seismic stratigraphic methods and therefore are not covered in this paper.

Turbidite fans are sequences of sands and shales deposited in conjunction with, and basinward of, deltas or submarine canyons. Turbidite sands can be generally classified into channel and suprafan sands. Certain seismic events and reflection patterns suggest the presence of turbidites. The interpreted events and reflection patterns include troughs, submarine canyons, mounds, a prograded fluvial-dominated delta reflection pattern and variations in its thickness, and onlap-offlap patterns on a depositional slope. Regional studies provide the best means of identifying and mapping depositional sequences. Examples from the North Sea, Gulf Coast, and Sacramento Valley illustrate the geologic and geophysical expression of delta and turbidite sequences, and their interrelation.

BERG, ROBERT R., Texas A&M Univ., College Station, TX

Calculation of Seal Capacity from Porosity and Permeability Data

Porosity and permeability measurements can be used to calculate oil columns trapped by grain-size changes. Calculations can be useful when capillary pressure measurements are not available. Calculations are based on two major assumptions: (1) the rocks are water wet; and (2) mean effective grain size and pore size may be determined from average porosity and permeability. The first assumption is widely applicable; the second assumption has been tested and found to be reliable over a wide range of porosities and permeabilities for sandstones. Important in the calculations is that interfacial tension does not decrease to low values under subsurface conditions of higher temperatures and pressures but remains at a relatively large value of 30 dynes/cm for both gas and oil.

Calculations of oil column based on porosity and permeability data are particularly useful in evaluation of hydrodynamic flow as a trapping mechanism. Once hydrostatic or capillary-pressure oil column has been estimated, the effects of hydrodynamic flow can be evaluated as in independent variable. In many simple stratigraphic traps, the amount of oil trapped by hydrodynamic flow greatly exceeds that which can be trapped by capillary-pressure differences alone.

Studies of Recluse Muddy and Kitty Muddy fields in the Powder River basin of Wyoming indicate that hydrodynamic flow makes up a major part of the trapping element for the hydrocarbon column. Such examples show that downdip hydrodynamic flow can be an effective trapping mechanism in basins where reservoir systems are subject to recharge by meteoric waters.

BERG, ROBERT R., Texas A&M Univ., College Station, TX, and D. G. KERSEY*, Robertson Research (U.S.), Houston, TX

Origin of Thin, Siliceous Beds in Monterey Shale, Elk Hills Field, California

The Miocene Monterey Shale consists of thinly interbedded black shale and siliceous beds in a section 1,800 ft (550 m) thick on the western anticline, Elk Hills field. Selected full-diameter cores were examined through the upper section west of, and partly equivalent to, the Stevens Oil Zone sandstones. The siliceous beds are commonly 1 to 5 cm, and rarely 8 to 10 cm, thick. The beds are generally structureless or contain a few indistinct laminae. Bases are in sharp contact with underlying shale, and some tops are gradational to overlying shale. In a few beds, the uppermost parts show curved laminae that represent low-amplitude ripples. Therefore, the beds seem to be distal turbidites composed of common, massive A divisions and rare, rippled C divisions.

Many beds have a fine granular, graded texture with a thin basal zone of coarser detritus. The beds are composed of finely-crystalline, siliceous material, in some places partly replaced by dolomite(?). Petrographic study shows a significant content of fine sand to silt-size detritus. In a typical graded sequence, grains of quartz, plagioclase, and rock fragments form a thin lag at the base where they comprise more than 50% of the rock and have an average size of 0.13 mm. Detrital grains decrease upward to less than 3% at the top, and average size decreases to 0.05 mm.

The thin, regularly bedded nature of the section, significant detrital content, and graded texture suggest that the siliceous beds are turbidity-current deposits. The siliceous component was probably pelagic, diatomaceous sediment from the basin floor that was incorporated in turbidity flows, transported a short distance, and redeposited with terrigenous detritus in massive A divisions of the turbidite sequence. Alternatively, subsequent recrystallization destroyed original lamination and produced the structureless beds.

