A Road Map for the Identification and Recovery of By-passed Pay GCAPaul F. WorthingtonGCAGaffney, Cline & AssociatesGCA To maximise Reserves, operators are searching for untapped hydrocarbons within mature fields

What is **By-passed Pay?**

By-passed pay relates to movable hydrocarbons that cannot be drained by any existing well and will be left behind in the subsurface if nothing is done. This definition is set in the context of conventional reservoirs. It excludes residual hydrocarbons, which are trapped in the reservoir.

Beyond economic considerations, pay has usually been by-passed where the degree of reservoir complexity was not fully evident at the time of formulating a development plan. As this explanation can be applied to virtually every reservoir, it follows that by-passed pay must exist in many fields. Moreover, its exploitation carries a lower risk and can be more cost effective than standard oilfield operations.

How Do We Recognise **By-passed Pay?**

- Changing commercial situation Commodity prices, contractual terms
- Advancing technology Effective stimulation practices
- Reservoir performance Vis-à-vis history-matched simulator
- Material balance studies In light of estimated ultimate recovery
- (Interwell) geophysics 3D/4D seismic and electromagnetics
- Well performance Relative to 3D reservoir model
- Movement of fluid contacts Observed vs. predicted
- Time-lapse/through-casing well logging Undepleted intervals
- Re-evaluate older wells in light of new understanding Discover previously 'hidden' pay

	By-passed
 Scenario D Hydrocarbon occurrences were detectable through geoscience but not recognised, e.g. due to misinterpretation (especially in the presence of faulting) or erroneous depth conversion placing the structure too low Key Messages – Type 2 Carry out a full reservoir appraisal (flanks contribute to volumes, too) Integrate benefits from enhanced workstation technology, better seismic-to-well ties, and advancing reservoir characterisation concepts Promote mid-life acquisition of sharpersensing seismic data Consider the conjunctive use of inter-well geophysical deliverables such as seismic attributes and electromagnetic tomography, especially in complex reservoirs Revise geological concepts to conform with production data Monitor flood front(s) to ascertain their effectiveness Remember that reservoirs become more complex as more data are acquired 	<section-header></section-header>
	 Perform full appraisal Flanks contribute to hydroca Update geoscience model con Perceptions of reservoir conditional

Types of By-passed Pay

There are two types of by-passed pay:

Type '

That which could be produced using an existing identified well, e.g. where a hydrocarbonbearing interval has never been perforated

Type 2

That which requires a side track or a new well in order to capture the Reserves, e.g. unswept hydrocarbon volumes

