

terraces formed during Pleistocene eustatic movements of the sea might permit detection of minute recent tectonic movements, thus pointing to structures which are still active.

Along continental margins affected by faulting and/or orpigenetic movements, the study of the coastal morphology might help in delineating ancient drainage patterns, making it possible to predict to a certain extent those areas of paleo-discharge, capable of containing favorable reservoir rocks.

RIGO, F., Rigo and Vercellino, Rome, Italy

RECENT DEVELOPMENTS IN PETROLEUM EXPLORATION IN ADRIATIC SEA, ITALY

When Adriatic offshore acreage first was opened for exploration, only part of it was known geologically. The northern part of the sea was known to be an extension of the prolific gas producing Po basin. The central and southern parts were known only as the transition between the Apennine and the Dinarids orogenic belts. Seismic reconnaissance in the Northern Adriatic revealed structural and stratigraphic features similar to the onshore portion of the Po basin. These structures are, in fact, now producing gas from 5 new offshore fields.

The geology of the central-southern part of the Adriatic revealed a more complicated geologic pattern. The Tertiary clastic cover had good seismic response and a very prominent seismic horizon, C, indicated several large structures on top of the Eocene-Cretaceous limestone. The reflections below the C horizons were very poor and affected by multiples. All the wells located on the horizon C features were dry, despite the presence of good oil and gas shows.

The second stage of exploration was begun in 1971. Improved seismic techniques showed disharmonic behavior in the structures below horizon C, which is a morphologic paleorelief horizon below the Miocene transgressive deposits. New structures located in the Mesozoic section show convergence of the pre-Miocene horizons. Also, it appears that alongside the Triassic evaporitic basin, younger Yugoslav evaporitic basins of Jurassic and Cretaceous age undergo a facies change in Italian waters. In Italy the sediments are basinal or biostromal with indications of reef development in the transitional belt and porous, prolifically gas-bearing calcarenite along the coast. This new understanding of the geology leads to highly encouraging possibilities for large accumulations in the Eocene and Mesozoic carbonates.

RISSER, H. E., U.S. Geol. Survey, Washington, D.C.

EXPLORATION AND DEVELOPMENT OF COAL RESOURCES, 1970-1975, AND BEYOND

The growth in coal use in recent years and projections for the future indicate need for an expansion in coal-producing capacity over the next several decades to 3-6 times the present output. Each of the mines contributing to this future production will require the identification and commitment of coal reserves in the ground equal to 30-60 times its annual output. Because of more stringent regulations on quality, especially with regard to sulfur content, large areas will be removed from prime consideration as mine sites until effective means of sulfur-emission control are in use.

As a result, future coal exploration efforts will involve, in addition to the determination of quantities, thickness, minability, and heat content of coal deposits, a much more careful analysis and consideration of the chemical makeup and the washability characteristics of each deposit being explored.

Future exploration will be devoted not only to the identification of new sources to meet the growing needs for coal and to replace the reserves being worked out, but also to provide substitute sources for mines now producing coal ruled unsuitable because of its sulfur content. On the basis of published projections, the need for reserves to support new coal mines to supply demand from now to the year 2000 will total somewhere between 60 and 100 billion tons. The lower estimate is based on conventional uses, in which sulfur content has become an increasingly important factor. The higher estimate would provide coal for gasification and liquefaction plants in which sulfur content is less critical. Based on average thickness of coal currently being mined, between 12 and 22 million acres will undergo extensive exploration to provide these reserves.

RITZMA, H. R., Utah Geol. and Mineral. Survey, Salt Lake City, Utah

EXPLORATION AND DEVELOPMENT OF OIL SHALE AND OIL-IMPREGNATED ROCK, 1970-1975

Most oil shale exploration has been accomplished in the half century prior to 1970. Deposits are delineated, but detailed blocking-out of reserves remains to be done in optimum areas where development is proposed. Eighty percent of thick, rich oil shale is in Colorado, 15% in Utah, and 5% in Wyoming.

Oil-shale development appears likely to begin on federal lands in Colorado, and possibly in Utah, in accord with the program of the U.S. Department of the Interior. Utah is the only oil-shale state having sizable blocks of state lands in optimum areas. Development could begin on these if the question of state entitlement to additional federal lands is resolved promptly. Development of private lands in Colorado and Utah also appears likely. Wyoming lands—federal, state and private—have attracted little development interest. All development to date involves underground mining and above-ground retorting.

Oil-impregnated rock—sandstone and limestone—occurs in 22 states, but few deposits are known in detail. Important deposits are known in 13 states. A concerted mapping program places about 90-95% of the nation's mapped reserve in Utah in deposits totaling 20-25 billion bbl of oil in place.

Deposits in about 11 states have been used for paving and aggregate. None has been exploited as a source of oil, although varied experimental and pilot work has been conducted for this purpose in at least 9 states. Although mining, processing, and refining technology is known and highly developed, unfavorable economics have deterred development. *In situ* methods are largely in an experimental stage. In many deposits techniques used in primary or secondary recovery of conventional or heavy crude oils show promise. Experience in the Canadian Athabasca tar sands deposit is expected to strongly influence U.S. activity.