BERNARD, BERNIE B., O. I. Corp., College Station, TX

Use of Sediment Gas Anomalies in Surface Prospecting

Measurements of methane and other hydrocarbon gases in near-surface marine sediments have been made with increasing frequency over the last 10 years as part of various geochemical prospecting efforts. Presumably, the presence of light hydrocarbon anomalies in sediments is indicative of seepage of hydrocarbons from nearby reservoirs. However, gas concentrations and compositions can be altered by filtering effects during gas migration through sediments as well as by microbially induced interferences and alterations. Methane is apparently consumed and oxidized by aerobic and anaerobic bacteria in near-surface sediments. The bacteria can alter isotopic compositions of microbially produced methane to yield thermal-like compositions which can be misinterpreted as oil-related gas. Ethane and higher (C_2+) hydrocarbon anomalies are considered more positive indicators of commercially prospective oil and gas accumulations but these gases can be selectively filtered by sediment chromatographic effects yielding bacteria-like compositions which might be passed over as non-anomalous.

These concerns, coupled with methodologic problems such as (1) the difficulty of measuring isotope ratios on small amounts of sediment gas, (2) the fact that the hydrocarbons which initially outgas from a sediment sample are different in composition than subsequent outgassing, and (3) disputes over the optimum depth for sediment gas measurement and anomaly detection, demand that surface gas anomalies used for prospect evaluation should be interpreted with care.

BERTAGNE, ALLEN J., Univ. Texas at Austin, Austin, TX

Seismic Stratigraphy of Veracruz Tongue, Southwestern Gulf of Mexico

The Veracruz tongue is an area of continental slope and rise sediments bounded topographically by the Mexican Ridges foldbelt and the Campeche-Sigsbee salt province. Study of two multichannel lines and single fold sparker data enables five

seismic sequences to be distinguished in the tongue. Correlation of reflectors with well data allows ages, ranging from middle Miocene to Holocene, to be assigned to the seismic sequences.

Sedimentary processes responsible for deposition of each sequence are determined on the basis of external geometry, internal reflection configuration, and where possible, core data. Primary deposits consist of proximal and distal turbidites, and hemipelagites and pelagites. Sediments may be later modified by creep or slumping and sliding. This seismic stratigraphic study allows the depositional history of the Veracruz tongue to be elucidated and aids in the dating of folding and salt movement at the edges of the tongue.

Detailed interpretation of seismic waveforms indicates that gas accumulations are present in the study area. Future seismic stratigraphic studies will allow quantitative evaluation of hydrocarbon potential of the Veracruz tongue and the adjacent foldbelt.

BEST, MAYA W., Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands

Miocene Reef at Baixo, Porto Santo (Eastern Atlantic)

In the eastern Atlantic Ocean, living hermatypic scleractinian corals which contain zooxanthellae are found only on the Cape Verde archipelago and the volcanic islands in the Gulf of Guinea. In the same region, the islands of Madeira and Porto Santo, with its outliers Baixo and Cima, yield similar hermatypic scleractinian corals of Miocene age. Porto Santo is almost entirely volcanic, but coral reefs were established there in the Miocene. Recent study has revealed interesting facts regarding the reef's paleoecology and stratigraphy.

The environment of the Porto Santo reefs in Miocene time appears to be similar to that of reefs which colonized the submarine slopes of Krakatoa (West Java) seven years after its great eruption. In that example, the corals suffered much from tephra deposition on the sea floor. The Baixo locality, however, is situated at the outermost fringe of the Porto Santo volcano. It is conceivable that this spot was less affected by tephra deposition than other localities, so that the Baixo coral fauna is far more diverse than any other Porto Santo locality. So far, nine hermatypic and nine ahermatypic coral genera have been found in this fossil reef. Two hermatypes have branching colonies (*Pocillopora* and *Stylophora*), one is ramose or massive (*Porites*), and the other six (*Acanthastrea, Montastrea,* and the *Haliastrea* group) are massive reef constructors. *Pocillopora,* originally described as a tabulate coral by Mayer in 1864, is the most important coral of the Baixo reef. The presence of these reef-building corals in the eastern Atlantic in the Miocene also sheds new light on the evolution and paleozoogeography of the Tethyan coral fauna, especially after the Tethys Ocean was severed by tectonic movement in the late Miocene.

