The Salinas basin has predominantly barren surface anticlines. The heavy oil giant, San Ardo, was found accidentally on a surface syncline. Finding new traps in this basin requires stripping back the stratigraphy to the time of accumulation, generally late Miocene. One starts at the top with the best available surface geology and geomorphology. The tilted Gabilan Mesa peneplain surface can be untilted by isopaching the thickness from the Mesa surface to the top of the Miocene. At this point we have a map of the structure before the late Pliocene to Recent deformation. San Ardo shows up at this point with 400 ft (122 m) of closure exactly coinciding with the present outline of the oil field and matching the 400-ft (122 m) oil column, in marked contrast to the present day structure contours on the producing horizons. Further isopaching of discrete stratigraphic intervals within the upper part of the Miocene produces a picture of the structure shortly after the deposition of the producing zones. In addition, shoreward sand strandlines and seaward sand shale-up lines can be defined. Analysis of this geologic history also shows the probable location of deltaic areas and longshore bars. Early loci of oil accmulation and wedge edges of permeability are apparent from this synthesis. Several small oil fields of the Salinas basin have been found deliberately by unraveling the subtle geologic history to the time of accumulation and deposition.

GRUNAU, H. R., Petroconsultants, Bern, Switzerland

Worldwide Review of Seals for Major Accumulations of Natural Gas

About 62% of the caprock seals for the world's 176 giant gas fields are shales and about 38% are evaporites. These two lithologies make up essentially all of the caprock for the 2,650-Tcf of gas expected to be recovered from these fields. Caprock thickness data is lacking from many fields, but 20 to several hundred meters are typical.

Optimal conditions for seal preservation occur in areas which had a comparatively simple geologic evolution. Complex fold belts and overthrust belts are commonly subject to seal destruction. Of the world's 25 largest gas fields, 21 are in cratonic settings and four in fold belts; those in fold belts have evaporite seals.

Lateral continuity of caprock has a favorable impact on the retention of gas over large areas such as the Arabian platform.

Gas hydrate accumulations illustrate both seal and reservoir. Seal destruction is caused by changes in the phase equilibrium.

Considerable multidisciplinary research still needs to be done to quantify knowledge of seal prediction for giant gas fields.

GUANGMING, ZHAI, China National Oil and Gas Exploration and Development Corp., Beijing, China

Buried-Hill-Type Oil Fields in Northern Part of China

Large-scale exploration for oil and gas started in north China during the 1960s, with Tertiary formations considered the main exploratory objective. In 1975, oil finds in Sinian dolomite beneath the Tertiary unconformity led to the discovery of the prolific Renqiu oil field, a buried-hill type. Since then, there has been intensified exploration for buried-hill oil pools. To date, more than 40 buried-hill oil and gas pools, and nine suites of oil-bearing formations, have been discovered. Reserves from these oil fields constitute 22% of the regional total, and current production accounts for 30% of the total. The success ratio in the exploration for hydrocarbons in the buried hills is 10 to 30%.

Based on the distribution of source rocks, and the pattern of oil migration, the buried-hill oil fields are categorized as follows: (1) hydrocarbons migrated into the reservoir through the unconformity surface and the fault planes, (2) through the unconformity surface, (3) through the fault planes, and (4) through the fault planes and then along the unconformity surface.

Two main types of the buried hills are classified according to the characteristics of their development during the Tertiary: (1) subsidence type, and (2) elevation and denuded type. The two types of reservoirs form a composite oil and gas accumulation zone with distinctive reservoir sequences. These factors provide a theoretical basis for finding various types of oil and gas pools on different parts of the buried hills.