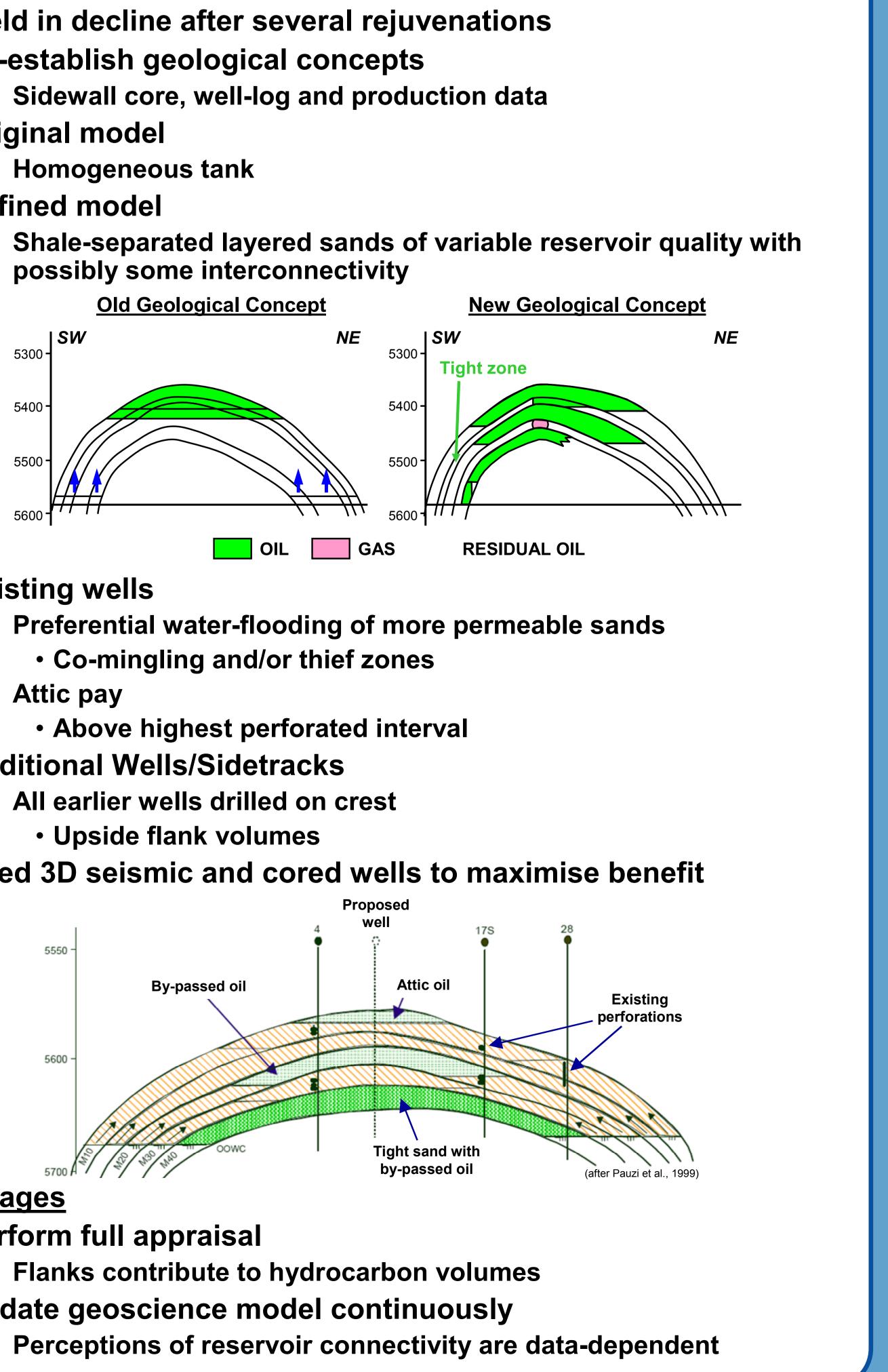
On this basis alone, the term 'by-passed pay' is inappropriate, because pay is a thickness that can only be measured at a wellbore. The phrase 'by-passed hydrocarbons' would be more generally applicable.

Pay – Type 2

nario E

not indicated seismically, rvoir complexity, weak **inadequate spatial**

History 3



Scenario F

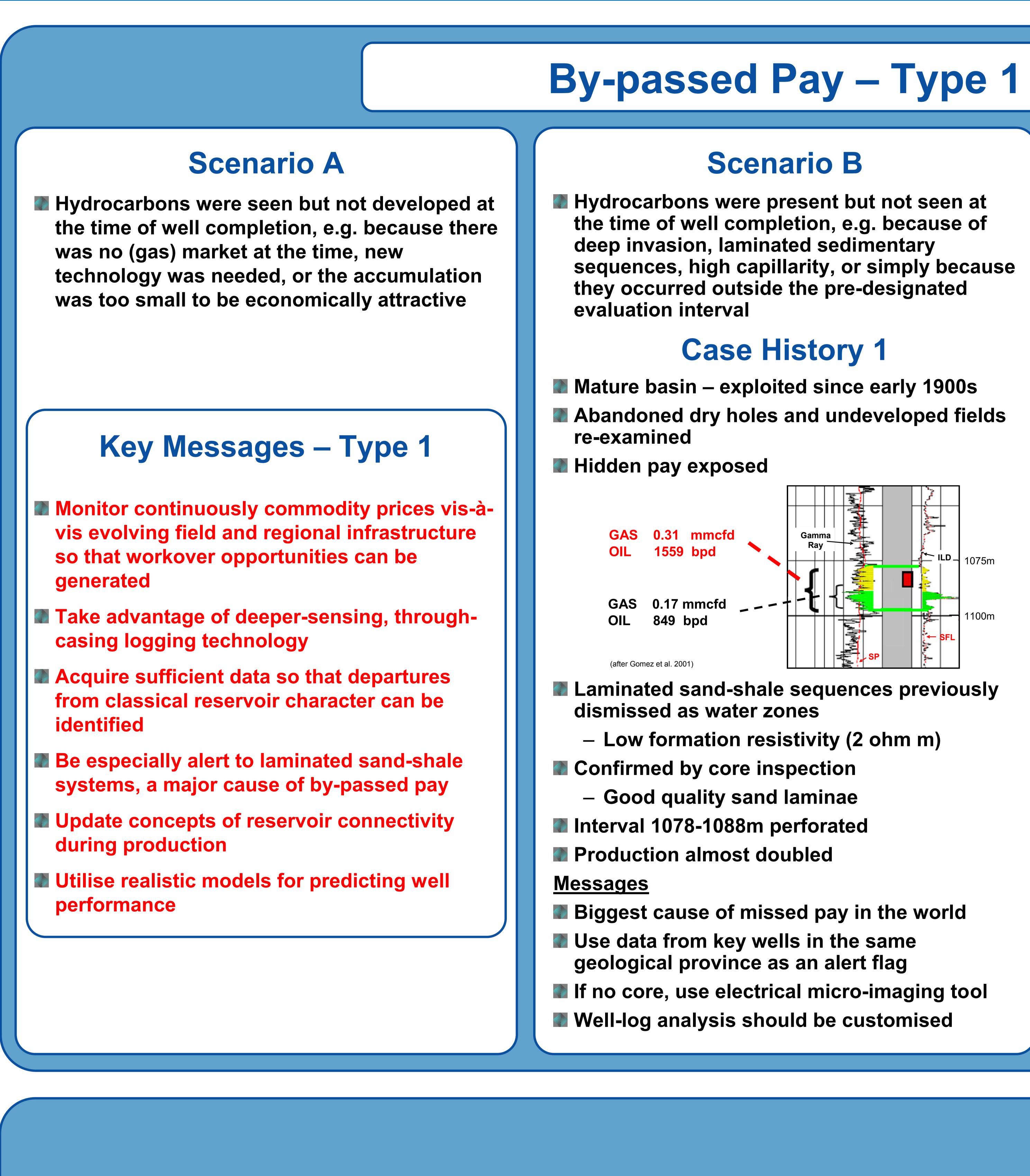
Untapped hydrocarbon accumulations are indicated during development, e.g. through improved seismic data, early water production or a refined geological architecture

