VOLK, R. W., Nelson, Leonard, Marchetti, Leonard and Tate, Denver, Colo.

FUTURE PETROLEUM POTENTIAL OF PRE-CRETACEOUS ROCKS OF EASTERN COLORADO

Throughout Permian time, eastern Colorado, like western Kansas, was on the shelf area of the Anadarko basin; and the Las Animas arch, as reflected on top of the pre-Pennsylvanian unconformity, was a south-trending nose in the north part of the Anadarko basin. This relation was very similar to that of the Central Kansas uplift, from which over 2 billion bbl of oil has been produced from pre-Cretaceous rocks. Many other geologic similarities can be discerned between the Las Animas arch and the Central Kansas uplift. The two most dissimilar factors are (1) that the pre-Pennsylvanian unconformable surface on the Central Kansas uplift is underlain chiefly by Cambro-Ordovician rocks, whereas on the Las Animas arch, Mississippian rocks underlie most of the area; and (2) that the dip of the pre-Permian beds in northeastern Colorado was reversed during the Laramide orogeny.

The entire pre-Pennsylvanian sequence in eastern Colorado and western Kansas demonstrates a very subnormal but continuous pressure system. Over most of eastern Colorado, the Mississippian is the porous and permeable stratigraphic unit of this very low-pressure system. Fluids will migrate from the higher energy Pennsylvanian system to the lower energy Mississippian. Thus, the Mississippian is capable of deriving hydrocarbons transversely as well as laterally.

Since 1965, exploratory interest has been primarily in Mississippian reservoirs, although some Pennsylvanian oil and gas fields also have been found. Since 1965, 20 Mississippian and Pennsylvanian oil and gas fields have been found and over 200 wildcat wells have been drilled. The data from these wells have resulted in new interpretations of hydrocarbon accumulations. Early Pennsylvanian growth strongly influenced Mississippian accumulations, and recent refinements in seismic techniques have allowed definition of these growth features. By incorporating recent subsurface interpretations with the extensive seismic control available, numerous prospects are being defined and doubtless will result in additional pre-Cretaceous discoveries.

WALL, J. H., and C. SINGH, Geol. Div., Research Council of Alberta, Edmonton, Alta.

PALEOGEOGRAPHIC SIGNIFICANCE OF LATE CRETACEOUS MICROFOSSIL ASSEMBLAGE FROM BUFFALO HEAD HILLS, NORTHERN ALBERTA

A small isolated outcrop of shale in the Buffalo Head Hills of north-central Alberta has yielded forams, radiolarians, and dinoflagellates. The assemblage is of Senonian, and most probably of Campanian age. The foraminiferal fauna, including *Haplophragmoides fraseri, Verneuilinoides bearpawensis, Praebulimina carseyae,* and *Cassidella tegulata,* suggests correlation with the upper Campanian Bearpaw Formation of southern Alberta. The radiolarian assemblage includes *Spongurus* (*Spongurantha*) sp., *Spongodiscus* cf. *S. renillaeformis, Spongostaurus* sp., *Sethocyrtis* sp., and *Dictyomitra multicostata,* all forms illustrated by H. R. Bergquist from the Schrader Bluff Formation of northern Alaska, for which a middle Senonian age is designated. Essentially the same assemblage is known from the Bearpaw Formation in the Cypress Hills of southeastern Alberta. Among the dinoflagellates are *Deflandrea victoriensis, Dinogymnium longicornis,* and *D. siriricum*—forms which are restricted to the Senonian.

The stratigraphic position of this outcrop is from 100–200 ft above the Cenomanian Dunvegan Formation. The Senonian, or more specifically, the likely Campanian age of the outcrop suggests at least a marked condensation, if not a pronounced unconformity, in the area. The microfossil assemblage may be construed as evidence in support of J. A. Jeletzky's 1971 hypothesis that a connection existed between the Arctic and western interior regions through northern Alberta during the Santonian and Campanian.

WARTERS, H. R., Trend Exploration Ltd., Denver, Colo.

PINNACLE REEFS OF MIDDLE DEVONIAN ONONDAGA LIMESTONE, UPSTATE NEW YORK AND NORTHERN PENNSYLVANIA

The Onondaga Limestone was first named by James Hall in 1839 for exposures in Onondaga County, New York. It was also Hall who in 1859 recognized that the facies of the lower part of the Onondaga (Edgecliff Member) originated through the accumulation of coral skeletons and wrote of the occurrence of "coral reefs" in many places.

It was not until 1967, 128 years after Hall's initial work, that the first hydrocarbon-productive Onondaga reef was entered in the subsurface with the drilling by the Wyckoff Development Company of the Douglas Cornell No. 1 well in Steuben County, New York. The well, which was to test a structural prospect in the underlying Oriskany Sandstone, quite unexpectedly found 148 ft of gas-productive Onondaga reef. Since that time, intensive seismic and subsurface work by Trend Exploration Limited, Anderson Oil, and Cabot Corporation has resulted in the discovery of additional gas-productive pinnacle reefs in the area. These reefs are approximately 200 ft high, have initial flow rates of 15 million cu ft/day and calculated open flow approaching 30 million cu ft/day.

A consideration of the regional paleogeology, as derived primarily from well-sample examination, mechanical well logs, and the integration of detailed seismic data, leads to the conclusion that the gas-productive area is part of a much more extensive potentially productive pinnacle-reef basin. The occurrence of pinnacle reefs within the basin is controlled by change of lower Onondaga (Edgecliff) reef-platform facies to nonreefal basinal facies accompanied by subsidence. The subsidence at reef growth time is extreme in some areas of the basin indicating that many reefs substantially taller than those already found are present.

WEBB, J. E., Phillips Petroleum Co., Bartlesville, Okla.

RELATION OF OIL MIGRATION TO SECONDARY CLAY CEMENTATION, CRETACEOUS SANDSTONES, WYOMING

Thin section, sieve, and clay-mineral analyses indicate that many of the clay-rich sandstones in Wyoming were deposited as clean, well-sorted sands. After deposition and burial these sands were filled with either hydrocarbons or secondary clay cement. It is proposed that hydrocarbon migration took place shortly after burial. Those sands not filled with hydrocarbons were subjected to continued precipitation of clay from the formation waters until all effective porosity and permeability were eliminated. Later tectonic movements may position these "sealed traps" in an off-structure position. A thorough understanding of the geologic and