Perspective and Overview of Currently Changing Exploration and Exploitation Strategies

"Sequence stratigraphy has provided the geoscientist with tools to interpret chronostratigraphy, a field that has been the exclusive domain of micropaleontology. Correlating T1 unconformities, parasequences, systems tracts, and maximum flooding surfaces of various frequencies among wireline logs rapidly provides a time-stratigraphic framework within field–size areas, even in the absence of microfossil data. When tied to 3-D seismic data, this very powerful paradigm becomes a new key tool in the geoscientist's tool box."

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Gulf Coast exploration began long before depositional systems and sequence stratigraphic ideas and methods evolved. Early prospecting focused on shallow, updip, postdepositional closures resulting from isostatic, compactional, and regional extension that reactivated uplift of deeply buried shale or salt masses and movement of associated minor extensional and major growth fault systems. Widespread, on-shelf wave-dominated deltaic and interdeltaic (highstand and transgressive) coastal systems comprise relatively tabular and highly correlatable reservoir sandstones. Consequently, in this early phase of prospecting and development, there were many superposed, high-quality shoreline sandstone bodies wherever structural closures existed.

Eventually, exploration moved deeper to prospect lowstand river-dominated deltaic and transgressive sandstones exhibiting fault and rollover closures. But again, these large, faulted, rollover anticlinal structural traps were the principal focus. Luckily, several lowstand deltaic and transgressive sandstones typically compose closed reservoirs. With closure, most of these large structures were identified by seismic and wireline-log structural mapping. Most were drilled during the two decades following World War II. Major advancements in digital seismic acquisition and migration processing of multifold 2-D data circa 1970 rejuvenated Frio exploration. Success rates climbed rapidly during the 1970's and 1980's. As finding rates again began to fall, 3-D seismic became commercially feasible in the late 1980's and 1990's. Technology again reversed the slide in finding rates.

<u>Today</u>, the application of 3-D seismic data has enormously increased the precision and resolution of structural traps and, hence, reserve additions in mature fields. Almost all of this success derives from recognizing smaller and subtler structural closures. Seismic processing, modeling, and the explosion of specialized workstation digital software now permits myriad data manipulations that were impossible in 1970.

<u>Paralleling the spectacular evolution of seismic technology</u>, **<u>sedimentary geology also made huge advancements</u>**. ***Circa*** 1970, the fortuitous convergence of digital methods in seismic and wireline geophysics with radical conceptual changes in geology fueled 30 years of significant advancement in exploration and development. *Depositional systems analysis, seismic and sequence stratigraphy, and their logical spin- offs, such as hydrocarbon systems and reservoir characterization, have revolutionized petroleum geology.* But unfortunately, geologists have not exploited their opportunities in the same way that geophysicists have expedited applications in their fields. Hardware and software technology has been accepted and utilized by major companies and now by small operators.

<u>At this time (*circa* 2000) sequence stratigraphy</u> integrated with depositional systems concepts has outpaced and jumped far ahead of more traditional exploration and development approaches practiced since the 1940's. Recognition of subaerial and submarine (T1) unconformities eroded during relative lowstands of sea level, as well as regionally continuous, seismically distinctive marine condensed sections that comprise maximum flooding surfaces, has provided the hands-on geologists the potential for constructing a <u>chronostratigraphic framework from wireline logs calibrated with 3-D seismic data even if microfossil data are absent</u>. Such field-scale frameworks preclude miscorrelations based on supposed correlation of similar geophysical log patterns**. The unconformities and flooding surfaces can be calibrated and dated** (***<u>Ma)</u>*** with global cycle charts that reflect a consensus view of micropaleontologists, isotope geochemists, and stratigraphers. Also, the depositional sequences bounded by unconformities generally comprise three-component **depositional systems tracts**: commonly **highstand, transgressive, and lowstand tracts**. These tracts are characterized by **parasequence stacking patterns** that reflect space available to accommodate sedimentation; their patterns (***e.g.***, progradational, aggradational, and retrogradational **parasequence sets**) reflect the interplay of rate of added or subtracted accommodation space and rates of sediment supply. Within field areas, detailed reservoir characterization requires precise correlation of the minor flooding shales or abandonment surfaces that terminate each parasequence or parasequence set. At this precision, it is possible to predict internal reservoir compartments and seals. Also, high-frequency erosional events can be predicted that might add heterogeneity to the reservoir. **Consequently, the explorationist and exploitationist today have new principles that must be learned and applied if they are to maintain competence within their profession. It is human nature to want to avoid relearning or changing one's educated knowledge base to accept new and somewhat radical ideas and methods, but it is a necessity if the professional is going to make full use of the latest principles and discontinue applying ideas that are now recognized to be false.**

Spectacular success experienced by geophysics has overshadowed the more subjective application of evolving modern geologic concepts. This is totally understandable because of the objective vs. subjective natures of hard technology of physical science vs. highly subjective application of valid but commonly qualitative geologic science. In addition, reeducating geologists to think differently is much more difficult than teaching someone to operate hardware that at a practical level "thinks" for the operators. Direct and spin-off computer science has supplied geophysicists with a treasure trove of technology driven by the world's hunger for electronic devices. Obviously, no such global tidal wave exists to drive geological science.

Nevertheless, unless basic geological science moves forward, technology may outstrip the fundamental foundation needed to ask appropriate questions and provide direction to geophysics, especially in petroleum science. Whether physics and computer sciences can maintain the level of advancement displayed during the past 25 years and whether future advances will impact geophysics as it has up until now is questionable. Sedimentary basins are being scoured by technologically driven methods. Powerful they are, but there must be a finite limit to the current level of success. Then what? Will the technological fix solve new problems and kick off another frantic phase in petroleum science? If geologists do not accelerate and improve their understanding about and recognition of new kinds of petroleum habitats and some radical departures from past and current ideas, who will keep the technologists aimed at targets? Ideas such as sequence analysis have been essentially ignored by a majority of practicing professionals who seem to see little to be gained by changing a century of antiquated science, especially when a few weeks of training makes them productive workstation specialists. But, when the drill goes deeper, prospecting moves into poorly understood habitats, and resolvable structural traps exceed resolution and economics, improved science and not technology will undoubtedly drive our current and future professionals and educators back to basics.