channel deposit for the Upper Devonian Speechley sandstone in Cherryhill field in west-central Pennsylvania. Isopaching indicates the channel trend, showing the geometry of the sand body perpendicular to basin contouring. Cross sections document a downcutting erosional contact with the underlying marine shales. Using a lithologic time correlator above the sand and the erosional basal contact, a GIS map shows that maximum reservoir development coincides with the central channel axis. Thus, the isopach and GIS maps are essentially identical; both confirm the channel trend.

Bedding characteristics, sedimentary structures, and petrology, from 59 ft (18 m) of conventional core, also suggest a turbidite channel. Bedding is predominately massive, and is comprised of incomplete Bouma sequences. Grain size decreases upward. Porosities which average 8%, and permeabilities, which are generally less than 1 md, were reduced by silica and carbonate cements and clays bridging pore throats. Sedimentary structures include shale clasts, erosional basal contacts, and bioturbation.

The combination of various mapping techniques and core interpretation suggest a turbidite channel origin for the Speechley sandstone. This approach may permit predictions for field development and exploratory drilling.

GROAT, C.

Gulf Coast Geopressured Geothermal Resources: The Hard Facts

(No abstract available)

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Geological Constraints on Models for the Late Jurassic-Early Cretaceous (Wealdian) Longroño-Soria Strike-Slip Basin (Northwest Spain)

The Longroño-Soria basin was formed between N60°E-striking, left-stepping, left-lateral strike-slip faults during the Late Jurassic-Early Cretaceous (Wealdian), when as much as 6 km (20,000 ft) of fluvio-deltaic strata accumulated in it. During basin development, the ends of the master faults propagated, increasing fault length and offset. Outside the basin, compressional deformation with superimposed folding was induced near the ends of the master faults. At the same time within the basin, normal faults and depocenters migrated in a direction opposite to that of the propagating master faults. The resulting extension allowed a N130°E-trending, 50-km (31-mi) wide, synsedimentary syncline to develop in the basin fill. This syncline was related to formation of a half graben in the basement. The high rate of subsidence and the high heat flow led to a sequential development within the sediments of water escape structures, hydroplastic-type compaction-related microfaulting, pseudo-cleavage, and metamorphism—420°C (788°F), 1-2 kb, 100-150°C/km (5.5-8.25°F/mi) gradient.

Our interpretation of the geometry, sedimentation, tectonics, and thermal evolution of the Longroño-Soria basin is based upon 2 mathematical models of strike-slip basins and one analogue model: (1) Rodger's calculations predicting vertical deformation, stress accumulation, and secondary faulting; (2) an unpublished finite element method by Liu that gives stress deviation and accumulation patterns; and (3) microtectonics, which provide a model for stress deviations at the tip of the microfaults and for the geometry of deformation during micro-rhombgraben development. The 3 models show comparable fault geometry and stress patterns, and fit our data from the Longroño-Soria basin.

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Deposition, Diagenesis, and Porosity Relationships in the Glorieta Formation, Keystone (Holt) Field, Winkler County, Texas

Production of hydrocarbons from the Chevron 7C H. E. Lovett well, Keystone (Holt) field, is from the upper part of the Glorieta formation (Leonardian). The field is located near the western margin of the Central Basin platform (Permian basin) on a present-day structural high.

The 116-ft (35.4-m) core contains at least 7 cycles of deposition, which consist, upward from the base, of progradational subtidal, intertidal and supratidal deposits. Supratidal deposits predominantly consist of dolostones with fenestral cavities; sabkha deposits are not represented. Scattered nodules of nonevaporitic anhydrite have been emplaced within subtidally deposited carbonates after dolomitization. Intrabiopelgrapestone grainstones, oointrabiopelgrainstones, intrabiopelpackstones and wackestones, and intrapelpackstones and wackestones are the predominant lithofacies. Dolostone is the predominant lithology.

The cored interval was exposed subaerially several times, and episodes of freshwater diagenesis were interspersed with influxes of dolomitizing and anhydritizing fluids. Most dolostone intervals record the following five stages of diagenesis: (1) early dolomitization; (2) emplacement of nonevaporite anhydrite as cement, replacement or a combination of both; (3) dissolution of anhydrite; (4) precipitation of dolomite cement; and (5) emplacement of second generation anhydrite as cement and replacement. Some intervals contain additional stages of diagenesis including precipitation of the clay mineral dickite and calcite as cements.

The core contains many highly porous dolostone intervals, and 9 distinct pore types are preserved. These include primary intergranular, fenestral, and intrabiotic voids; secondary intercrystalline pores; hollow micrite envelopes; biomolds, oomolds and fractures; and tertiary anhydrite molds. The most abundantly represented pores are secondary intercrystalline and tertiary anhydrite molds.

