

thermal (0.1%) power account for a relatively small share of the electric budget.

During 1920, America consumed slightly more than a half billion bbl of oil. By 1935 our needs had grown to over 1 billion bbl and in 1950 we exceeded 2 billion bbl annual consumption. A 3 billion bbl yearly need was approached in 1960 and today 5 billion bbl will not meet the needs of 1972's demand for oil.

In the past 10 years, our consumption of natural gas has risen from 13 Tcf to a present rate of 23 Tcf. Should this rate of increase continue at its present trend, we could deplete our known reserves in 10 years. Possible future sources of gas are coal degasification, western oil shale, and imports (Alaska pipeline and LNG). Drawing on any of these alternate sources for oil or gas will have a profound impact on our environment.

KLEINPELL, ROBERT M., Univ. of California, Berkeley and Santa Barbara, Calif.

HISTORICAL REVIEW OF EARLY PACIFIC COAST MICROPALAEONTOLOGY

From its beginnings in the wake of World War I, Pacific Coast industrial micropalaeontology had at its disposal the superjacent stratigraphic column blocked out by predecessors chiefly on the basis of marine megafossils. Only a few stratigraphically isolated foraminiferal faunules had been recorded in print, as by Chapman and by Bagg. With the growing interest in micropalaeontology, several such local microfaunules soon were being analyzed and taxonomically described, notably by the Hanna brothers, Wissler, Church, Hughes, Hobson, Barbat and von Estorff, Galliher, Goudkoff, the Stewarts, Parker, and Siegfus. Age equivalents of the classic Tertiary time-rock subdivisions of Series-Epoch magnitude had been recognized here by Conrad, Arnold, and others. Finer time-rock subdivisions, however, still were spoken of in terms of faunas, usually as found in mapped and formally named formations.

Soon, in spite of earlier traditions to the contrary, in the minds of geologists and paleontologists alike, formational terminology was being transferred into time terminology, and unhappily so, as subsequently clarified by Schenck and Muller. Other finer subdivisions, based more intrinsically upon fossils, had previously been given zonal terms. Some were simply fossil beds. J. C. Merriam's two valuable middle Tertiary *Turritella* zones proved, however, to be teilzones; eventually they were shown by Loel and Corey to overlap in time-stratigraphic range. Helpful echinoid bioseries proved limited in their correlative usefulness because of the lateral as well as vertical evolutionary sensitivity to selective environmental change. In turn, a fauna or an "index fossil" found at one or a few stratigraphic zones within a formation, were apt automatically to be taken as indicative of the age of the entire formation. In short, correlations more refined in magnitude than an epoch were in essence local and particular synchronicities defying general classification, rather than biochronological deductions derived through references to some typifying standard stemming from multiple induced generalizations. Resultant confusion in semantics was reflected in the use of formational names for "stages," as reflected in the West Coast Paleogene, and the analogous use of terms such as San Lorenzo, Vaqueros, Temblor, Santa Margarita, Pancho Rico, Repetto, and Pico. For refined correlations of the sort required for the recognition of structural and stratigraphic traps in oil exploration, such symbols were woefully inadequate.

With Elliot's perfection of the core-barrel for use in rotary drilling, the significance of micropalaeontology for refined correlations in oil geology was immensely enhanced. The chief vehicle involved was detailed biostratigraphy, carried on in private industrial micropalaeontology after the manner of 19th century paleontologist August Quenstedt. The first published record of such a local detailed biostratigraphic continuum was that of Herschel Driver in 1928, using informal taxonomy for natural

phyletic realities. In the same year, consistency along strike, of Pliocene biostratigraphic units such as Driver's, was emphasized by the late O. C. ("Jimmy") Wheeler, and soon also Neogene by Rankin, Lohman, and others.

Yet biostratigraphy, left in a purely empirical state, has its chronologic hazards even over and above the factor of error that is inherent in any scientific deduction at its syllogistic best. Criticisms based on demonstrable lateral change in fauna were particularly telling; yet many geologists, by then wary, were nevertheless still thinking biochronologically in terms of William Smith's principle, which is not relevant below System-Period levels in paleontologic time-refinement. In 1933 Natland published his demonstrated parallels between five living, bathymetrically controlled, foraminiferal community-types ("ecological formations") and comparable groupings in a nearby Pliocene sequence; and though his work did not extend to either whole true communities or faunules, and biostratigraphic chronology was not attempted until later, the significance of foraminiferal chorology and facies in biostratigraphic chronology was clearly documented.

Meanwhile the late Ralph Reed—active field geologist, oil company executive, and voracious reader in the field of earth history generally—had suggested that seemingly Albert Opper, Quenstedt's student, had managed to circumvent the stumbling blocks of both ecologic and lithologic facies by culling them out of biostratigraphic data for purposes of refined biostratigraphic chronology. The suggestion was appreciated by his associates, and the germ of the consequences already appears formally in a 1931 paper by Cushman and Laming. Subsequently 15 benthonic foraminiferal stages and more than twice as many zones, in the sense of Opeelian zonation, have been recognized within the Pacific Coast provinces of the Tertiary.

LAMB, J. L., Esso Research Co., Houston, Tex., and R. L. HICKERNELL, Atlantic Richfield Co., Bakersfield, Calif.

LATE EOCENE TO EARLY MIOCENE PASSAGE ALONG SOUTHERN PERIMETER OF SAN JOAQUIN VALLEY, CALIFORNIA

The stratal succession along the southern perimeter of the San Joaquin Valley affords a unique opportunity to observe the late Eocene to early Miocene passage within sequential marine episodes where faunal relations of the upper Narizian (Late Eocene), Refugian and Zemorrian (Oligocene), and Saucesian (early Miocene) Stages can be studied.

A monophyletic group of species of *Uvigerina* and *Siphogenerina* aids in defining successive faunal zones or biozones that correlate in part with the type sections of the Refugian, Zemorrian, and Saucesian Stages. For example, *Uvigerina jacksonensis* (= *U. cocoaensis*) characterizes the Refugian, *U. tumeyensis* characterizes a provisionally defined lower Zemorrian, *Siphogenerina nodifera* characterizes a provisionally defined upper Zemorrian and *S. transversa* characterizes a provisionally defined Saucesian. The application of these biozones offers a feasible method to account for all of past geologic time within this depositional continuum, something which is not possible using existing time-rock units or stages.

Vaqueros mollusks occur consistently in lowermost Saucesian strata. This suggests that the *Uvigerinella sparsicostata* Zone (Zemorrian of current usage) of the Santa Barbara embayment, which overlies the Vaqueros Formation, is mostly coeval with early Saucesian as applied in the San Joaquin Valley. This requires an expanded concept of the Saucesian Stage as the type section for the Saucesian overlies the *U. sparsicostata* Zone in the Santa Barbara embayment.

Faunal bases for comparing the Eocene—Oligocene and Oligocene-Miocene boundaries in California with those of the Middle Americas are discussed. In both regions the boundaries seemingly coincide with eustatic lowering of sea level, as observed in other parts of the world.