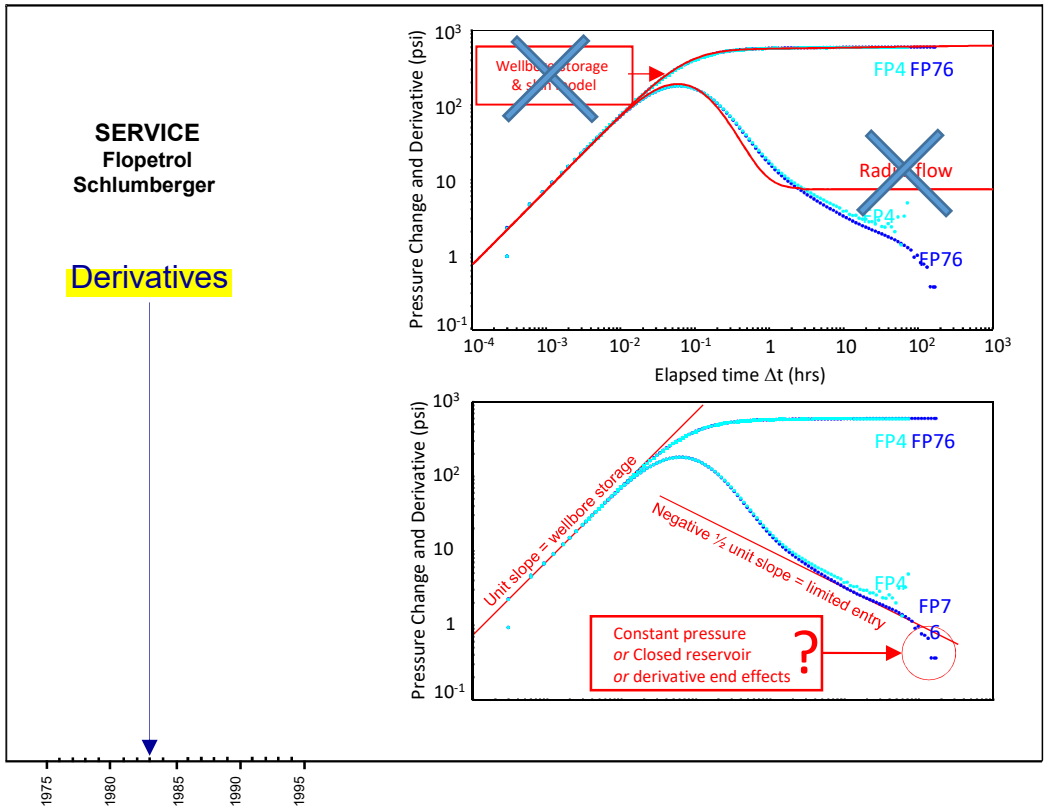




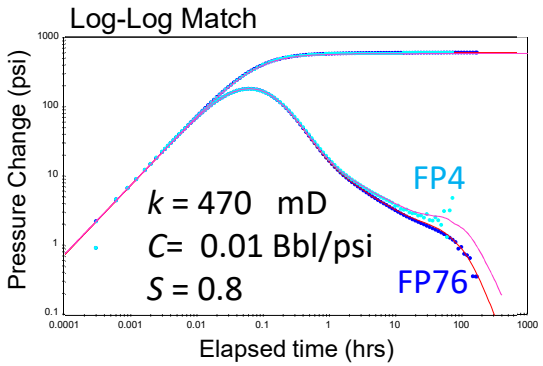


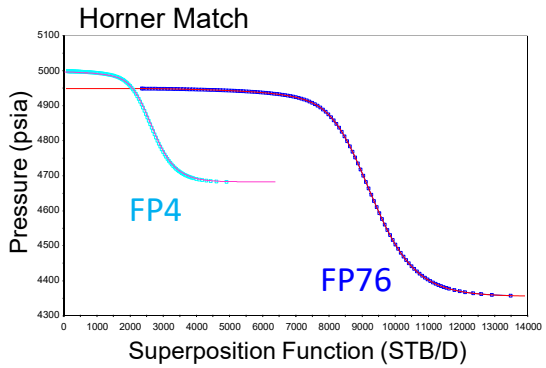


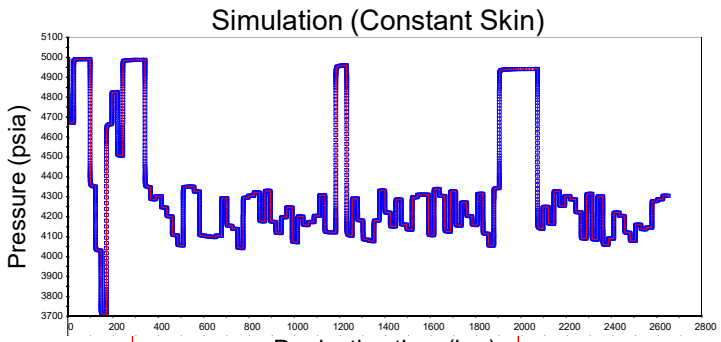
PRESSURE DERIVATIVE ANALYSIS

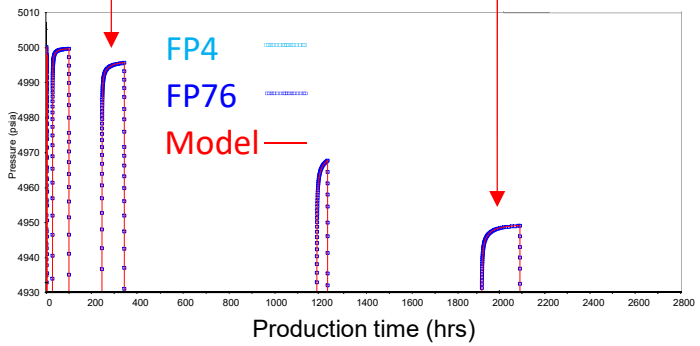


VERIFICATION: Wellbore storage and Skin, Limited entry, Homogeneous behaviour, Closed reservoir







