metastable mineral equilibrated.

Because aragonite and magnesium calcites, in most cases, equilibrate moderately rapidly in time, either by replacement, inversion, exsolution, or dissolution. their disappearance from a rock might be a logical process of carbonate diagenesis. If true, diagenetic processes, as opposed to post-diagenetic processes, would in many cases reflect the environment of deposition.

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PETROLEUM IN TIME AND SPACE

Conditions favorable to the formation of petroleum precursors have been in existence since early Precambrian time. Indigenous petroleum in commercial quantities is known today in strata ranging in age from Cambrian to early Quaternary. Discoveries of indigenous oil in the Precambrian can be anticipated where the limitations of space are met. Petroleum in space has no limitation in latitude, longitude, or present shoreline. It is limited to continental platforms and other sedimentary environments. It is also limited by a low tolerance for metamorphism. For this reason there is a "twilight zone" where oil and gas give way to gas only, both laterally in those basins that are bordered by tectonically disturbed belts, and with depth in deeper basins. Where coal is present, the degree of incipient metamorphism, or eometamorphism, can be determined roughly by carbon ratios, and more accurately by reflectance.

The lateral phase-out of oil caused by eometamorphism is found in many basins, including the Appalachian, Arkoma, and Alberta. Vertical phase-out occurs in the Gulf Coast, Permian basin, Anadarko basin, and the Baku district. During the last 16 years, 68 per cent of the new discoveries in the United States below 15,000 feet were gas (or gas and condensate); during the same period, only 30 per cent of the new discoveries above 15,000 feet were gas. Because of wide differences from place to place in thermal gradients and down-hole pressures, the depth of the oil "floor" changes considerably from place to place. In some areas oil phase-out can be expected from 15,000 feet (or above) to 17,000 feet; in others oil can exist a few thousand feet deeper. There is a distinct possibility that there is very little commercial oil below 22,000 feet.

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NEW LOOK AT GEOLOGY AND PETROLEUM POTENTIAL OF NORTHERN ALASKA

Three terranes in northern Alaska have potential for petroleum: a Tertiary basin in the eastern Arctic Plain, a post-Neocomian Cretaceous basin in the Northern Foothills and western Arctic Plain, and a complex of thrust-faulted late Paleozoic and pre-Albian Mesozoic rocks in the Brooks Range and Southern Foothills. Recent re-analysis of these terranes suggests that the disposition of extensive thrust sheets may have controlled the distribution of petroleum reservoirs in much of the area. This interpretation has significant implications in evaluating the petroleum potential of northern Alaska.

The Tertiary basin contains interfingering marine and non-marine clastics. A few open folds are present and may provide structural traps. Stratigraphic traps may be expected along the tectonically active southern margin and along the stable basement rise under the present continental shelf. Elements of the Brooks Range may have been thrust over the southern margin of the basin in late Pliocene time. This basin awaits exploratory drilling. In the post-Neocomian Cretaceous basin, interfingering marine and non-marine terrigenous clastic sediments in open folds offer a host of structural and stratigraphic traps. Some of these have been drilled, and a few contain sizable reserves of high-quality oil and gas. Stratigraphic traps may be expected also in pre-Cretaceous rocks along the basement rise that forms the northern margin of the basin. Buried detachment fault planes may underlie some of the southern folds, offering the possibility of different, and possibly equally interesting, structures and stratigraphic sections.

The Brooks Range and Southern Foothills terrane is the most complex and difficult to assess, but its geology and oil potential are the most intriguing. The distribution of formations and facies is the result of northward movement of extensive thrust sheets during at least two major episodes of thrusting in mid-Early Cretaceous (pre-Albian) and early Tertiary times. Tectonic movement may have been as much as 75 miles, thus telescoping facies trends in all formations. As a result, Upper Devonian through Lower Cretaceous (Neocomian) rocks of numerous facies are now exposed in a belt of imbricate thrust plates. Holes drilled in this terrane can test a variety of structures and numerous facies of several formations, but the geology is so complex that paleogeographical and palinspastic reconstructions must precede the drilling. Similar terranes elsewhere have been very productive.

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PENNSYLVANIAN AND PERMIAN INFLUENCE ON TENSLEEP OIL TRAPS, BIGHORN BASIN, WYOMING

The Bighorn basin is located in northwestern Wyoming in the central Rocky Mountain province. Near the close of Desmoinesian time, regional uplift on the west and north elevated the Tensleep Sandstone of the Bighorn basin above sea-level. Broad, low-relief, northeast-trending folds developed during this orogenic uplift. Drainage patterns superimposed on the exposed Tensleep surface provided stream courses which furnished eroded Tensleep Sandstone sediment for the younger, upper Minnelusa Formation deposited in the east and southeast. During Middle Permian time, the Phosphoria sea transgressed the area, and the stream channels which had been incised in the Tensleep surface were filled with impervious shale, anhydrite, and reworked Tensleep Sandstone. Subsequent Phosphoria deposition onlapped post-Tensleep cuestas and monadnocks.

The majority of Tensleep accumulation discovered to date has been in traps which are structurally controlled. The effects of hydrodynamics have been recognized by many as factors in anomalous oil-water contact conditions. However, it is proposed here that accumulations in several of these traps are the result, partly or wholly, of three stratigraphic variables: (1) an intraformational change in permeability and (or) lithofacies, thereby providing a stratigraphic trap; (2) incised channels in the Tensleep surface which were later filled with impervious sediments, providing a truncational subcrop trap; and (3) a combination of (1) and (2) with later Laramide anticlinal folding superimposed on or near these primary traps, which commonly results in tilted oil-water contacts. Meteoric waters percolating basinward from Tensleep outcrop areas also had the effect of forming a "tar seal" in the oil-water transition zone; this seal effected a "frozen" oil-water contact, further preventing re-adjustment of paleoaccumulations into crestal positions in the Laramide closures.

