[PS]Stratigraphic Traps: Quantitative Approach Based upon a Producing Field Database*

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Search and Discovery Article #40436 (2009)
Posted September 22, 2009

*Adapted from poster presentation at AAPG Annual Convention, Denver, Colorado, June 7-10, 2009

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Abstract

Stratigraphic traps are hydrocarbon accumulations independent of structural or fault closure. The factors controlling the stratigrahic traps involve facies change, depositional pinch-out, erosional truncation, hydrodynamics, diagenesis, or other factors or a combination.

The prediction of stratigraphic traps relies on a good undestanding of complex geological settings. Modern exploration tools such as 3D seismic data generally provide fair imaging of the stratigraphy. Therefore, detailed sequence stratigraphy analysis calibrated by core data and biostratigrahical results must be performed to predict facies variations and geometric architecture of the reservoir-prone section and seal-prone section, respectively, even if the trap has Direct Hydrocarbon Indicator (D.H.I.) support.

The efficiency of bottom seal, lateral seal and top seal is the driving mechanism of the success as any failure in the capacity of the weakest seal will alter hydrocarbon (HC) accumulation.

A series of queries performed on a non-exclusive database provided a statistical evaluation of the relationships between geometric parameters of the traps and HC types. Geometrical aspects, such as the dip of the top of the reservoir and the physical conditions, such as HC density and pressure in bottomhole conditions, control the seal integrity. Porosity and permeability of the reservoir control recovery factors and therefore contribute to economic calculations.

Assessment of stratigraphic traps is best achieved when supported by good understanding of the geology, statistical analysis of geometric parameters and reality check with possible analogues from the database.

Stratigraphic traps: a quantitative approach based upon a producing field database

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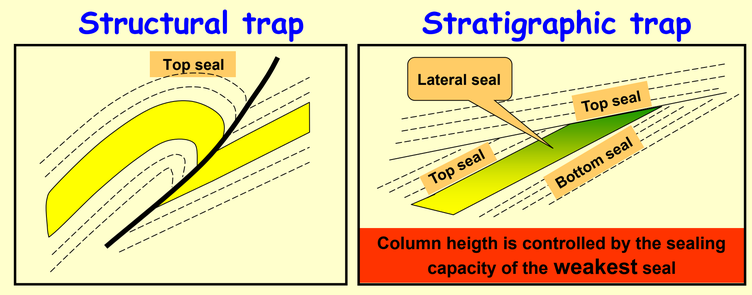
Definitions

·Structural traps are post- or syndepositional deformation or displacement of reservoirs and/or seals:
  ·Folds, faults, thrusts, fractures…

·Stratigraphic traps have specific configurations of reservoir and/or seals. Therefore they are independent of structural or fault closure (Structural traps).
  ·Depositional, erosional, diagenetic…

·Fluidic traps are related to physical and/or chemical property or condition of reservoir fluids:
  ·Pressure, temperature, fluid composition…

·Combination traps occur where structural nosing and/or faulting modifies the hydrocarbon distribution but is not the sole reason for the accumulation.



Modified from Exploring for Oil and Gas Traps - Treatise of Petroleum Geology -AAPG (1999).