Case History 4

- First production 1972
- Depletion mechanism water/pressure drive Candidate for sale – 1988
- High operating costs
- 3D seismic 1988 High velocity – high water saturation
- High amplitudes hydrocarbon accumulation

- Migrating flood front was resolved seismically • Where residuals behind the front were low (Sor 20%) Unswept zones could be identified and targeted
- New drilling campaign 1992
- High success rate of commercial producers Field production doubled after one year of targeted drilling campaign
- Field kept going until 2005 - Sales point destroyed by Hurricane Rita
- 1973
 1976
 1979
 1982
 1985
 1988
 1991

 (re -drawn from Sibley et al., 1994)
 Messages Combination of workstation technology, better seismic to well
- ties, and improved reservoir characterisation Can lead to recognition of by-passed hydrocarbons through attribute analysis
- But, be mindful of the spatial resolution of surface seismic Attribute analysis should be undertaken in conjunction with geological, petrophysical and engineering data



Recovery of By-passed Pay

- The location of by-passed hydrocarbons is – Well-log driven at the wellbore (through casing
- Geophysically driven between wells (3D/4D seismic)
- By-passed hydrocarbons can be recovered
- Through gas and water displacement technology
- By improving hydraulic connectivity with existing wellbores through re-completions By establishing hydraulic connectivity with new wellbores through infill drilling
- It is implicit that additional recovery is deemed to be economic
 - Essential if volumes are to be classified as Reserves

Looking Ahead

- Exploitation of by-passed pay is likely to be increasingly economic with field size There are documented case histories of
- failure and these are mostly small fields