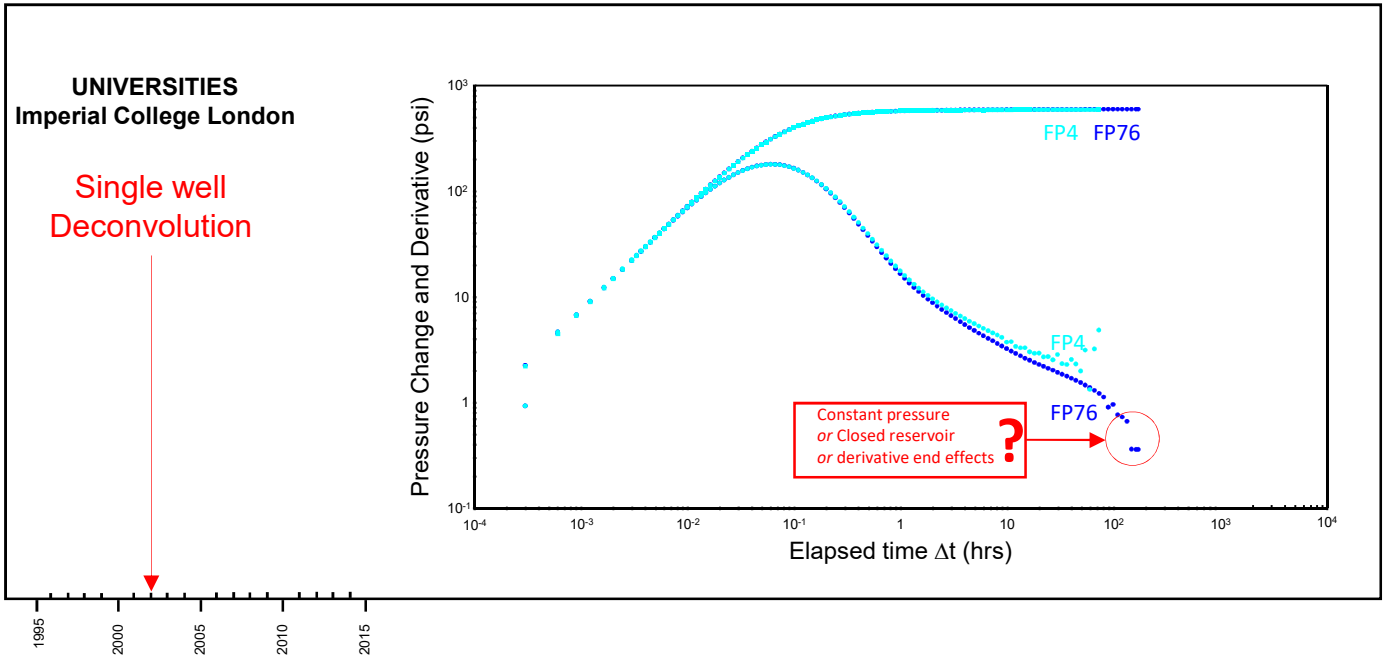


WELL TEST ANALYSIS RESULTS

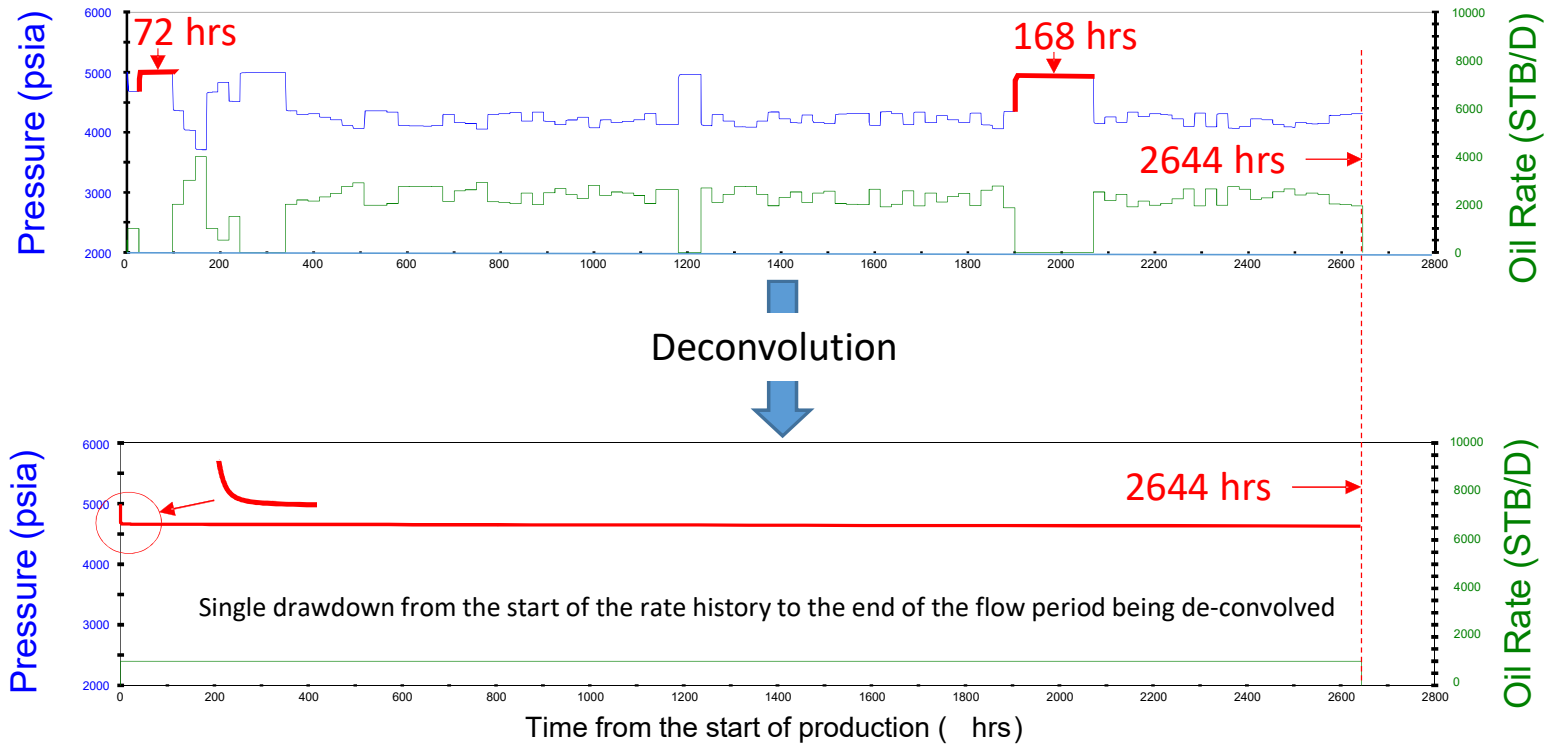
MODEL	a well with wellbore storage and skin and limited entry in a closed homogeneous reservoir

