HELMOLD, KENNETH P., Stanford Univ., Stanford, Calif.

Diagenesis of Tertiary Arkoses, Santa Ynez Mountains, Santa Barbara and Ventura Counties, California

The stratigraphic distribution of authigenic minerals in feldspar-rich sandstones from tectonically active settings is important in determining reservoir quality. Scanning electron microscopy (SEM), optical microscopy, and X-ray diffractometry were utilized to determine the types and distribution of secondary minerals in Paleogene sandstones of the Santa Ynez Mountains, and to determine their paragenesis. Four main types of authigenic minerals are present: (1) early-stage phyllosilicate pore linings and pore fillings; (2) silicate overgrowths on quartz, plagioclase, and K-feldspar grains; (3) middle-stage zeolite (laumontite) replacement; and (4) late-stage calcite replacement. The honeycomb structure and high iron and magnesium content indicate that the clays are *montmorillonite* or *chlorite* type or possibly a close mixture of the two. Microanalyses show that regardless of the composition of the nucleus all plagioclase overgrowths are chemically pure albite. Authigenic albite also occurs as fracture fillings in plagioclase grains. K-feldspar overgrowths were recognized on both microcline and perthite grains. SEM photographs of quartz overgrowths reveal the same paragenetic sequence as described by E. Pittman; isolated incipient overgrowths with well-developed rhombohedral and prism faces which coalesce to partly or completely envelop the nucleus. Within the most deeply buried sandstones laumontite occurs as (1) patches interstitial to framework grains; (2) alterations within plagioclase grains; and (3) displacive patches along the cleavage of detrital biotite. Some interstitial laumontite may be pore filling, but most is believed to be replacement of calcic plagioclases. The analyzed laumontite is a pure Ca-Al hydrous silicate with only minor amounts of sodium, potassium, and iron. The first appearance of laumontite in the eastern and central parts of the basin is at vitrinite reflectivities of 1.1 and 1.3% $R_o$ respectively, corresponding to an estimated paleotemperature of 200°C. Calcite ranges from less than a few percent to almost 50% in some samples and is the latest authigenic mineral, replacing quartz, feldspar, and in rare instances laumontite. The authigenic minerals present in the lower Paleogene sandstones of the Santa Ynez Mountains render them ineffective as reservoirs.

HELWIG, JAMES, Atlantic Richfield Co., Dallas, Tex.

Plate Tectonics, Basin Analysis, and Exploration

The purpose of basin analysis in exploration is to predict oil and gas occurrence. Successful prediction requires (1) an understanding of the physical processes of generation, migration, and trapping of oil and gas, and (2) a certain minimum of geologic information. Capabilities of basin analysis are expanded as we develop better links between the theory of plate tectonics that has revolutionized global geology and the specific geologic events and processes that determine oil and gas occurrence on the scale of a basin. By developing reliable tectonic models of physical processes, the artful prognosticator can obtain improved results in exploration of frontier provinces where geologic information is severely limited.

In these circumstances, plate tectonics can be directly and reliably applied to problems of the pattern and timing within a basin of structures, subsidence, uplift, igneous activity, and thermal maturation, as illustrated by North Atlantic basins, California, Alaska, and elsewhere. An advantage of the tectonic approach to basin analysis is that it stimulates an integrated review of geologic and geophysical data with emphasis on timing of geologic events. It remains questionable whether plate tectonics can be applied to problems of the distribution of source and reservoir rocks or of hydrocarbons on the scale required for exploration of a basin.

HENDRY, HUGH E., Univ. Saskatchewan, Saskatoon, Saskatchewan

Resedimented Conglomerates in Submarine Channel, Miocene Flysch of Northern Appennines, Italy

The Marnoso-arenacea Formation (Miocene) near Bologna contains a well-exposed, turbidite-filled channel. Conglomerates are restricted to the basal 50 m of the channel-fill sequence, where they are interbedded with sandstones and a few thin pelites. The beds were studied along an 800-m section running at a high angle to the trend of the channel axis, and although broad correlations can be made between closely spaced sections, individual beds generally cannot be traced from one section to the next. The conglomerate beds are pebble to cobble grade, and are up to 10 m thick; bases are sharp and commonly planar; tops have abrupt gradations to sandstones. Structures indicating bottom traction of clasts are absent, but imbrication of platy clasts indicates southeast-flowing currents. Most of the long axes of clasts plunge to the northwest. Most beds are clast supported, but in some, there are so many soft intraformational clasts that the clasts derived from outside of the basin are widely dispersed, and there is no well-developed clast fabric. Graded bedding is very uncommon, but individual beds are not texturally homogeneous from bottom to top. Abrupt changes in sorting, in places marked by layers of intraformational clasts, occur in many beds. In a few exposures, these changes coincide with gently inclined surfaces of lateral accretion. The clasts are considered to have been deposited rapidly from the bases of sandy turbidity currents. Individual beds of conglomerate likely were built by both lateral and vertical accretion of gravel layers deposited from several currents.

HERN, JOHN L., G. J. Long & Assoc., Inc., Houston, Tex.