Stratigraphic traps and trapping mechanism

SYSTEM	REGIME	CLASS	FAMILY	SCHEMATIC CROSS-SECTION	DEFINITION
2 STRATI-GRAPHIC-FLUIDIC: Trapping mechanism related to non-structural processes, including depositional, erosional, diagenetic and fluidic factors	21 DEPOSITIONAL: Trapping due to depositional pinch-out of reservoir	211 LATERAL DEPOSITIONAL CHANGE: Reservoir pinch-out by lateral depositional facies change or pinch-out	2111 LATERAL FACIES CHANGE		Reservoir pinch-out due to lateral gradation of depositional facies into non-porous lithology
			2112 LATERAL DEPOSITIONAL PINCH-OUT		Reservoir pinch-out due to depositional termination of porous lithology
		212 BURIED DEPOSITIONAL RELIEF: Upward convexity of trap formed by reservoir deposition	2121 ORGANIC BUILDUP		Positive relief of trap due to biogenic/reefal aggradation
			2122 CLASTIC MACROFORM	(e.g., submarine-fan lobe)	Positive relief of trap due to depositionally controlled reservoir thickness variation
	22 EROSIONAL: Trapping resulting from erosional truncation of reservoir	221 SUB-UNCONFORMITY TRUNCATION: Reservoir truncation beneath a regional unconformity	2211 REGIONAL SUBCROP		Reservoir truncation beneath regional-scale unconformity
			2212 PALEOSTRUCTURAL SUBCROP		Erosional trucation of faulted / folded structure
		222 BURIED EROSIONAL RELIEF: Trapping beneath a local truncation surface and/or within a buried hill reservoir	2221 BURIED-HILL		Erosional trucation of basement reservoir
			2222 TRUNCATION-EDGE		Reservoir truncation beneath local / subregional unconformity or sequence boundary
		223 ONLAP ONTO EROSIONAL SURFACE: Onlap pinch-out of reservoir onto relative high	2231 ONLAP ONTO REGIONAL UNCONFORMITY		Onlap pinch-out onto a regional unconformity
			2232 ONLAP ONTO STRUCTURAL FLANK UNCONFORMITY		Onlap pinch-out onto flanks of structural/basement high
		224 EROSIONAL-TROUGH FILL: Lateral termination of reservoir against an erosional trough	2241 CHANNEL-FILL		Reservoir confined within a channel incision
			2242 VALLEY-FILL		Reservoir confined within a major channel incision
			2243 CANYON-FILL		Reservoir confined within deep-water submarine erosional trough
	23 INTRUSIVE: Reservoir consisting of porous / fractured igneous intrusion	231 INTRUSIVE IGNEOUS BODY			Reservoir consisting of porous/ fractured igneous intrusion
	24 DIAGENETIC: Traps related to post-depositional microscopic-scale factors	241 DOLOMITIZATION / DISSOLUTION			Trap formed by localized formation of porous lithology as a result of dolomitization and/or dissolution, within non-porous lithology
		242 FRACTURING		oil-filled fractures	Trap formed by localized development of fracturing within non-porous lithology
		243 CEMENTATION		cemented	Pinch-out of porous reservoir as a result of cementation
		244 TAR SEAL		tar	Pinch-out of porous reservoir as a result of tar-plugging. Typically a near-surface trap type
	25 FLUIDIC: Diverse range of trapping mechanisms resulting from hydrodynamic, capillarity, phase-change and gas adsorption factors	251 BASIN-CENTER GAS		water-bearing porous sand / Basin-center / gas-bearing tight sand	Trapping of gas beneath water as a result of capillarity variations
		252 COAL BED METHANE		surface / coal beds	Gas adsorbed onto organic macerals within coal-bed methane and organic shale reservoirs
		253 GAS HYDRATE		gas hydrate / free gas / water zone	Trap formed by phase-change from gas to sealing gas hydrate
		254 HYDRODYNAMIC			Trap modified by aquifer pressure. Hydrodynamic forces affect position and thickness of hydrocarbon column

Modified from C&CReservoirs

A multi-disciplinary approach

·Commonly a detailed chrono- and lithostratigraphic chart established from the interpretation and integration of the whole set of available data provides the material to predict seal and reservoir distribution for the stratigraphic section of interest.
·Understanding of the depositional models within a stratigraphic pattern is also a key elements for predicting facies variations which have impact on both reservoir quality and seal quality.
·Prediction of seals is a three fold issue as it involves bottom seal, lateral seal and top seal.
·Understanding of subtle but real structural elements such as a monocline or flexure might add a structural component to the trap that would be named as combination trap in this case.