Future trends

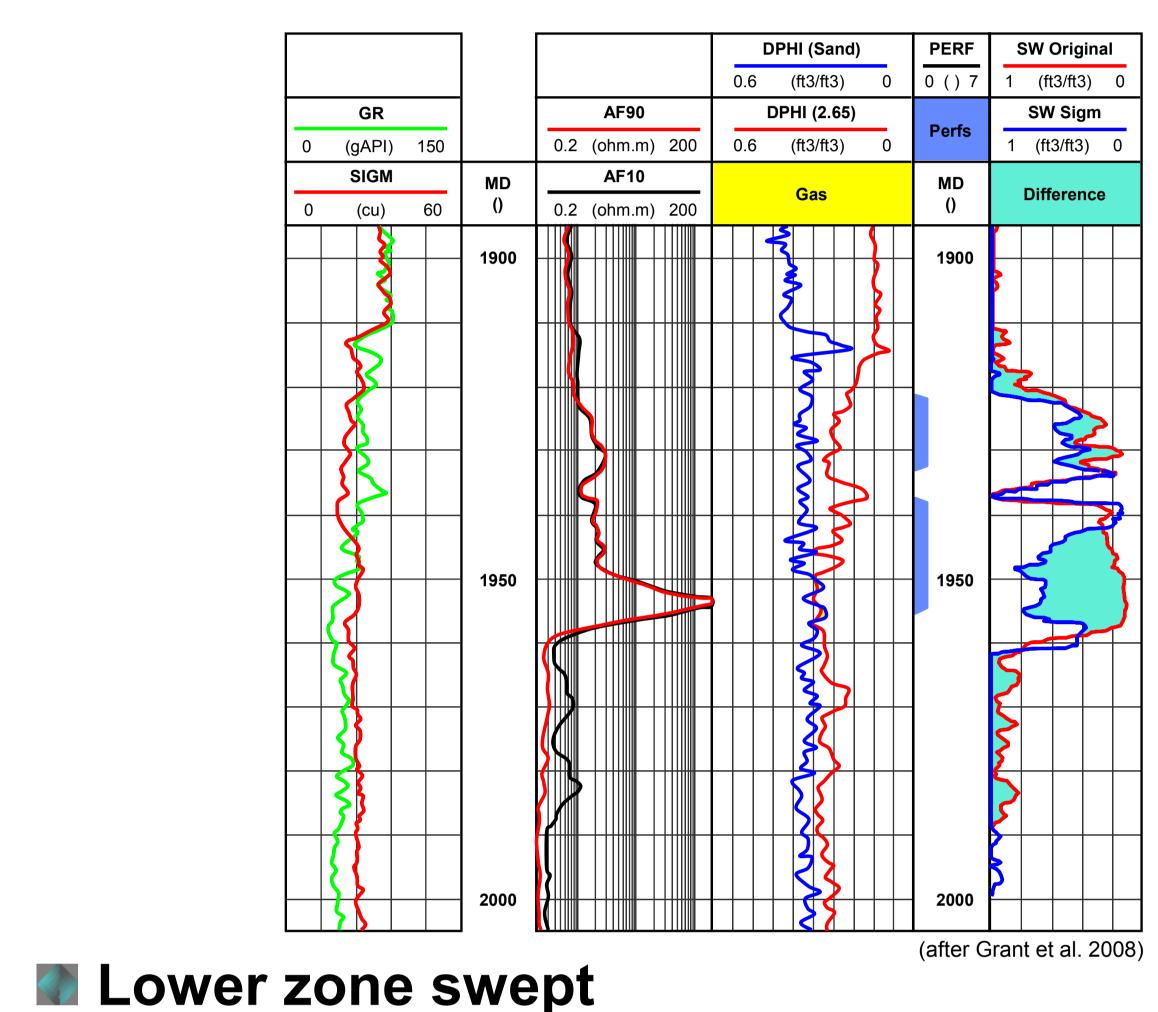
- Re-interpretation of existing field databases
- Through-casing well-log calibration and analysis
- Cross-hole geophysics Electromagnetic imaging – Time-lapse seismic with permanent
- sensors
- Increased application to unconventional reservoirs (e.g. coal bed methane)
- The improvement of poorly-performing waterfloods remains a highly pertinent objective
- The fruits of these ongoing efforts are evident in contemporary press releases from operators who specifically report the commercial discovery of (hitherto) by-passed hydrocarbons, with corresponding uplifts in Reserves

Scenario C

Unswept hydrocarbons become identifiable post-production, e.g. through improved geoscience insights, premature well decline, or early break-through of waterflood fronts

Case History 2

- Mature field
- (Through-casing) pulsed neutron logs run
- Logs are compared with initial conditions
- Swept zones identified



Upper zone unswept Candidate for recompletion

<u>Messages</u>

- Cased-hole nuclear logs have advanced considerably
- Other options include through-casing resistivity

The Last Word

EPL Finds Bypassed Oil in the Heart of its 100% **Owned East Bay Field** March 31, 2008 9:33 AM ET

Energy Partners Ltd. ("EPL" or the "Company") today announced that an exploitation well drilled in its 100% owned East Bay field, located in its Eastern core area on the Gulf of Mexico Shelf (Shelf), has uncovered...bypassed oil, penetrating 7 hydrocarbon bearing sands for a total of 120 feet of apparent high quality oil pay. The well is currently being completed and is expected to be on line early in the second quarter with an expected initial gross production rate of 400 to 800 barrels of oil per day...