Geophysical Investigations for Pilot Plant for Nuclear-Waste Isolation in Southeastern New Mexico

A thick salt bed, the Salado Formation, is present in the northwestern part of the Delaware basin. In an area about 30 mi east of Carlsbad, Eddy County, New Mexico, this salt bed is being investigated as a possible site for a pilot plant for radioactive-waste isolation. Geophysical investigations have been carried out at the pro-

posed site since 1976. This work was performed under the direction of Sandia Laboratories, Albuquerque, under contract to the Department of Energy. The purpose of these geophysical investigations was to study the geologic conditions of the bedded salt deposit, including the evaporite section and overlying and underlying formations as part of site evaluation and characterization.

Both nonseismic and seismic geophysical techniques were employed. Seismic investigations were used to map from the top of the Salado Formation downward to Precambrian basement in order to locate and delineate (1) salt breccia pipes or collapse features that penetrate into and possibly through the Salado Formation, (2) an igneous dike that cuts the Salado Formation, (3) salt-dissolution fronts within or above the evaporite section, and (4) slump, faulting, or other structural disturbances above, below, or within the evaporite section.

The seismic site-evaluation studies included two Vibroseis programs plus a review of all the petroleum industry data available in the area of interest. The 1977 seismic program was for the semidetailed analysis of anomalies located during all earlier data studies. Any indications of slumping, faulting, and dissolution within the evaporite zones or any other structural departure from a "stable" condition in the post-Delaware deposits on the first review were subjected to additional seismic study. Forty-eight miles of extended frequency Vibroseis data were gathered over the anomalies in 1977. Sweeps to 110 Hz were utilized.

The results of the 1977 program indicated that in some areas the Castile and lower Salado Formations are deformed, a fact supported by a follow-up series of drill holes. Examples of the early interpreted anomalies with the normal petroleum industry field-recording parameters clearly show the need to modify the parameters to obtain shallow information. The latest Vibroseis data indicate the enhancement obtained by shortening the geophone and source intervals and by raising the sweep range to 100 Hz. The earlier observed anomalies are compared with later examples and, in all cases, the detailed studies give excellent definition as to salt deformation, timing of movement, and extent of structural effect on the salt beds.

HILL, GARY W., U.S. Geol. Survey, Menlo Park, Calif.

Applications of Crab-Burrow Orientation to Environmental Analysis

Burrows of the ghost crab *Ocypode quadrata* (Fabricius) are widespread in beaches of Texas and Georgia. The orientation of these burrows and the factors that influence it are potentially useful in recognizing and interpreting ancient beach environments, shoreline position and orientation, and direction of dominant winds.

*O. quadrata* burrows generally slope downward away from the shoreline with branches being landward of the main shaft. This preferred orientation is controlled by the direction of onshore winds. During the short excavation period (several minutes), individual crabs burrow 45° to either side of the local downwind direction. The mean orientation of all ghost crab burrows over days or larger periods of time, however, corresponds to the mean onshore wind direction.

Other factors that influence burrow orientation include temperature and local landforms. When air temperatures drop below 15.5°C, ghost crabs generally stay in their burrows and reduce their activity. In Texas and Georgia, winter winds of these temperatures are generally offshore winds and consequently have little effect on burrow orientation. Where fore-dune ridges exist, burrows are randomly oriented in the interdune flats owing to wind shadows. In other places, mean burrow orientation is parallel with geomorphic features such as swales which tend to funnel the wind in specific directions.

A model of ghost crab-burrow orientation was developed from laboratory experiments that can be combined with wind data to predict field observations in modern beach environments.

HILL, J. RANDEL, Texas Railroad Commission, Austin, Tex.

Responsibilities of Texas Railroad Commission for Uranium Mining Pursuant to Surface Mining and Reclamation Act of 1975

The Texas Surface Mining and Reclamation Act was enacted on June 21, 1975, with the expressed intent of regulating the surface mining of coal and uranium and activities associated with a surface mining operation. The Railroad Commission of Texas has certain responsibilities pursuant to this legislation, although some types of activities are not affected by this law.

HILL, P. J., and G. V. WOOD, BP International, Aberdeen, Scotland

Forties Field, United Kingdom Continental Shelf, North Sea

The Forties field, located about 180 km east-northeast of Aberdeen, mainly in UK Licence Block 21/10 in the North Sea, was discovered in October 1970 in Paleocene sandstones of the Forties Formation. Four appraisal wells drilled during 1971-72 proved the existence of a giant oil field with an area of about 90 sq km and estimated oil in place of 4,600 million bbl.

Additional geologic data from the 50 development wells drilled to date show rapid facies variations over the field, with some sand bodies having a cross section less than the prime well spacing of 700 m. A large, partly isolated sand body, the Charlie sand, is recognized in the upper, western part of the reservoir.

The sandstones and shales of the Forties Formation are considered to have been deposited in a middle and lower submarine-fan environment. A mixture of sedimentary processes including grain flow, debris flow, and turbidity currents have been identified and four broad facies defined from cores. The facies types form significant vertical associations that are related to specific depositional environments and recognized by petrophysical log patterns.

Detailed lithofacies studies, together with pressure-decline data and log-pattern analyses, provide a practical means of correlating and mapping the complex sand geometry. These techniques provide a method for well location and a better understanding of the reservoir performance.