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Abstracts

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Diagenetic Mineral Reactions Reveal Rates of Fluid Movement and Timing of Oil Emplacement

The San Joaquin basin of California is a young, rapidly buried basin in which feldspar alteration has major control over calcite cementation and porosity forming reactions in hydrocarbon reservoirs. The eastern part of the basin includes up to 3,658 m (12,000 ft) of Miocene and younger arkosic marine sand and shale. The Miocene sand is cemented by numerous thin bands of dolomite and calcite, which, as oxygen isotopic studies indicate, formed at burial temperatures between 20° and 90°C (68° and 194°F).

Strontium isotopic studies show that the calcium source for the calcite cements is plagioclase feldspar. Calcium in calcite cements forming at shallow burial depths and low temperatures (40°-70°C or 104°-158°F) was derived from plagioclase alteration reactions at deeper levels and higher temperatures (>80°C or 176°F) in the basin. Time-temperature burial plots indicate that minimum required flow rates from deep to shallow basin levels would have to be about 1 cm/yr (0.4 in./yr). In contrast to the low temperature cements, the calcium source for cements forming at deep burial depths and at high temperatures (70°-90°C or 158°-194°F) was plagioclase dissolving within the reservoir. In addition, aluminum released from the dissolving feldspar was precipitated as kaolinite in adjacent pore spaces. These diagenetic trends reflect increasingly restricted pore-water mobility during the basin history.

Strontium isotopic values in modern pore waters of the basin record increasing feldspar alteration with depth and suggest that present mixing of basin waters is restricted to subregions (10-15 mi or 16-24 km horizontally by 2 mi or 3 km vertically). Helium isotopes also suggest limited mobility of this gas on a scale similar to that of strontium.

Plagioclase dissolution (up to 5% of the rock volume) occurred just prior to the incoming of hydrocarbons, which suggests that acids associated with and perhaps moving in front of the hydrocarbons effectively created a substantial part of the reservoir porosity. Modern pore waters in the basin are rich in organic acids that may be responsible for the dissolution reactions.

The last calcite cements formed about 2-3 Ma, based on time-temperature burial plots. Thus, hydrocarbons filled the reservoirs (up to 500 million bbl) within less than 3 m.y. This short time for oil emplacement is surprising considering the low permeability of the reservoir rocks (1-10 md).

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Stratigraphy from Three-Dimensional Seismic Data

The interpretive benefits of three-dimensional seismic data are enormous because of the considerable improvements in subsurface resolution. In addition to the benefits for structural definition, the horizontal section can provide a display of ancient deposition and stratigraphy similar to that of modern deposition seen from an airplane window. On horizontal sections and horizon slices, we can observe directly the shape of offshore bars, meandering channels, delta-front channels, and crevasse splays, and also the extent of bed truncations at unconformity surfaces. Many of these features may be hydrocarbon reservoirs, and color display of modern well-processed three-dimensional seismic data considerably aids reservoir identification. Proper interactive use of three-dimensional data during appraisal and development permits the determination of downdip limits and the mapping of reservoir quality, especially porosity and net-pay thickness.

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Fluctuating Mesozoic and Cenozoic Sea Levels and Implications for Stratigraphy

Sequence stratigraphy encompasses depositional models of genetically related packages of sediments deposited during various phases of cycle of sea level change, i.e., from a lowstand to highstand to the subsequent lowstand. The application of these models to marine outcrops around the world and to subsurface data led to the construction of Mesozoic-Cenozoic sea level curves with greater event resolution than the earlier curves based on seismic data alone.

Construction of these better resolution curves begins with an outline of the principles of sequence-stratigraphic analysis and the reconstruction of the history of sea level change from outcrop and subsurface data for the past 250 Ma. Examples of marine sections from North America, Europe, and Asia can be used to illustrate sequence analysis of outcrop data and the integration of chronostratigraphy with sea level history.

Also important are the implications of sequence-stratigraphic methodology and the new cycle charts to various disciplines of stratigraphy, environmental reconstruction, and basin analysis. The relationship of unconformities along the continental margins to hiatuses and dissolution surfaces in the deep basins must also be explored, as well as the relevance of sequence-stratigraphic methodology to biofacies and source rock prediction.

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Development Geology of Giant Fields on Alaskan North Slope: Key to Successful Reservoir Management

The giant fields on the North Slope of Alaska (combined Permian-Triassic/Lisburne pools at Prudhoe Bay and the Kuparuk River field) produce approximately 2 million BOPD and contain about 30 billion bbl of oil in place. This production rate amounts to almost one-fourth of the United States daily production. Because the reservoirs in these fields are complex and the stakes in efficient field management so high, the development geology of these fields presents a great challenge.

The technical challenge of managing these fields lies in the fact that secondary and tertiary recovery projects have been initiated soon after start-up to ensure maximum recovery. Thus, the development geologist has to recommend primary development locations while formulating a reservoir description without knowing the full areal extent and heterogeneity of the reservoirs. To support the waterflood and enhanced oil recovery projects, permeability pathways and barriers have been identified using sedimentological, log, and engineering data. Because structure also plays an important role in controlling fluid pathways, the fault geometries, fracture patterns, and detailed structure are being mapped using two-dimensional and three-dimensional seismic, well, and log data.

The management challenge of development work in these fields is keeping communications channels open among the development geoscience group and the reservoir, production, operations, and drilling engineers. The development geologists must communicate in engineering language not only to be able to understand the problems engineers