Data: cores, outcrops, biostratigraphy, magnetostratigraphy, chemostratigraphy, well logs, seismic, structural maps…

- **CORE DESCRIPTION**
  - -Facies analysis

Iterations

- **BIOSTRATIGRAPHIC BREAKDOWN**

Iterations

- **High Res. SEQU. ANALYSIS of WIRELINE LOGS**
  - –Deepening upward vs shallowing upwards cycles
  - –Correlative Geological Surfaces

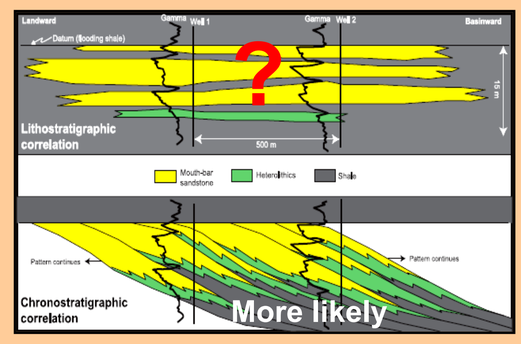
Iterations

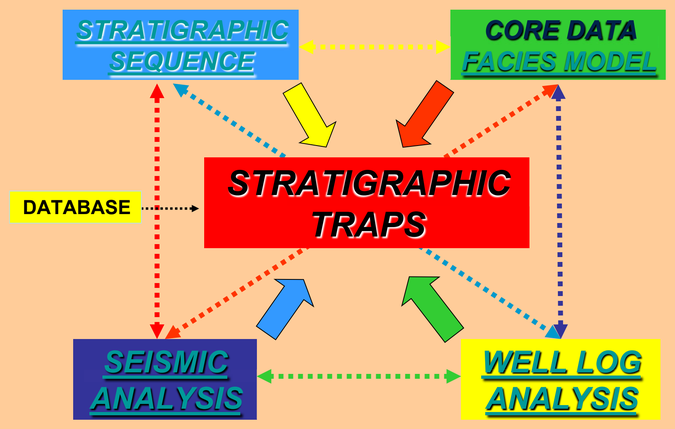
- **WELL CORRELATION**

Iterations

- **SEISMIC STRATIGRAPHY**
  - –Seismic terminations
  - –Seismic facies
  - –Seismic attributes

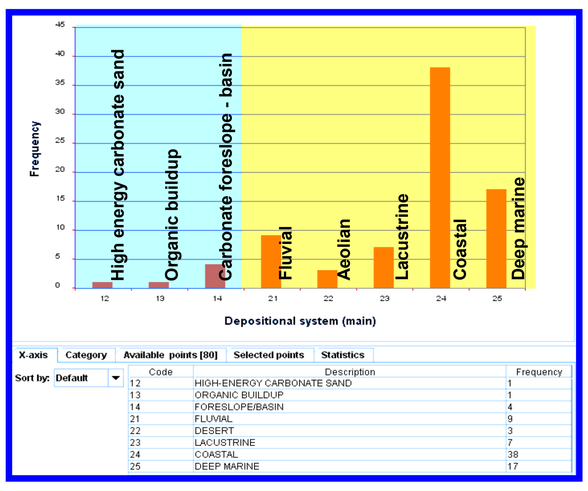
- **CHRONOSTRATIGRAPHIC CHART**
  - –Unconformities-disconformities
  - –Reservoir-prone sections
  - –Seal-prone sections (bottom-, lateral- and top seals)