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Hydrocarbon Maturation in Laramide Basins—Constraints from Evolution of Northern Big Horn Basin, Wyoming and Montana

Thermal and mechanical models were used to quantify the effects of Laramide uplifts and subsequent synorogenic deposition on the hydrocarbon maturation of Cretaceous source rocks in the Big Horn basin. Laramide deformation and resultant sedimentation has clearly affected hydrocarbon maturation of Cretaceous source rocks (Thermopolis, Mowry, Frontier, Cody). Modified Lopatin-type reconstructions suggest that a significant region containing Cretaceous source rocks has been within the liquid hydrocarbon window. The earliest onset of hydrocarbon maturation in the northern Big Horn basin was latest Eocene, with some regions still containing immature Cretaceous source rocks as a consequence of Cenozoic erosion, uplift of the Pryor Mountains, and lack of burial.

Regional geologic features indicate that the basin formed as a result of flexural compensation of an elastic lithosphere during emplacement of the Beartooth and Pryor Mountains, and possibly the Absaroka volcanics. This was determined by 2-dimensional models which predict sediment thicknesses caused by tectonic loading and subsequent sedimentation. Flexural rigidities of 10^{21}-10^{22} newton-meters adequately explain flexural subsidence in the northern Big Horn basin.

The present basin configuration also was compared with a theoretical profile based on geologic constraints. Subsidence models for the present basin profile suggest that Paleocene thrusting of the Beartooth block contributes a majority of the tectonic loading and that Cenozoic erosion has drastically affected the resultant sedimentary sequence (Fort Union and Wasatch). These models, along with stratigraphic reconstructions, can be combined to pinpoint areas of potential hydrocarbon maturation within Laramide-type basins.

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Energy in the Reindustrialization of America

America's future industrial growth will depend on our energy growth, and energy growth depends on the choices we make today. In the petroleum exploration industry our choices are based as much on energy and economic analyses and forecasts as they are on geologic factors. The theme of this convention, "Energy, Economics, Exploration—in Transition," is most timely, for these elements are truly in transition now more than ever before in the petroleum industry's history.

Of critical importance is the role of energy in the reindustrialization of America. Energy supply, in whatever form of fossil fuel or alternate source, will determine the success of America's industrial progress in the global community. Without a sound energy base, new industries cannot be started. Without the assurance of adequate energy supplies, existing industries cannot grow or even maintain production on a modest scale. We must therefore carefully examine our energy needs, our energy supplies, and our energy alternatives. We must continually reassess our economic and geologic models to formulate our future petroleum exploration programs to meet our goals. The challenges of America's future economic and industrial growth will be met only if we in the energy-related professions and industries diligently work toward a successful transition in energy, economics, and exploration.

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Normalizing Exploration Functions for Powder River, Denver, and Midland Basins

A method of normalizing exploration functions for petroleum basins leads to an effective basis for comparing their exploration histories. In this study, an exploration function of a basin is a plot of cumulative footage drilled versus cumulative oil reserves discovered. However, 2 different basins may have the same amount of absolute drilling, but one basin may be much smaller and therefore more extensively explored. It is more meaningful to compare exploration functions independent of basin size. One way to do this is to plot the cumulative footage drilled per basin volume versus cumulative oil reserves discovered—i.e., normalizing the exploration functions according to basin size.

Exploration functions and their corresponding normalized functions based on historical data have been drawn for the Powder River, Denver, and Midland basins and their subdivisions. The subdivisions are horizontal depth zones, vertical well density zones, and the blocks formed by the intersections of those zones. The volume used for determining a normalized function corresponds to the volume of sedimentary rock within the basin, zone, or block under consideration.

Results show that normalizing exploration functions makes a difference in the apparent extent to which a basin has been explored. Furthermore, the rate of finding oil and the forecasted total amounts of oil can be determined. Of the 3 basins considered, Midland basin is the best choice for further oil exploration.

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Fast Reservoir Calculations Using Seismic Data and Well Logs

A fast, new technique has been implemented to encourage effective, realistic appraisals of hydrocarbon prospects at an early stage in the exploration of an area. A FORTRAN program using a modest amount of memory uses wavelet-processed, inverted seismic data control and existing petrophysical information to predict the dollar value of in-place reserves at potential drilling locations.