Parameter		Analysis		Design	Difference	Typical field uncertainty
Initial pressure	(pav)i	5000	psia	5000	0%	± 5 psia
Horizontal permeability	k(xy)	470	mD	500	-6%	± 20%
Vertical permeability	k(z)	0.54	mD	0.5	8%	± 20%
Wellbore storage coefficient	C	0.01	bbl/psi	0.01	0%	± 20%
Penetration ratio	hw/h	0.06		0.05	20%	± 20%
Wellbore skin effect	S(w)	0.8		0	+ 0.8	± 0.5
Reservoir area	A	$6\ 10^{7}$	ft^2	$6\ 10^{7}$	0%	± 30%

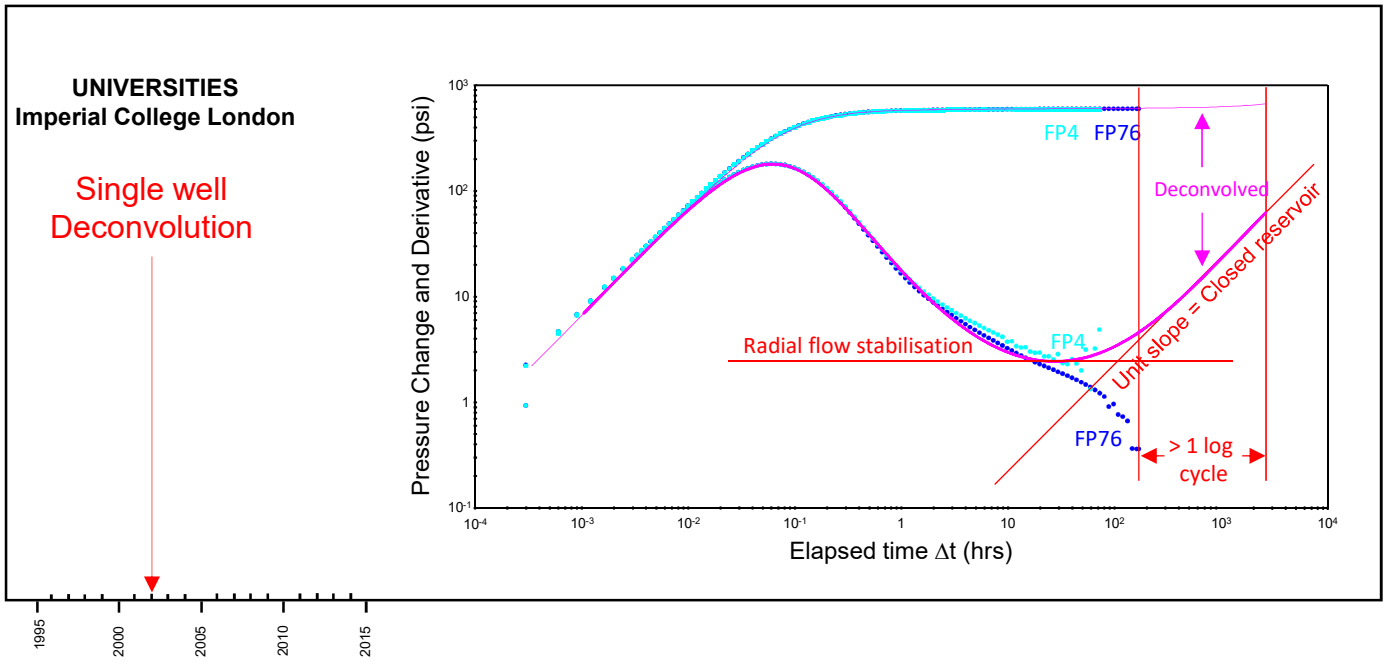
SINGLE WELL DECONVOLUTION



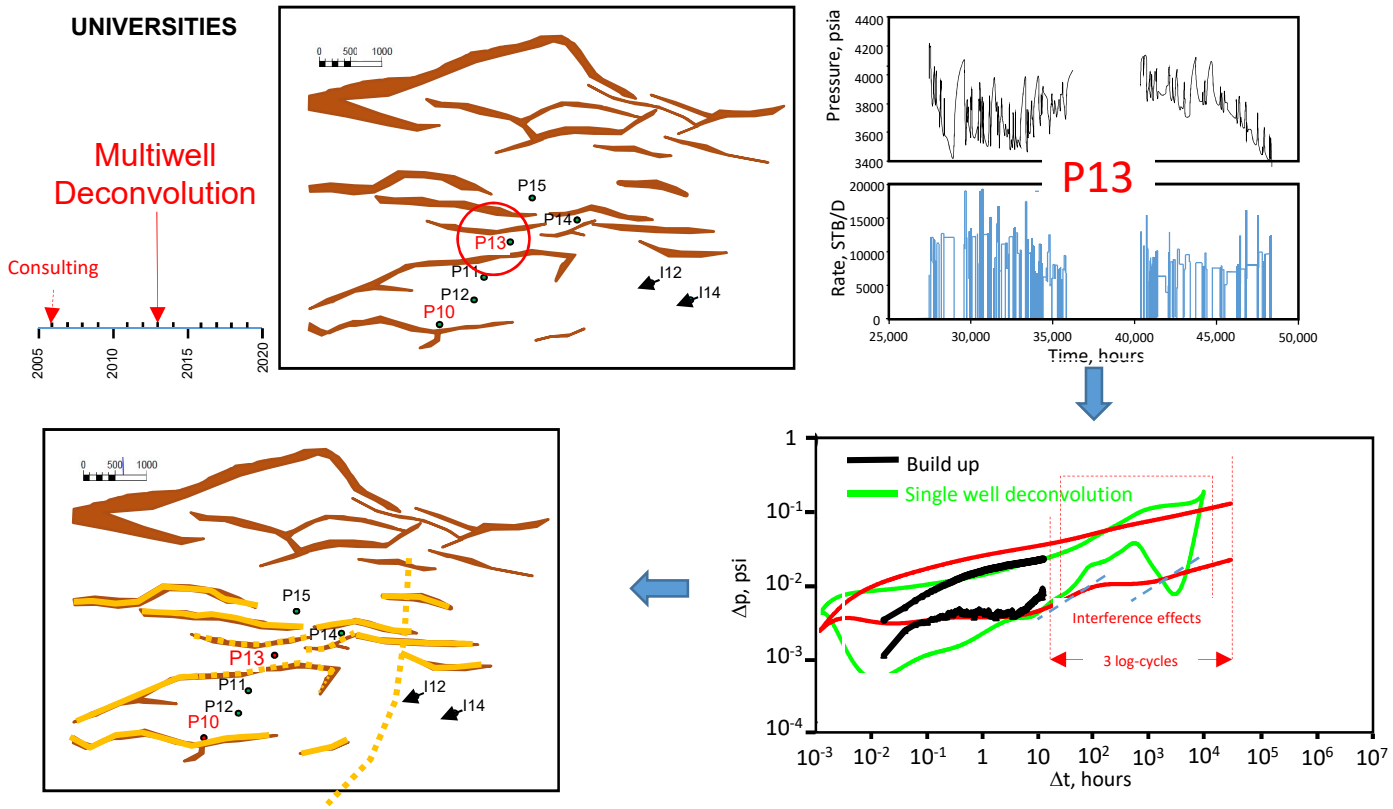
SINGLE WELL DECONVOLUTION



SINGLE WELL DECONVOLUTION



MULTIWELL DECONVOLUTION



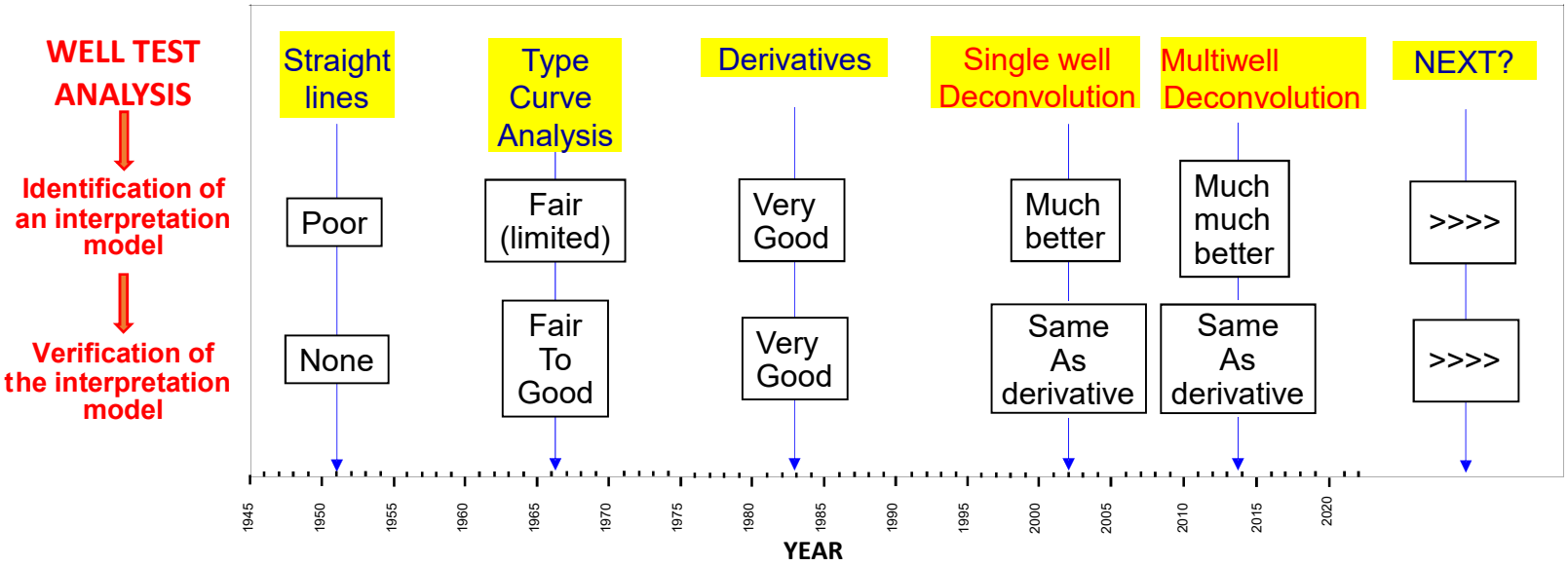
WHERE WE ARE

- Well test analysis has improved immensely since straight lines and pressure log-log analysis, and even derivative log-log analysis
