

steam field, California, hot water fields in California, Nevada, Utah, and Idaho, and the LASL hot dry rock project in the Valles Caldera of New Mexico.

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Global Occurrence of Abnormal Formation Pressures

In the worldwide exploration for hydrocarbon resources both onshore and offshore, abnormal formation pressures have been encountered in all continents. Such abnormal formation pressures are defined as any departure from the normal hydrostatic pressure at any given depth.

Abnormal subsurface pressure environments occur as shallow as only a few hundred feet below the surface or at depths exceeding 25,000 ft (7,620 m). These abnormal pressures can be present in clastic sequences or massive evaporite and carbonate sections on a regional or very limited, localized basis. Sediments of Pleistocene age to as old as Cambrian age contain abnormal pressures.

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Modification of Linear Sand Ridges by Bed-Form Migration—Bering Sea and United States Atlantic Shelf

Linear sand ridges are a dominant topographic feature of the United States mid-Atlantic shelf and the northeastern Bering Sea, as well as other coastal plain shelves of the world. Similarities in geometry, lithology, and stratigraphy of ridges in these two areas of markedly different oceanographic environments reflect a similarity in the processes that modify and shape these ridges.

The best development of ridge topography occurs on the Atlantic shelf off Maryland where all stages of formation and modification can be identified. Progressive changes in ridge shape and relief and in bed-forms occur from onshore to offshore. Side slopes of ridges demonstrate characteristic trends related to water depth, and textural properties are 90° out of phase with topography. Historical documentation, seismic reflection and vibrocore data, and sonographs of migrating sand waves all indicate southward migration of ridges, the dominant direction of storm-directed bottom flow.

Ridges in the Bering Sea are exposed to a strong unidirectional and continuous flow of water northward into the Bering Strait. Repeated surveys of these features show that families of large north-facing sandwaves undergo migration infrequently. These periods of transport occur only when the strong oceanic flow is reinforced by northward storm-driven currents.

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Diapir-Like Ridges and Possible Hydrocarbon Occurrence, Northern California Continental Margin

The Eel River basin of northern California contains a relatively thick (>4 km) section of Miocene, Pliocene,

and Quaternary fine-grained sedimentary rocks that extends more than 200 km northward from Eureka along the shelf and adjacent Klamath plateau. The east margin of the basin is a fault contact with the coastal belt Franciscan assemblage; the west margin is defined by a zone of uplift along the outer plateau-upper slope. This uplifted zone is characterized by a series of north-south trending ridges that rise as much as 200 m above the adjacent seafloor and against which Quaternary sediments thin.

Seismic reflection profiling and coring studies of these ridges have shown them to be diapiric. Quaternary sediments thin against the eastern flanks and are generally absent on the upper flanks and crests of the ridges. Many of the ridges are bounded by one or more faults showing large vertical separation. Seismic reflection records show internal structure of ridges to be homogenous and acoustically opaque, or to consist of faulted and deformed strata. Ridge crests are irregular in surface topography and are presumed to be highly deformed. Shallow cores from ridge crests contain stiff clayey silts of Pliocene age.

A 2-m core from ponded sediments on the crest of one of the diapir-like ridges contained significant amounts of gasoline-range hydrocarbons as well as anomalously high quantities of gas in the methane to butane range. We infer that these hydrocarbons are derived from sediments deeper in the Neogene sedimentary section and are being released through fractures in the ridges. Deformation of young surface sediments in ridge areas indicates that uplift is presently occurring along the 200-km long lineament defined by the ridges. These diapir-like ridges may prove useful targets for evaluating the hydrocarbon potential of the offshore Eel River basin.

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Structure and Hydrocarbon Potential of Kodiak Shelf, Alaska

The Albatross basin underlies the southwest one-third of the Kodiak shelf, Alaska, and contains about 5 km of gently to moderately deformed rocks that are as old as late Miocene or Pliocene. The seaward limit of the basin is a large, northeast-trending anticline that underlies the shelf break.

The Dangerous Cape high, northeast of Albatross basin, is distinguished from the basin by shallow depth (1 to 2 km) to the base of reflective strata, by decreased relief of structures that underlie the shelf break, and by the central-shelf uplift. This uplift lies midway between Kodiak Island and the shelf break and is made up of several anticlines cut by numerous, northeast-trending reverse faults. Based on seismic evidence, deformed, nonreflective Paleogene rocks are inferred to unconformably underlie the less deformed upper Miocene or Pliocene reflective rocks.

Stevenson basin, northeast of the Dangerous Cape high, includes two subbasins that are separated by the northwest-trending Portlock anticline. The southwest subbasin contains as much as 4 km of rocks, and the northeast subbasin contains as much as 5 to 7 km.

