highly drilled areas. One of these identified subbasinal areas has emerged as productive and subsequent to this analysis has continued to gain momentum and recognition as a major producing trend.

Color-coded computer maps summarize the degree of drilling saturation for shallow, moderate, deep, and ultra deep stratigraphic sections. Statistics gathered during the study indicate that at present drilling rates certain areas will require hundreds of years before even a moderate degree of saturated testing will be achieved. This lends support to the position that considerable additional hydrocarbon reserves can be found, but in more remote areas, deeper sections, and at higher costs.

The study illustrates the importance of adequate structured computing resources for historical well data storage, data base accessing, applications processing, and computer graphical display.

MAY, JEFFREY A., Marathon Oil Co., Littleton, CO

Progradational Conglomeratic Shoreline, Eocene of San Diego

Published examples of conglomeratic sandstone shorelines are extremely rare. Two different middle to late Eocene facies sequences reflect variable proximity to sediment influx and high-energy domination. Storm-generated deposition predominated away from fan-delta input. A tripartite coarsening-upward transition represents an offshore to shoreface succession. The lowermost mudstone contains graded rhythmites, starved ripples, flame structures, and bioturbated zones, indicating alternating low- and high-energy offshore deposition. Overlying sheet sandstones thicken and amalgamate upward, denoting shallowing and increased storm deposition still below fair-weather wave base. These beds contain a basal lag overlain by planar laminae, then hummocky cross-stratification, and finally wave-ripple laminae. Coarse-grained, cross-stratified, upper-shoreface sandstone caps the seqeunce.

In contrast, sedimentation associated with subaerial flooding dominated a coarsening-upward sequence seaward of and truncated by an alluvial fan. T_{bce} turbidites characterize offshore deposition below fair-weather wave base. Thick climbing-ripple intervals and intervening unburrowed rhythmites indicate high sedimentation and/or freshwater influx. The overlying fine-grained, planar-laminated, lower-shoreface sandstone also lacks bioturbation and contains isolated cobbles surrounded by scours. An enigmatic succession of lensoid sandstone bodies, each 2 to 10 m wide and draped by mudstone, caps this sequence. Upper surfaces of these antiformal beds create a swell-and-swale topography. Internally, planar laminae pass upward to trough cross-stratification, then an upper organic-rich, muddy zone with *Ophiomorpha* and *Gyrolithes* burrows. Subaqueous channeling and/or bar formation in front of the fan delta, with intervening quiescent periods, are suggested.

MAYNE, W. HARRY, Geosource Inc., Houston, TX

Evolution of Offshore Seismic Exploration

True offshore seismic exploration had its inception in 1947. Although considerable work had been done prior to this in coastal estuaries, wetlands, and inland waterways, the methods used were adapted almost entirely from the conventional land operations.

The first tentative ventures into the real offshore environment indicated that radical departures from land procedures were required in the following areas: (1) cables and receivers, (2) positioning (surveying, navigation), and (3) seismic energy sources.

Leroy Paslay's continuous tow streamer cable and the replacement of the velocity-responsive geophones with pressure-sensitive hydrophones were significant early breakthroughs.

At first, line positions were determined by land-based optical surveying methods, and shot locations were marked with buoys placed by wire-line distance measurements or triangulation. As work progressed farther offshore, a number of radio location systems were adapted or developed to provide positioning without the need for marker buoys. The present satellite and inertial navigation systems and the projected development of the new Global Positioning System represent continuing developments in this area.

Dynamite and other chemical explosives were exclusively used as seismic sources for a number of years despite their many disadvantages. Development of suitable non-dynamite energy sources was mandated by the advent of the common reflection point method, and the Lamont-type air gun has become the most popular present-day source.

Concurrently, the vessels used were progressively upgraded from converted shrimp boats to surplus air-sea rescue vessels and then to the currently popular 165 ft mud boats.

Individually, these developments may appear to be only evolutionary. In the aggregate, however, they represent a major revolution when compared to our first timid ventures of the late 40s.