- Methodology makes it repeatable and easy to learn
- Derivatives and deconvolution make well test analysis a reliable tool for reservoir characterization

WTA Value = Identification + Verification

	ANALYSIS METHOD	IDENTIFICATION	VERIFICATION
1950's	**Straight lines**	Poor	None
1970's	**Pressure Type Curves**	Fair (limited)	Fair to Good
1980's	**Pressure Derivative**	Very Good	Very Good
2000's	**Deconvolution**	Much better	Same as derivative
2010's	**Multiwell deconvolution**	>>	>>
↓	**NEXT ?**	>>>	>>>

IN SUMMARY


WELL TEST ANALYSIS
Identification of an interpretation model
Verification of the interpretation model
Straight lines
Poor
None
Type Curve Analysis
Fair (limited)
Fair To Good
Derivatives
Very Good
Very Good
Single well Deconvolution
Much better
Same As derivative
Multiwell Deconvolution
Much much better
Same As derivative
NEXT?
>>>>
>>>>
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
YEAR

But

Understanding of WTA still required

Derivatives must be calculated correctly

Deconvolution requires interpretation

WTA requires other knowledge (geology, etc…)

AND concepts proven wrong 30 years age still used

MDH instead of Horner

Horner instead of superposition

Horner equivalent production time

Ramey's one and ½ cycle rule

Different start of radial flow in Drawdowns and Build ups

Derivative plotted vs. Agarwal effective time

Uniform flux vs. infinite conductivity solution

etc……