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# Stratigraphy applied to oil industry

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**Summary**

Stratigraphy and the oil industry are intricately intertwined and have been so ever since the industry started exploring in challenging settings. Stratigraphic understanding forms the basis for basin exploration, field evaluation, reservoir development and production. Because of this need for stratigraphic understanding, the oil industry is a key driver in the development of new and faster ways to develop stratigraphic correlations. However, this end user position of the oil industry is repaid many times over by the sheer amount of stratigraphic information supplied during a drilling campaign as well as funding supplied for academic development of the science. Indeed, the relationship between the oil industry and the science of stratigraphy is a very healthy one and is truly symbiotic.

***Keywords*:** Oil and Gas Industry, Basin Exploration, Stratigraphic Methods, Commercial Stratigraphic Application

## Introduction

The science of stratigraphy (the study of layered rocks (strata) which obey Steno's Law of Superposition (younger strata overly older strata) has obviously been studied for centuries, dating back to the work of William Smith and Georges Cuvier around the turn of the 17$^{th}$ Century. The history of stratigraphic concepts and methods are summarized in numerous places and not dwelt upon here. However, as emphasized by Schoch (1989) in his textbook on stratigraphy, correlation is "of overriding importance" to stratigraphy and the science would be reduced to the description of innumerable, localized successions of strata without it; that is where the oil gas industry comes into the picture. Charactersing single well-bores is of little importance, but being able extend that characterisation over an oil field or a prospective basin is without doubt the single most important building block for all later studies in the oil and gas industry.

While the subject of stratigraphy is in itself fascinating and one that even non earth scientists will have been in contact with when out and about in mountains, on beaches or even driving through road cuts, it is a subject that may well have remained firmly bedded in the ivory towers of academia if it were not for the petroleum industry and its over-arching need to correlate between what are essentially 1-dimentional representations of stratigraphies (well-bores).

## Stratigraphic applications

In offshore basins, for instance, exploration starts in shallow waters migrating into deepwater. To follow this trend, geologists have the constant and hard task to extrapolate shallow water geological data into deepwater realm. The exploration in the less known areas of the basin must be done after analyzing the petroleum system of the basin. Such analysis comprises studies of source rock, reservoir rock, hydrocarbon migration, trapping and most of all, predictive facies maps showing the distribution of the best reservoirs along the basin. Such regional work is challenging for geologists and geophysics, demanding strong stratigraphic knowledge of the basin.

The understanding of any oil field starts with a good definition of chronostratigraphic units. Commonly, lithostratigraphic units are more evident and thus easier to be interpreted, however lithostratigraphy alone is not enough in the development phase of an oil field. It is necessary additional studies of high resolution physical stratigraphy, based on rock data (cores and side wall samples), log and seismic.

Detailed stratigraphic work is an important step in the designing accurate of geological models aiming to reduce exploratory risks and a more profitable explotation. To achieve such predictive geological models it is utterly important to have a good genetic facies association, in a logical stratigraphical and precise distribution. Based on robust geological models bearing strong stratigraphic and sedimentological knowledge, it is possible to design a much better distribution of production and injection wells, consequently increasing the hydrocarbon recovery factor.

## Stratigraphic methods

For many decades toward during last millennium, stratigraphic correlations in the oil and gas industry were reliant upon seismic, wireline logs and biostratigraphy. Seismic data are obviously expensive and slow to acquire and often lack the resolution required for detailed well-bore correlations. Wireline logs, as mentioned above, more often than not represent lithological variations and therefore produce lithostratigraphic correlations. Biostratigraphy, undoubtedly the mainstay for producing chronostratigraphically significant correlation in the oil and gas industry, also has many problems; in many depositional settings preservation potential is poor, facies variations negate regional correlations or resolution of time-significant species is low.

Therefore it is hardly surprising that over the past 20 years there has been a proliferation of “new” stratigraphic methods being applied to the oil and gas industry looking rocks properties such as inorganic geochemistry, aspects of their magnetic properties, various isotopic compositions and detailed mineralogy (clay, heavy mineral). Additional the concept of cyclostratigraphy and sequence stratigraphy are commonly applied to well-bore information these days. Several of these methods and their applicability to the oil industry are discussed in Ratcliffe & Zaitlin (2010).

No single event typically sees a stratigraphic tool become a commonly used method in the oil and gas industry, several factors need to converge. For example, the technique of chemostratigraphy - chosen only because it is obviously close to one of the authors (Ratcliffe) heart – started to be used in the UK Oil and Gas industry in the 1990’s. During that period, exploration was active in the Barren Red Measures of the Southern North Sea, which is a complex fluvial system in which biostratigraphic recovery was poor. At the same time research was being published using Inductively Coupled Plasma technology to get elemental data quickly and inexpensively from rock chips. Therefore, there was a need for a tool in the industry and concurrently research becoming public that offered a solution. Had there been a need but no research or vice versa, then chemostratigraphy may never have developed.

## Oil industry pay back?

Undoubtedly, the oil and gas industry is the main pragmatic end-user of stratigraphy and is benefits commercially from the science of stratigraphy. This usage and benefit, however is repaid many many times over by the sheer amount of stratigraphic information that each new well-bore provides. Vast tract of the World’s stratigraphy would not even be available if it were not for oil and gas exploration.

Furthermore, countless millions are spent each year on stratigraphic projects, both utilizing existing stratigraphic concepts to better understand basins and reservoirs, but also in developing new, quicker and less expensive stratigraphic methods.

Therefore, the relationship of the oil and gas industry with the science of stratigraphy is a truly altruistic one.

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