MAZZULLO, S. J., Consultant, Midland, TX, and JOHN M. CYS, Mapco Inc., Midland, TX

Extensive Coniatolite-Pelagosite Diagenetic Sedimentation in Marine Limestones, Tansill Formation (Permian), New Mexico

Pelagosites (calcareous crust formed in splash zone) and coniatolites (supratidal tufa) composed of inorganic precipitates of aragonite and some high-Mg calcite have been described from Holocene deposits along the western Persian Gulf and elsewhere. Such diagenetic deposits are believed to be restricted to intertidal and supratidal environments, and are only rarely encountered in ancient carbonate rocks. Laminated encrustations, coated grains, and pseudostromatolites of presumed former aragonite mineralogy, all associated to some extent with encrusting marine fossils, are the dominant if not exclusive components of shallow-marine limestones in the Tansill Formation (back-reef facies of the Capitan) in New Mexico.

These deposits occur in shallow back-reef environments of possible hypersaline character. In landward directions, they are replaced by peritidal dolomites. The vertical and lateral occurrence of particular coniatolite-pelagosite structures is related to the hydraulics of the depositional environment in a manner somewhat similar to that which controls algal laminite and stromatolite distributions in modern and ancient deposits. Internally, the laminae of crystalline calcite in these deposits are interlayered with the alga *Archaeolithoporella* and encrusted by *Tubiphytes*. Petrographically, this crystalline calcite consists of square-tipped crystal ghosts and divergent fan-druses in neomorphic sparry mosaics identical to altered aragonites described from other ancient carbonates.

These deposits are similar to the coniatolites and pelagosites described from the Holocene, but represent the first reported occurrence of extensive diagenetic sedimentation of this type in ancient shallow-marine carbonate rocks.

MCBRIDE, JOHN H., Univ. Chicago, Chicago, IL

Significance of Corallite Patterns in Fossil Anthozoan Colonies

Polygonal patterns of corallites in fossil anthozoan colonies have been traditionally explained as a result of close packing arising from space compaction. Such a view envisages polygonal cor-

allite patterns as "fabricational noise" while ignoring any possible phylogenetic constraints. This study rephrases the question of the adaptational significance of fossil corallite patterns.

The set of all possible two-dimensional mosaics of regular, identical polyhedra consists of triangular, square, and hexagonal nets, and thus represents a simple *constructional* constraint on pattern in a developing or evolving colony of anthozoan polyps. A regular hexagonal pattern of corallites possesses the utmost possible reduction of surfaces in contact by way of equal-angle triple junctions. This makes a regular hexagonal array to be ideally most efficient. However, most polygonal patterns of corallites deviate from this ideal with a particular pattern often being characteristic of a taxon. For example, a less efficient, irregular pattern may be common for one particular group (e.g., *Eridophyllum*) but a regular hexagonal array for another (e.g., *Hexagonaria*). This deviation from ideal form leads to the recognition of a second, *phylogenetic* constraint on corallite pattern.

The significance, constructional versus phylogenetic, of pattern development can be better understood by also considering the ontogeny of individual corallites in a colony which shows a hexagonal array. Within the continuum of varieties of colony patterns, polygonality first appears in cerioid forms. Transitional phaceloid/cerioid colonies of the Lithostrotionidae demonstrate that corallite centers do not closely approach one another until their margins are actually in apposition. It is at this stage of margin contact that hexagonality is achieved, not at the onset of close packing.

Hexagonality in fossil anthozoans is concluded to have probably first arisen in cerioid colonies as an adaptation to maintain and further a higher level of colony integration.

MCCARTHY, HARRY, DOUGLAS V. FLINT, and JOEL GEHAUF, Synfuels Engineering Development Inc., Golden, CO

Economics of Scale Versus Completion Risks, Cottonwood Wash Oil Shale Project, Uinta Basin, Utah

The major problem plaguing the synfuels industry is the financing of large capital requirements in a technologically unproven field. This is exemplified by the two to three billion dollar investment required by oil shale development. Despite an unquestionable resource which is well characterized and a wealth of information from processes which have undergone extensive pilot development work, financing of a project is difficult because of the risk.