Anticlines on which production has been established in the Phosphoria, Tensleep, and older Paleozoic reservoirs, exhibit a common oil-water contact datum for each of the producing formations. Extensive vertical fracturing, allowing commingling of reservoir fluids, is a possible mechanism which would allow oil originating in the Phosphoria to accumulate in underlying formations and account for the common oil-water contact conditions.

Subsurface data presently available indicate a loss of porosity with increased depth in the Tensleep Sandstone. It is suggested that possibilities for locating adequate porosity at greater depths will be enhanced by exploration in those areas favorable to the accumulation of oil in primary traps which have not been modified greatly by Laramide folding.

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Fabric of a Middle Ordovician Limestone at Colborne, Ontario

The limestone of the Middle Ordovician Cobourg Limestone at Colborne, Ontario, occurs, in decreasing order of occurrence, as sparse biomicrite, fossiliferous micrite, biosparite, micrite, and packed biomicrite.

Individual beds display a sequence composed of graded bedding at the base, overlain by a zone of lamination, and structureless micrite. This resembles the sequence in terrigenous turbidites of the Alps and other places. Most disarticulated brachiopod and ostracod shells are convex upward in biosparite and convex downward in biomicrite and fossiliferous micrite. The percentage of brachiopod shells increases toward the bottom of the quarry; a variation in the percentage across the quarry has been found. The percentages of echinoderm, bryozoan, and ostracod fragments have a high positive correlation with the quantity of quartz grains, whereas the percentages of brachiopod shells and trilobite fragments do not. Orientation patterns of elongate fossils show two dominant trends, northeast-southwest and northwest-southeast.

Sedimentation of the Cobourg Limestone was characterized by weak currents. Strong currents were introduced sporadically to form graded and non-graded biosparites, which are suggested tentatively as products of turbidity currents.

All relations between geological entities were calculated by computer.

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Patagium and Some Spumellarian (Radiolaria) Genera

Patagium is a unique structure found in some spumellarian Radiolaria and has been considered to be a diagnostic criterion at the generic level in the generally accepted scheme of classification. A continuous variation in degree of preservation and (or) developmental stages of this structure from complete to absent has been found in genera such as *Hymeniastrum-Dictyastrum* and *Euchitonia-Rhoparastrum* from northeast Pacific Ocean bottom sediments. The study of a rich radiolarian fauna in core samples from Java, Mindinao, and Mariana trenches reveals similar features and indicates that such a complete sequence of variation is neither a rare phenomenon nor biogeographically significant.

The taxonomic value of *Patagium*, therefore, needs critical reconsideration. The degree of development or preservation of *Patagium* found in a specimen seems to be unrelated to radiolarian ontogeny, although its real significance can not now be determined.

Fragments of the diatom *Ethmodiscus rex* (Wallich) Hendey also are found abundantly and consistently in the middle and lower parts of the Mindinao trench subsurface section, whereas only a few sporadic occurrences are found in the Java and Mariana trench samples.

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Planktonic Foraminiferal Zonation of California "Miocene"

Planktonic Foraminifera occur abundantly in most California "Miocene" strata, but have not been studied previously in detail. By using these planktonic forms, 11 zones are recognized and are related to the existing "Miocene" stages which are based on benthonic species. Correlation of these zones with the standard reference sections of tropical regions is complicated by paleoecologic factors, which probably include regional variation in water temperature between the tropics and California. Stratigraphically lower zones correspond more closely than do higher ones, indicating a general cooling of the California seas throughout middle Cenozoic time.

Species of *Globigerina* and *Eoglobigerina* are abundant in the California "Miocene," whereas species of *Turborotalia, Globoquadrina, Globigerinoides, Globorotaloides, Protentella,* and *Candorbulina* are less common but provide bases for tentative correlation with the tropical zones. The "lower Miocene" Zemorrian and Saucesian stages are correlated with the *Globigerina sellii* through *Turborotalia kugleri* zones (Oligocene to Aquitanian); the "middle Miocene" Relizian and Luisian stages correlate with the *Catapsydrax dissimilis* through *Turborotalia fohsi* zones (Aquitanian to Burdigalian); and the "upper Miocene" Mohnian and Delmontian stages correlate with the *Globorotalia lobata* through *Sphaeroidinella seminula* zones (Burdigalian to Sarmatian).

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Ostracodes and Siluro-Devonian Boundary in South-Central Oklahoma

Detailed studies of the morphology, ontogeny, variation, and stratigraphic distribution of the ostracodes in the Henryhouse (Silurian) and superjacent Haragan (Devonian) Shales indicate the presence of an unconformity at the Siluro-Devonian boundary in the Arbuckle Mountains of Oklahoma. The ostracodes indicate a late Niagaran (early Ludlovian) age for the Henryhouse Shale and Helderbergian age for the Haragan Shale.

The ostracode faunas of both stratigraphic units are large and diversified. The Henryhouse Shale contains 46 species representing 28 genera and 17 families. The Haragan ostracode fauna consists of 53 species, 27 genera, and 16 families. These taxa are distinctive and readily identifiable.

Biostratigraphic evidence for the unconformity be-