Rocks that fill both subbasins are probably as old as late Miocene or Pliocene and are gently deformed, except near the Portlock anticline and near the shelf-break uplift.

If hydrocarbon-source characteristics of rocks offshore are similar to those of rocks onshore, good hydrocarbon source rocks do not underlie the shelf. Eocene through middle Miocene rocks onshore, and upper Miocene or Pliocene rocks offshore, contain less than 0.5 wt % organic carbon, which is predominantly of herbaceous and humic origin. The volume of total extractable hydrocarbons (C_{15+} Soxhlet extraction) from onshore Eocene through Miocene rocks ranges from 165 to 412 ppm. Offshore upper Miocene and Pliocene strata are thermally immature. Paleogene rocks, which are thermally mature, are the most likely sources for any hydrocarbons generated offshore, although indications are that they are low-quality sources.

Onshore Paleogene rocks generally have poor reservoir properties—porosities range from 1 to 10% but most are less than 5%, and permeabilities are less than 1 md. The best offshore reservoirs are probably in late Miocene and younger strata.

Structural traps for hydrocarbons include Portlock anticline, anticlines in the central-shelf uplift, and parts of Albatross Bank.

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Dipmeter Validity in Deviated Bore Holes

Usually, offshore field development wells will be drilled as highly deviated bore holes and evaluated by a series of logs including dipmeters. Dipmeters run in a deviated bore hole have often been treated with the same respect for validity of accuracy as any regular dipmeter run in a practically vertical bore hole. However, when the formations exhibit small dip magnitudes (from the horizontal) and are penetrated by rather highly deviated bore holes, accuracy of the dipmeter results should be held suspect. Recent work has indicated any small error in any one of several instrument measured parameters can result in an error in the final dipmeter results such that the formation dip magnitude will be erroneous and even the dip direction can be wrong.

Errors in relative bearing and bore-hole diameters (including caliper accuracy and pad depth of investigation) are the most susceptible to causing errors in the final computed results. This could have serious consequences in that erroneous dip vectors would be displayed as valid dip vectors. Unfortunately it is almost impossible, even for an "expert," to visibly determine that wrong dipmeter vectors have been plotted as the result of poor input data.

Several actual and theoretical dipmeter computation results will be presented wherein a controlled amount of error will be deliberately introduced to show its effect upon the computed dip vectors.

Results of these computations indicate that to give consistently good dipmeter results under most conditions encountered in highly deviated bore holes, practically all of the instrumentation must perform at accu-

cy levels considerably in excess of current instrument capabilities to yield results of the same quality as those obtained in nearly vertical bore holes.

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Ebb-Tidal Delta Stratification and Its Relation to Tidal Inlet Processes

Shallow, high resolution seismic reflection profiles at nine tidal inlets along the South Carolina coast have shown that ebb-tidal delta stratification is dominated by small to large-scale accretionary beds associated with channel cutting and infilling sequences. The deeper parts of the ebb-tidal delta (15 to 25 m) are comprised chiefly of shallow-landward and seaward-dipping beds (3 to 6°) and horizontal stratification. These beds represent initial sedimentation in large channel-fill sequences and original delta deposits. At intermediate depths (5 to 15 m) the stratification is dominated by large-scale (2 to 5 m in height) multidirectionally dipping accretionary beds (3 to 15°) that were formed owing to channel migration. Small channel cut and fill deposits are also prevalent at this depth. The upper delta is characterized by laterally continuous landward-dipping foresets formed by landward-migrating swash bars. Because of the depth of the ebb-tidal delta sediments (25 to 30 m) their preservation through a transgression appears likely.

The development of this stratification is caused by a southerly migration of the inlet's main ebb channel through the ebb-tidal delta sediments. Eventually, the channel becomes hydraulically inefficient and a new channel is breached through a spillover lobe to the north. The abandoned channel is then filled with sediment that is derived from seawash sand shoals which flanked the old main ebb channel and with sand that is transported seaward in the new main ebb channel. The landward transport of sand which causes an infilling of the abandoned channel and a southerly migration of the main ebb channel is the result of accretion through bed-load sediment transport and landward-migrating swash bars.

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Petroleum Potential of Basin and Range Province, Western United States

Five oil fields have been discovered within the Basin and Range province of the western United States. They are Eagle Springs (1954), Trap Spring (1976), and Curran (1978) fields in Railroad Valley graben of east-central Nevada, and in the Great Salt Lake area of Utah, Rozel Point (circa 1904) and West Rozel (1978) fields. Rozel Point and Curran fields are non-commercial accumulations. Reservoirs are either fractured Oligocene ignimbrites, Eocene lake sediments, or fractured Miocene-Pliocene basalts. Accumulations occur in truncation-fault traps or in drape over faulted structure. The source of the oil is believed to be Tertiary lake deposits and/or Chainman Shale of Mississippian age.