In recent studies on a worldwide basis as a background for evaluating the Cottonwood Wash Project in the Uinta basin, Utah, we have shown that the concept of small scale or modular development of this type of resource can lead to acceptable economics with a substantially higher probability of actual completion. This small scale or modular system approach may be applied to other synfuel developments.

This paper discusses Uinta basin oil shale resources and current developments and evaluates the economics of small scale or modular development for the Cottonwood Wash Project processes. This evaluation shows the effects of such a development in reducing the project's economic and technical risks.

MCCOY, ALEX W., III, and CARL A. MORITZ, Alex W. McCoy Associates, Inc., Tulsa, OK

Countess Oil Field, South-Central Alberta, Canada: Case History in Finding a Stratigraphic Trap

The Countess field produces oil and gas from zones in eight geological formations from the Upper Cretaceous Belly River to the Mississippian Pekisko. The principal producing zones are the Lower Cretaceous Glauconitic and Ostracod (Mannville) Sandstones, at an average depth of 1,097 m (3,600 ft). These zones were deposited as offshore sandstone bars on submarine topographic highs, caused by underlying Pekisko cuestas. The bars are encased in marine Mannville shales. The sandstones are gray to brown, fair to well-sorted and subrounded to rounded. Porosities average 22%; permeabilities average 580 md. Reservoir thickness averages 9.75 m (32 ft). The productive sandstones cover approximately 4,243 hectares (10,500 acres). The reservoir contained approximately 34,136,000 cu m of oil (215,000,000 bbl) of which approximately 12,288,000 cu m (77,300,000 bbl) or 36% will be recoverable. In addition, the reservoir contained 3,826,000,000 cu m of gas of which 60% or 2,295,000,000 cu m (81,500,000,000 cu ft) will be recoverable. Other formations will produce 32,980,000,000 cu m of gas. Twelve dry holes, drilled prior to November 1965, a drilling density of 1.7 wells per township, indicated the probable presence of this stratigraphic trap. A wildcat drilling program of 34 wells was designed to explore the seven townships. Three of the first four exploratory wells were dry. One was a discovery. Finally, seventeen of the exploratory wells were successful and seventeen were dry. The statistical exploration method, an adequate number of wildcat tests, for this large geographical area resulted in the ultimate exploratory success.

MCCOY, SCOTT, JR., Amoco Production Co., Denver, CO

Gulf of Alaska: A Cold Bath

The Gulf of Alaska continental shelf has proven to be one of industry's major disappointments in hydrocarbon exploration during the last decade. Eight of the nine major structures leased for 560 million dollars in the 1976 OCS Sale 39 have been drilled without finding commercial hydrocarbons. Thermal immaturity of the potential source rock, extreme depth of as yet untested potential reservoirs, and problems caused by overpressured shales have all contributed to the lack of success.

Stratigraphy and structure are the result of the northwestward movement of the Gulf of Alaska microplate. Movement is primarily in conjunction with the Pacific plate although there is minor oblique subduction beneath it. Progressive deformation from the northwest toward the southeast is the result of collision with the North America plate. OCS Sale 39 was located in the area of growing anticlines and active deformation. OCS Sale 55, held in 1980, and the subsequent reoffering sale in 1981 were on the relatively undeformed southeastern part of the plate. Prospective horizons in this area lie at much shallower depths, but the lack of significant structures and unknown thermal maturity of the source rocks tend to downgrade prospects in the area which is untested to date.

MCCRACKEN, WILLARD A., Texaco USA, Bellaire, TX

Recognition of High Gradient Braided Stream Deposits, Sespe Formation (Tertiary), Ventura Basin, California

Lower Sespe arkosic sandstones and petromictic conglomerates of late Eocene and Oligocene age rim the Ventura basin in California and are interpreted as high-gradient, braided river deposits. Lower Sespe deposits contain a high ratio (over 20/1) of bedload/suspended load. Lenticular, poorly sorted, imbricated, bar-shaped conglomerate units interbedded with graded to parallel-laminated sandstone beds are typical of lower Sespe deposits. Graded and reverse graded conglomerate units, graded