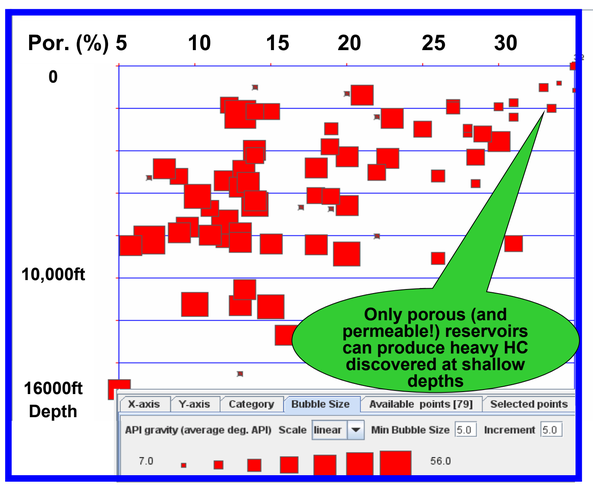


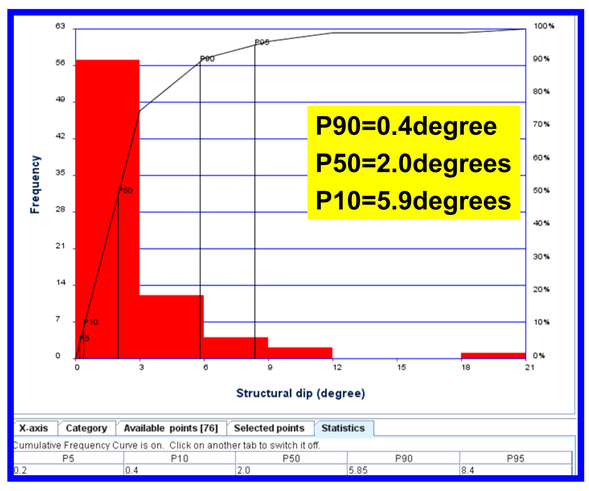


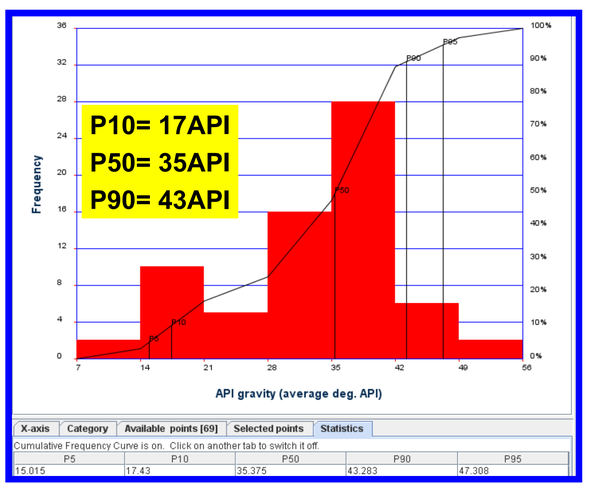
Example of stratigraphic trap: lateral pinchout of a reservoir

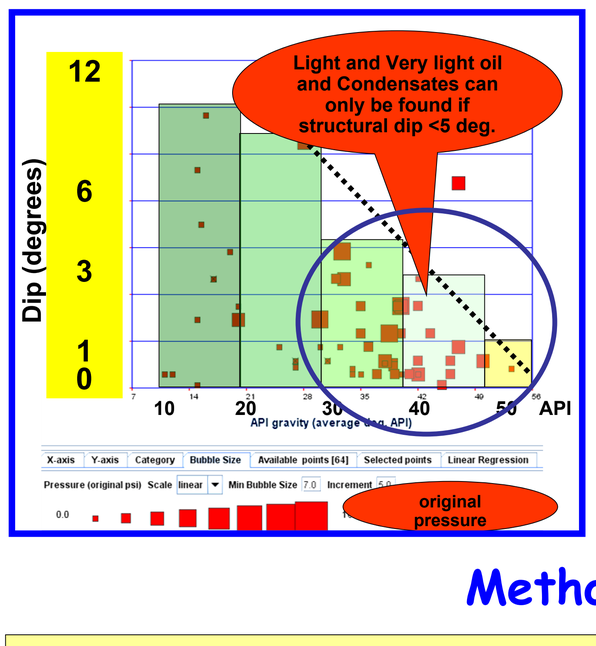
80 producing fields in C&CReservoirs database