By 1975, small-scale production of shale oil should nearly be under way in western Colorado and possibly in Utah. From about 50,000 bbl/day of oil in 1976 this

should escalate to 800,000 to 1,300,000 bbl/day in 1985. Production of synthetic crude oil from oil-impregnated rock should develop in the decade 1975-1985. Both supplemental oil sources are certain to be important parts of the nation's pool of available energy from 1980 into the next century.

Unforeseen world events and political/economic decisions at high government levels can profoundly affect and alter these timetables.

ROONEY, W. S., Water and Trade Wastes Consultants, Sydney, Australia, and R. D. PERKINS, Duke Univ., Durham, N.C.

MICROBORING ORGANISMS AS ENVIRONMENTAL INDICATORS AND SEDIMENT TRACERS, ARLINGTON REEF COMPLEX, AUSTRALIA

Sediments surrounding the Arlington reef complex of the Great Barrier Reef of Australia were examined to determine the types and relative abundances of microborers present, to describe the morphology of their excavations, and to plot and interpret their distributional patterns. The most widespread and abundant microborings found within carbonate particles were those produced by fungi, which appear to be among the first endolithic organisms to attack skeletal debris. A characteristic branching red (?) alga was found to be most abundant at depths in excess of 18 m, although it was not restricted to these depths. However, a distinctive endolithic sponge was found only at depth below 18 m, and may prove valuable as a paleoecologic guide.

An 8-10 μ endolithic green alga actively infests carbonate particles of the interior reef platform to depths as great as 30 m, although it is generally more abundant at shallower depths. This alga serves both as a photic zone indicator and sediment tracer within the study area. Its distribution within sediments suggests that net transport is from the interior reef platform landward with little or no sediment being carried seaward.

Endolithic organisms were observed to infest molluscan fragments preferentially, thereby selectively removing them from the carbonate fraction. The distribution and spatial relations of endolithic organisms within Arlington reef complex sediments suggest that microborers may be useful as relative depth indicators in recent, and possibly ancient, carbonates.

ROSE, P. R., Shell Oil Co., Denver, Colo.

FORAMINIFERIDA AND CARBONATE ENVIRONMENTS OF SOUTH FLORIDA AND BAHAMAS

Previous studies in the Florida-Bahamas region have shown that organic constituents of modern shallow-water carbonate sediments vary systematically and predictably with sediment grain size, submarine topography, areal geography, and hydrography, so that persistent associations of certain facies tracts and dominant organisms now are well known. Although such dominant organic constituents generally are segregated into gross taxonomic groups (coral, coralline algae, forams, mollusks), the present study shows that similar systematic variation also can be observed within a single gross taxon (Foraminiferida). Such variation produces 5 faunas that reflect 5 major environments (forereef slope, shelf margin, open shelf, interior shelf, restricted shelf) of the shallow-marine carbonate realm, as well

as local depositional features, such as mudbanks and patch reefs. Sediment classes and foraminiferal faunas are probably only indirectly related, but they are remarkably congruent. Transport of Foraminiferida by currents affects distribution locally, but does not materially affect the 5 major faunas.

Lateral successions in foraminiferal faunas are present in the ancient rock record just as they are in modern sediments and can be used as a predictive tool, but for comparison with ancient faunas, recent death assemblages are more meaningful than living faunas.

Many previous studies of modern forams have emphasized water depth as the dominant environmental parameter, but most modern carbonates are forming in very shallow water so that possible range in water depth is necessarily small. Accordingly, circulation of oceanic waters supersedes water depth as the dominant environmental control of forams in the carbonate realm.

ROSS, C. A., Dept. Geol., Western Washington State College, Bellingham, Wash.

PROBLEMS IN PROVINCIALITY

Paleogeographic provinciality is a subject that has attracted attention for more than 150 years. Most of the early models of distribution of paleogeographic provinces conformed to the concept that the major cratonic areas of the world had remained geographically stable through geologic time and that the rate of dispersal of biota through barriers between these stable areas varied during geologic history. Such models were challenged critically by the concept of "drifting" continents. The recent model of plate tectonics appears to present a mechanism for moving and variously connecting and disconnecting cratonic masses. This idea has resulted in renewed interest in many different fields of geology and suggests reevaluation of all types of pertinent data that bear on the subject of paleogeographic provinces.

The intent of the 1972 SEPM Research Symposium is to examine many of the different aspects that contribute to the development, changes, and stability of provinciality and the paleogeographic patterns of different types of provinciality. A broad spectrum of interpretations on this diverse subject is drawn from sedimentology, oceanography, zoology, paleontology, paleobotany, clay mineralogy, tectonics, climatology, and paleomagnetism. These interpretations outline the magnitude, extent, and direction of many changes in physical and paleobiological geography during the geologic past.

RUBIN, B., Teton Exploration Drilling Co., Casper, Wyo.

URANIUM ROLL-FRONT ZONATION IN SOUTHERN POWDER RIVER BASIN, WYOMING

Uranium deposits in the Powder River basin have been found during the past decade through the extensive use of the "roll-front" concept. Until now far more holes were drilled than were needed to complete successfully each profile across the various "roll-fronts" discovered. The recognition of 6 zones across the "roll-front" has enabled the geologist to effectively utilize his drilling so as to intersect the high-grade ore zone with fewer holes per profile. Consequently, time, effort, and money have been saved allowing the geologist more time to do more imaginative geologic thinking.