GUTSCHICK, RAYMOND C., Univ. Notre Dame, Notre Dame, IN, and CHARLES A. SANDBERG,* U.S. Geol. Survey, Denver, CO

Mississippian Continental Margins of Conterminous United States

The paleogeographic, paleotectonic, and paleobathymetric reconstruction of continental margins around the present western, southern, and eastern sides of the conterminous United States can be defined for a brief span (about 1.5 m.y.) of Mississippian time. Interpretations are made by applying a biostratigraphic and sedimentological model for the Deseret starved basin of Utah and Nevada to recently published shelf-margin studies. The time span is that of the middle Osagean *anchoralis-latus* conodont zone. Precise dating and paleobathymetric interpretations are based on the biostratigraphy and paleoecology of conodonts, and also of corals, calcareous and agglutinate foraminifera, and radiolarians. At this time, a shallow tropical sea covered most of the southern North American craton and was the site for sedimentation of a broad carbonate platform. Surrounding this carbonate platform was a starved trough comprising several bathymetrically distinct starved basins. These starved basins lay on the inner (continentward) sides of foreland basins that were bordered on their outer sectors by orogenic highlands. The highlands formed in response to convergences or collisions with the North American continent by an oceanic plate to the west, by South America to the south, and by Africa and Europe to the east. During a eustatic rise of sea level that accompanied the orogenies and reached its maximum during the *anchoralis-latus* zone, the carbonate platform prograded seaward and carbonate sediments cascaded over the passive shelf margins to intertongue with thin carbonate slope deposits and very thin (~10 m) phosphatic basinal sediments. Simultaneously, thick (~500 m) flysch and deltaic terrigenous sediments, such as the Antler flysch on the west and the Borden and Pocono deltaic deposits on the east, were shed into the outer parts of the foreland basins from active margins along the orogenic highlands. This Mississippian reconstruction provides a unique opportunity for comparing and contrasting shelf-slope boundaries in parts of contemporaneous passive and active margins on three sides of a Paleozoic continent.

HALBOUTY, MICHEL T., Consulting Geologist and Petroleum Engineer, Independent Producer and Operator, Houston, TX

The Time is Now for All Explorationists to Purposefully Search for Subtle Trap

Geologists and geophysicists have made little effort to purposefully search for the subtle traps—stratigraphic, unconformity, or paleogeomorhic—because of (1) motivation to continue looking for structures which can be found with present-day tools and ideas, and (2) the pressure exerted on explorationists by their knowledge that anticlines, domes, and fault structures are more acceptable to management. As a result, our domestic exploratory successes during the past decades have been declining not only in number of fields found annually, but also in the quality or economic worth of the fields.

Hidden trends may occur below unconformities, at undrilled depths in productive trends, and in relatively unexplored regions. Hidden features may be ancestral anticlines and domes, faults, stratigraphic traps, and buried geomorphic features. The difference between these hidden features and the obvious type is that the former are not obvious to present-day exploratory methods and thinking. Many of these probably can now be found, but only if we point our methods and thinking toward them, not around them.

Domestic explorationists must make a turn in the direction of purposefully looking for the obscure trap. The large domestic reserves required for the future are contained in hidden trends and features. If we are to succeed in finding them, geologists and geophysicists, and, equally, management, will have to place greater emphasis on the deliberate search for the subtle trap. In this search, emphasis must be placed on detailed study and research in stratigraphy, paleogeomorphology, paleogeography, paleostructure, paleontology, and palynology.

HALLEY, ROBERT B., U.S. Geol. Survey, Lakewood, CO

Burial Cement in Sunniland Reservoirs, Lower Cretaceous of Southern Florida

Loss of porosity in the Sunniland Limestone is the result of processes associated with burial of the formation to its present depth of about 3,400 m. Early diagenetic alteration was a relatively minor factor in porosity loss. Significant processes which reduced porosity are mechanical compaction (dewatering, grain fracture, and deformation), chemical compaction (stylolitization, both on a macro and micro scale, and interpenetration of grains along contacts), and burial cementation. Burial cements, the product of chemical compaction and calcite solution transfer, are most evident in grainstones, including Sunniland reservoir rocks.