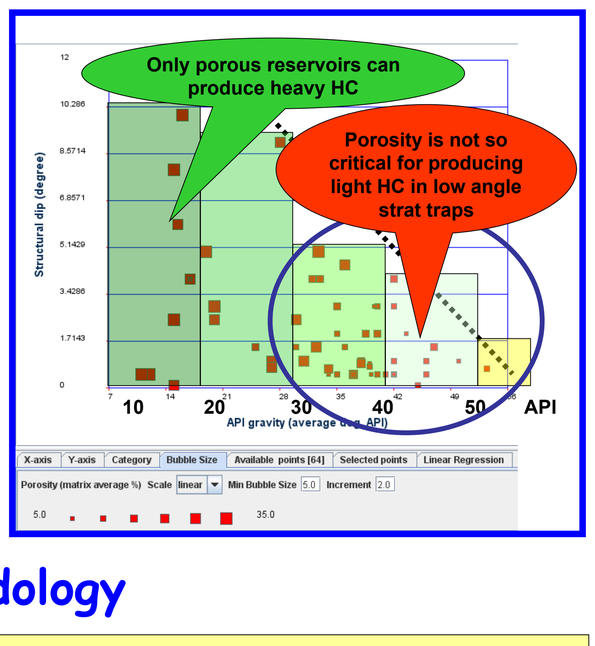


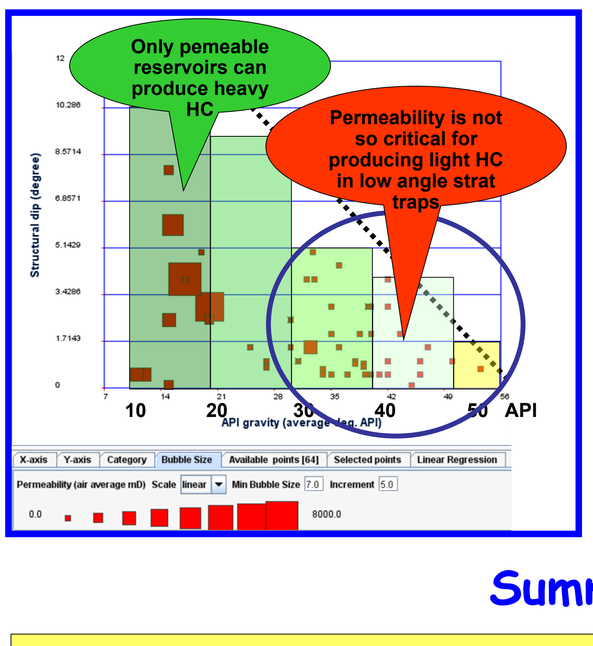


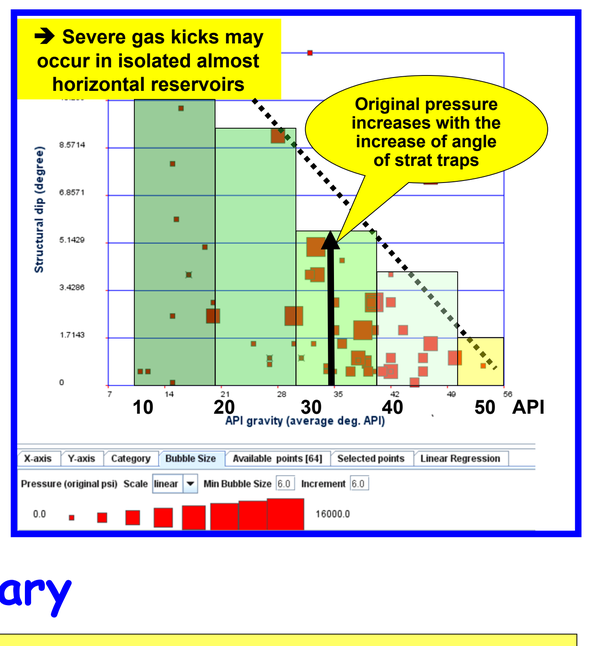












Methodology

• One way of understanding stratigraphic traps is to analyze statistics of producing reservoirs that have a stratigraphic component in their trapping mechanism. Databases with standardized quantitative information of production for many years bring valuable knowledge and provide objective information and analysis for E&P risk-analysis and decision-making.

• Here, one type of stratigraphic trap "depositional pinch-out" is analyzed by a series of queries to highlight the main characteristics of this type of trap.

Summary

·HC Production from stratigraphic traps having angles >12 degrees almost do not exist!

·Stratigraphic traps have commonly a structural dips <3degrees.

·In high angle stratigraphic traps, it is likely that only heavy HC might be discovered as the seals cannot contain the light fraction of HC.

·As there are different types of stratigraphic traps, understanding of the stratigraphy is essential to conceptualize non-conventional traps.