a top seal will also be a lateral seal. Stratigraphic traps and faulted prospects have substantial seal risks. Hydrocarbons are not distributed randomly or arbitrarily on complexly faulted structures. Their distribution follows simple physical principles, and preferential hydrocarbon distribution can be predicted, given adequate data. Improvements in assessing seal risk for an exploration prospect directly affect the estimation of exploration success.

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Mediterranean Miocene Carbonates: Facies Models and Diagenesis

Miocene carbonates can bridge the gap between Holocene and older carbonate sequences, thus enhancing understanding of depositional and diagenetic patterns. Miocene carbonates can bridge this gap because of their similarity to Holocene counterparts and the ease of using these carbonates to reconstruct tectonic, paleogeographic, and paleoclimatic settings. In the Mediterranean, the Miocene provides a superb set of exposures and a wide variety of facies models in different geologic settings.

Mediterranean Miocene carbonates contain three major types of platform facies: coral reefs, macroforaminifer-rodolithic carbonates (rodalgal facies), and molluscan-bryozoan-foraminifer calcarenites (foramol facies). A combination of interrelated factors (e.g., water depth, temperature, and nutrients) control the distribution and lateral vertical transitions of these platform types. The rodalgal facies is widespread and occurs as a transition between the coral reef platform and the foramol platform. Modern carbonate sedimentation in the Mediterranean provides instructive analogies for many varieties of foramol and rodalgal facies. The most extensive porosity type is a combination of secondary intergranular and moldic porosity with chalky microporosity, locally in association with minor primary integranular porosity. *This porosity is normally associated with dolomitization and is interpreted* as having originated in intermediate burial environments.

Miocene coral reefs were particularly abundant and well developed in the late Miocene, before and during the Messinian salinity crises and basinal evaporite deposition. These events implied drastic variations in sea level, water chemistry, and nutrients, and coincided with high sedimentation rates in coastal areas. To survive these adverse conditions, coral reefs grew very fast, with spacially successful colonial morphologies and intense carbonate cementation. Many coral reef sections present marked cyclicity with repeated intercalations of exceptionally well-developed stromatolitic carbonates. Present outcrops record details comparable to Quaternary reefs, as well as details of the facies geometry of the different reef complexes and their responses to Miocene sea level oscillations.

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Unconformities, Paleokarst Facies, and Porosity Evolution

The study of unconformities and paleokarsts from the perspective of modern facies analysis and modeling offers potential advantages in terms of organizing and guiding observations, comparisons, interpretations, predictions, and hydrodynamic considerations.

Karsts that developed at major unconformities may result in karst facies and profiles different in many respects from those of meteoric diagenesis in Quaternary carbonates in tropical areas (e.g., the Caribbean). *Many paleokarsts developed on mud-supported carbonates* after mineralogical stabilization, deep burial, and tectonic deformation, but without the diffuse recharge and flow characteristics of the Caribbean model or the influence of a coastal marine mixing zone. The general concepts of water table and vadose and phreatic regimes need careful review when applied to heterogeneous permeability networks.

Karst facies and profiles are controlled by (1) previous permeability networks of the affected formation, (2) balance and interaction of climatic, biologic, and hydrologic environments that enhance or reduce these permeability networks, and (3) timing, rate, and succession of environments, and stages of evolution. Karst facies, facies associations, and their profile arrangements generally vary, and may be complicated by relict and rejuvenated features common in evolved karst profiles. In detail, karst facies are defined in terms of (1) corrosion-erosion morphologies, (2) diagenetic overprints, (3) karst sediments and cements (speleothems), and (4) biologic associations.

A common, mature, authigenic karst profile consists of the following zones. (1) Soil, infiltration zone—down to the limit of root penetration. (2) Percolation zone—with vertical passages and abundant sedimentation, collapse, and cementation, commonly containing relict features (cave levels) from deeper horizons or local saturation zones. (3) Oscillation *zone—characterized by periodic water saturation and, in terms of* lithofacies, commonly indistinguishable from the permanent lenticular zone (shallow phreatic); predominantly horizontal passages with bedding-plane control and erosional features are the key characteristics of this zone; cave sediments show evidence for reducing depositional environments; many well logs show a characteristic kick in the gamma ray (B marker), together with a decrease in the sonic activity. And (4) deep phreatic zone—characterized by incipient, slow corrosion and/or cementation and grading into the unaffected formation.

In most places, a rock formation is first exposed to the deep phreatic zone and evolves through the shallow phreatic into the vadose as a result of the dismantling of the upper part of the profile. In this way, the classic concepts of youth, maturity, and senility can apply to parts of the karst profile or to the entire profile, and can provide a basis for comparing other profiles of the same karst system. Base level changes are commonly sharp and produce repeated horizontal cave levels that are abandoned in the vadose part of the profile. In many paleokarsts, those relict cave levels have been confused with repeated surfaces of subaerial exposure.

Correlating different karst profiles and the structural-lithologic patterns of the affected formation offer the possibility of reconstructing the evolution of drainage patterns during major unconformities. This karst facies modeling can also provide a basic tool for reservoir evaluation in exploration and production.

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A Dry Hole or Reservoir Damage? What We Need to Know

Stories abound in the industry about the oil or gas field drilled and abandoned by one company, only to be "discovered" by a second company that evaluated the data from a different perspective. The Elmworth field (Canada), and Beeville, North Resenberg, and Running Duke fields (Texas) are all examples where the initial well penetrated the hydrocarbon column but was not completed, or was completed, tested, and abandoned.

Numerous explanations exist as to why fields are abandoned and then rediscovered. Often contributing to this cycle is a lack of understanding of the reservoir's pore geometry, and of the effects of drilling or completion-induced damage on production or pressure performance measured by drill-stem tests, repeat formation testers, and well logs. Additionally, the inability to tell the difference between a low-permeability noncommercial reservoir and a damaged commercial reservoir results in a lot of missed field discoveries.

In my lecture, I discuss the causes of formation damage, as well as factors that signal the reservoir's vulnerability to damage (e.g., small pore throats, authigenic clays, low reservoir pressure). I also include case examples of conventional tests that, by routine analysis, show the zone to be noncommercial when, in fact, the well was completed and produced commercially.

Understanding the type of reservoir system being tested and using all available tools and data are the key to determining reservoir behavior.

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Carbonate Facies and Reservoir Heterogeneity—The Value of Modern Analogs

Secondary and enhanced processing of hydrocarbon fields requires a critical understanding of reservoir heterogeneity by both geologists and engineers. Carbonates have more varied facies and diagenetic patterns than their siliciclastic counterparts, thus offering a greater challenge to reservoir evaluation. This challenge is illustrated by American Petroleum Institute data showing average primary plus secondary recovery efficiencies of carbonate reservoirs of only 32% original oil in place. Studies of modern analogs are valuable because they constrain interpretations and lend predictability to unraveling facies patterns in reservoirs. These patterns help to understand the lateral continuity of