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.

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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.

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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.

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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.

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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-

bearing Kanawha Formation (Middle Pennsylvanian) of southern West Virginia. Projecting marine-zone control points onto nearby geophysical and core logs has greatly aided understanding of the complex stratigraphy of the Kanawha Formation, which was deposited in a rapidly subsiding basin.

Recent work has indicated problems with several type sections, notably those of the Seth Limestone, Hernshaw coal, Peerless coal, Buffalo Creek coal, and the Buffalo Creek Limestone. Also, it appears that previous mapping of the Dingess Limestone in Boone, Raleigh, Logan, and Mingo Counties (from the West Virginia Geological Survey County Reports) actually represents several separate marine units which were mapped as a single unit. Stratigraphic cross sections, constructed from gamma-ray, density, and core logs and incorporating biostratigraphic information from field investigations of marine zones, allow better correlation of units, more reasonable interpretations, and a new evaluation of the coal measures of the Kanawha Formation in southern West Virginia.

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Biostratigraphic Relation of Neogene Benthic Foraminifera from Southern California Outer Continental Borderland to Monterey Formation

In recent years there has been considerable discussion concerning the biostratigraphic correlations between planktonic zonations and the classical Neogene California benthic foraminiferal stages. One of the primary objectives of IPOD Leg 63 was to explore these correlations and to determine the possibility of temporal variation of the benthic stages between the outer continental borderland and land sections.

Site 468 was drilled on the Patton Escarpment, which lies under the present southeastern margin of the California current system. The sediments yielded well-preserved calcareous and siliceous planktonic assemblages that ranged in age from Holocene to middle Miocene. Samples also contain abundant benthic foraminiferal assemblages that consist of species characteristic of both oceanic and continental margin environments.

The benthic foraminiferal assemblages range from the Venturian stage of the Pleistocene to the Luisian-Relizian stages of the middle Miocene. Because of the dependence of benthic species on bottom environmental parameters, the dominant occurrence of lower bathyal to abyssal faunas present problems for direct correlations to local California stages. The majority of key species needed for recognition of the late and middle Miocene benthic stages, as defined in land sections, are indicative of upper to middle bathyal environments and are excluded from the deeper habitats because of environmental restrictions. The occurrence of the lower bathyal pseudo-Saucesian assemblage as a major faunal constituent in the late and middle Miocene samples furthers adds to the complexity of correlations between the planktonic zonations and benthic foraminiferal stages.

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Sedimentology and Structure of Franciscan Assemblage, Yolla Bolly Terrane, Northern California

The Yolla Bolly terrane of the Franciscan assemblage in northern California is a typical subduction complex that has undergone penetrative deformation and metamorphism to the high-pressure/low-temperature blueschist facies. Detailed mapping combined with sedimentologic analysis has enabled us to: (1) reconstruct a probable paleosedimentary environment; (2) analyze the interaction between deformation and metamorphism during and after subduction; and (3) speculate on subsequent deformational history including tectonic accretion to North America.

The Yolla Bolly terrane consists of several thrust-bound lithologic units: a lower unit of disrupted mudstone and thin-bedded sandstone (broken formation) containing scarce volcanic flows and beds of radiolarian chert; a middle unit of predominantly thick-bedded to massive sandstone (metagraywacke) that includes several zones of radiolarian chert; and an upper unit of mudstone and thin-bedded sandstone (broken formation) containing numerous intrusive and extrusive volcanic rocks as well as rare radiolarian chert. Coeval ages (Tithonian to Valanginian) on radiolarians from all three units, together with the sedimentologic data, suggest that the rocks represent a continent-derived submarine fan, deposited in a complex transform graben possibly similar to the present-day Gulf of California or basins in the California continental borderland.

Radiometric ages of approximately 100 m.y. on metagraywacke containing lawsonite and aragonite indicate that these rocks were subducted and metamorphosed to a high-pressure/low-temperature mineral assemblage about 30 m.y. after they were formed. Closely following subduction, the rocks were probably involved in a collision that imbricated and tectonically returned the subduction complex to the surface.

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Infaunal Influences on Sedimentology of Shelf-Slope Boundary

Although the benthic infauna of the inner continental shelf and continental slope have been studied in some detail, the infauna of the shelf-slope break have received scant attention. The shelf-slope break marks the transition from the highly variable and physically controlled environment of the shelf to the more stable biologically controlled environment of the deep slope and basins. A slight change in depth across the shelf-slope break can cause a drastic change in the composition of the infauna. Since sediment grain size at the shelf-slope break can range from silt-clay to sand and is commonly coarser than the sediment shoreward on the adjacent shelf, infaunal composition of a particular assemblage can range from predominantly suspension feeders to predominantly deposit feeders. The density and biomass of these assemblages, which in some areas may be greater than on the adjacent shelf or slope, appear to be related mostly to current patterns and degree of sediment heterogeneity whereas salinity and temperature variations are minimal and play only a minor role. In those areas such as the shelf-slope break off New England, infaunal densities are relatively large and these infauna may be a significant factor in regulating sediment structure through carbonate and feces deposition as well as through bioturbation. In addition, the removal of organic material from the pelagic realm and the reworking of deposited organic material by the organisms make the infauna at the shelf-slope break an important mechanism for enhancing the transport or organic material to the ocean basin.

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