The data base is composed of the following input: (1) an estimate of the volume of closure of the anomaly, determined from conventional seismic structure mapping; (2) spatial distribution of transit times at the level of interest, which contribute to calculation of effective porosity in a volumetric sense; and (3) well-logging parameters such as water saturation, true resistivity, water resistivity, shale fractions, and other coefficients that characterize the properties of the rock system. Also, an interpreter may superimpose a geologic model by smoothing and interpolating such data appropriately.

Recovery of reliable low-frequency velocity information from inversion is critical. Acoustic and electric data are crossplotted to determine, in a statistical sense, how plausible it is that the rock-fluid system being described is the anticipated target zone.

Fast reservoir calculations in the Western Canada and Williston basins have produced reasonable bids for Crown land sales.

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Fracturing and Brecciation Along the Max Meadows Thrust, Southwestern Virginia

Fracturing is an important mechanism of porosity development in deformed hydrocarbon provinces such as the Eastern Overthrust belt, but the sizes and shapes of fractured zones place critical constraints on exploration strategies. Fracturing and brecciation associated with the Max Meadows thrust, along which the Cambrian Rome Formation have been emplaced atop the younger Cambrian Elbrook and Conococheague Formations of the Pulaski thrust sheet, are controlled by lithology, proximity to the fault, and mesoscopic folding. Within the Max Meadows sheet, Rome carbonates are highly fractured and, in fold cores near the fault, brecciated. Rome mudstones and sandstones are tightly folded, and near the fault have developed both an incipient axial planar cleavage and a set of closely spaced fractures striking perpendicular to fold axes. In comparison, the wholly carbonate sequence of the Pulaski sheet had earlier been folded into a large syncline characterized by bedding-parallel shear in shaly and thin-bedded layers, flexural slip folding, and localized fracturing of thick layers. Thus breccia and fracture porosity zones in the study area are highly localized, of irregular geometry, and essentially restricted to the upper thrust sheet. Zones of tectonic breccia and fracture porosity are not attractive exploration targets, then, unless they occur as uniform and widespread broken zones in sedimentologically and mechanically homogeneous beds.

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Determining Pore-Water Salinities from SP Response: A Thermodynamic Reevaluation

Quantitative knowledge of the salinity of deep formation waters is critical in assessing the degree of hydrocarbon saturation in sands, in predicting methane solubility, and in deducing pathways of fluid migration. Calculation of salinity from the spontaneous potential (SP) response of borehole logs using conventional algorithms can yield inaccurate values, particularly for geopressured waters. Thus, a theoretical reevaluation has been made of the relation between pore-water salinity in NaCl-dominated waters and SP response, taking into account pressure as a variable and recently-developed, improved, thermodynamic models for brines.

The following expression satisfactorily relates pore-water salinity, as molality of total dissolved NaCl, to the static spontaneous potential (SSP) over P-T-salinity conditions of sedimentary interest:

$$\log m\,\mathrm{NaCl}\,(\text{pore water}) = (\mathrm{SSP} \times \mathrm{F})/(2.303\,\mathrm{RT} \times b \times t) + \log m\,\mathrm{NaCl}\,(\text{mud filtrate})$$

where m = molality, F = faraday constant, R = gas constant, and T = absolute temperature. The complex, non-ideal behavior of NaCl solutions can be described by a single, pressure-temperature dependent, concentration independent variable, b. The term t accounts for the differential mobility of Na^+ and Cl^- ions through sands and shales.

Use of the equation provides several important advantages over conventional techniques: (1) pore water salinity is given explicitly as a dependent variable, facilitating analysis of error; (2) the expression is simple and avoids use of electrical resistivities, which have no direct theoretical role in the relation between SP and salinity; (3) the improved thermodynamic base provides a more rigorous means of assessing the effects of grain size, mineralogy, and streaming potential on SP response.

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Western Gulf of Mexico Continental Slope Geology, Hazards, and Processes Atlas

An analysis of approximately 18,074 km (11,231 mi) of high-resolution geophysical records (3.5 kHz and 1,000-joule sparker) in the western Gulf of Mexico has delineated relationships between sedimentation patterns, diapiric activity, tensional tectonic features, and sediment instability. The continental slope of the Gulf of Mexico is the most promising petroleum frontier on the conterminous United States continental margin. However, adequate regional geologic information with which to conduct lease sales and manage lease operations does not exist. Mapping was done at 1:250,000 and selected features were synthesized on a regional scale of 1:1,000,000 as part of the U.S. Geological Survey Continental Margin Mapping Project. Because the reconnaissance spacing of the tracklines makes topical investigations difficult, in a few areas the U.S. Geological Survey has gathered more closely spaced lines to examine particular features. Analysis of one of these areas near the large slide reported by Lehner in 1969 indicates a possible relationship between rapid sediment loading and diapiric rise.