BILAL, M., and M. TARTIR, Ministry of Petroleum and Mineral Resources, Damman, Saudi Arabia, and L. W. SLENTZ*, Chevron Oil Field Research Co. (on loan to Aramco)

Hydrocarbon Habitat in Main Producing Areas, Saudi Arabia

Current hydrocarbon production in Saudi Arabia is from reservoirs of Cretaceous and Jurassic age. Geochemical studies of the sediments and oils suggest that the hydrocarbons were derived from two separate source-rock provinces. Oil production from the large fields in the southern part of the area is from Jurassic carbonate reservoirs. Most of these oils were derived from thermally mature, thinly laminated, organic-rich carbonate rocks of Jurassic age (Callovian-Kimmeridgian). These source rocks were deposited in an intra-shelf basin which is limited to the southern part of the main producing areas. Extensive vertical migration of oils in these sediments is prevented by superjacent evaporite seals deposited during Late Jurassic.

Fields in the westernmost and northern producing areas appear to have derived their hydrocarbons from a source-rock province to the north. Production from Cretaceous clastic and carbonate reservoirs is limited to the northeastern part of the producing areas. This distribution may be explained by limitation of thermally mature Cretaceous source rocks to the northeastern areas or by the lack of subjacent evaporite seals to separate these reservoirs from Jurassic source rocks.

Thermal maturation studies indicate that the hydrocarbons in Mesozoic reservoirs migrated into the present traps during the early Tertiary.

BISWAS, S. K., Inst. Petroleum Exploration, Dehra Dun, India

Rift Basins in Western Margin of India with Special Reference to Kutch Basin and its Hydrocarbon Prospects

The western continental margin of India can be classed as a divergent or passive margin. The western continental shelf is an extensive carbonate bank (Bombay offshore basin) passing into clastic sediments to the north and south. Three craton-margin embayed basins, Kutch, Cambay, and Narmada, in the northern part of the shelf, are filled with predominantly clastic sediments. These basins occupy grabens bounded by faults diverging seaward. The grabens were formed by three rift systems along major Precambrian tectonic trends. The rifting developed sequentially from north to south around the Saurashtra horst. Kutch basin was formed in the Early Jurassic, followed by Cambay basin in Early Cretaceous and Narmada basin in Late Cretaceous. It appears that these rifting events occurred at successive stages during the northward migration of the Indian plate after its break from Gondwanaland in Late Triassic or Early Jurassic. It is inferred that these rift basins opened up successively as a result of the drift of the Indian craton anticlockwise.

Bombay offshore and Cambay are two major oil producing basins in the western margin. These basins are characterized by high geothermal gradients attributed to the shallowness of the mantle in this region.

Oil has not been found in Kutch basin. This is mainly a Mesozoic onshore basin. The basin depocenter shifted offshore in the northwestern part of the continental shelf where the shelf is wider. The onshore-offshore prospects of this basin are discussed considering global tectonics and basin history.

BLAKE, BASCOMBE M., JR., ALAN F. KEISER, and ROBERT S. REPPERT, West Virginia Geol. and Econ. Survey, Morgantown, WV

Geophysical Logs and Marine Zones as Useful Coal-Exploration Tools in Southern West Virginia

The coal resources study currently in progress at the West Virginial Geological and Economic Survey using gamma-ray logs, density logs, core logs, and marine zones aids in regional correlation problems in the stratigraphically complex, coal-