Three petrographically distinct burial cements are recognized as: (1) scalenohedral or dogtooth calcite, of grain size generally less than 100 $\mu$m, filling primary porosity and fractured by burial pressure; (2) equant or blocky calcite, of grain size generally larger than 100 $\mu$m, filling primary, secondary, and fracture porosity, and commonly poikilotopic; and (3) equant or baroque dolomite, of grain size generally larger than 100 $\mu$m, filling primary, secondary, and fracture porosity, occasionally poikilotopic, with larger grains exhibiting undulatory extinction and curved crystal faces.

These cements account for as much as 30 to 40% porosity loss in some grainstones and are present to a lesser extent in most reservoir rocks.

Isotopic analyses of cements ($\delta^{18}O$, $\delta^{13}C$) and water ($\delta^{18}O$) are consistent with an interpretation that these cements formed in the subsurface over a range of temperatures (about 40 to 100°C) in pore water that was continually modified by dissolving Suniland calcite. Quantification of these processes requires accurate predictions of the rate of calcite solution transfer. Estimates of this parameter suggest that very little cement is precipitating now and that most cementation was complete before the Oligocene (burial depth about 3,000 m).

HANDFORD, C. ROBERTSON, Louisiana Geol. Survey, Baton Rouge, LA

Facies Anatomy of Modern Continental Sabkha, Bristol Dry Lake, California

Bristol Dry Lake is a 155-sq km fluvial-lacustrine dominated, continental sabkha, or playa, in the Mojave Desert of southeastern California, and is filled with at least 300 m of interbedded terrigenous clastics, gypsum, anhydrite, and halite. The evaporite facies roughly form a bull's-eye pattern with abundnat gypsum and anhydrite surrounding a basin center accumulation of halite. Transects through Bristol Dry Lake, from the alluvial fan and sand flat to the center of the playa, reveal (1) crudely bedded, coarse-grained clastics prograding over and interfingering with either (2) wadi (alluvial/eolian) sand and silt, or (3) mud-flat facies of nodular to enterolithic gypsum or anhydrite and blades of gypsum in red-brown silt and clay, followed by (4) saline mud-flat facies of red-brown silt and clay crowded with giant (15 cm diameter), displacive, hopper-shaped crystals of halite, and (5) salt-pan beds of chaotic mud-halite up to 4 m thick in the center of the playa.

Deposition of terrigenous clastics was by fluvial-sheetflood processes around the toes of alluvial fans, fluvial flow through very shallow rills and suspension settling in the mud-flat environments. Much of the sediment is reworked by eolian processes. Evaporites are precipitated at or just below the sabkha surface from discharging brines.

Lithofacies of this modern continental sabkha are nearly identical to those comprising the Middle-Upper Permian evaporites of the Texas and Oklahoma panhandles, and they are excellent process analogs for ancient facies analysis.

HANOR, JEFFREY S., Louisiana State Univ., Baton Rouge, LA

Control of Early Carbonate Diagenesis by Carbon Dioxide Production and Loss

The early diagenesis of recent marine carbonate sediments is pervasive and rapid in coastal ground-water systems characterized by the dynamic influx and mixing of meteoric and marine waters. In coastal areas subjected to high and continuous seaward fluxes of meteoric water, such as the eastern coast of Yucatan, extensive dissolution and removal of carbonate result simply from the physical mixing of meteoric and marine waters. However, comparative studies of coastal phreatic systems on St. Croix, Bermuda, and Jamaica demonstrate that where there is a marked seasonal variation in the influx of meteoric waters, carbonate dissolution and precipitation become progressively controlled by the in-situ production and loss of $CO_2$. In seasonally variable systems, rates of $CO_2$ production are controlled primarily by the availability of oxygen and the abundance and type of organic water episodically introduced into the pore waters and sediment. Rates of $CO_2$ loss are controlled by the dissolution of carbonate and by vertical mass transport resulting from the spatially and temporally variable processes of diffusion, dispersion, and hydraulic pumping.

A quantitative mass transport model has been developed to evaluate the diagenetic response of a vertical, magnesian