much clastic material and are placed in the Montevallo Supergroup. The upper three formations, Maynardville Dolomite to Chepultepec Dolomite inclusive, consist mainly of dolomite and comprise the Knox Dolomite Supergroup.

Sedimentation studies indicate that rocks of the Sauk Sequence were deposited in a transgressing sea which advanced from the southeast. The stratigraphic succession of Cambrian and Ordovician rocks of the Appalachian basin is clearly evident across Ohio. In northeastern Indiana, however, a transition occurs between the Appalachian basin carbonate facies and the Upper Mississippi Valley clastic facies of Wisconsin and Minnesota.

Cross sections reveal that the Sauk Sequence is truncated northward beneath the Knox unconformity. Petroleum production is related to stratigraphic traps below the unconformity. Chepultepec (Beekmantown) rocks have produced small quantities of oil and gas to the south in Kentucky. Copper Ridge (Trempealeauan) Dolomite is producing in central Ohio. Shady Dolomite is the reservoir rock of the Clearville pool in southern Ontario, and the wedge-edge of the Mt. Simon Sandstone is productive in the Gobles pool of central Ontario.

An isopach map of the Sauk Sequence shows a narrow, north-south area of thin Sauk in central and southern Ohio, over which lower beds are relatively thin or absent. This is interpreted as a Precambrian buried ridge known as the Waverly Arch. A lesser ridge may be present in eastern Ohio. In central-northern Ohio, isopach studies indicate a Precambrian platform in the vicinity of Lake Erie.

Oil accumulations of Morrow County are in stratigraphic traps of the erosional remnant type. Many are buried hills of local areal extent (100 to 300 acres), but most have high relief (100 to 200 feet) with pay sections up to 150 feet or more in thickness. Angle of west slope appears to be the critical trapping factor in remnant reservoirs. The Lower Chazy Dolomite ("Glenwood") and part of the Middle Chazy Limestone are generally missing by non-deposition. Commonly, secondary dolomitization of the Middle Chazy Limestone has occurred above the unconformity in these pinnacle type remnants, making the top of the Cambrian difficult to find.

Accumulation in the Marengo area of Bennington Township is apparently in a buried ridge of low relief, with 20 to 30 feet of overlying Lower Chazy Dolomite present. Pay thicknesses in remnants of the buried ridge type commonly range from 5 to 20 feet.

Erosional remnants are gas-solution type reservoirs with a possible moderate water drive. Porosity commonly varies from 6 to 20 percent and permeability from 1 to several hundred millidarcies. Water saturation is commonly 18 to 25 percent. Initial gas-oil ratios of 300 to 400 cubic feet per barrel increase gradually with production. Primary reserves are conservatively estimated at 140 barrels per acre foot, based upon 25 percent recovery of 560 barrels per acre foot in place.

Statigraphic traps due to truncation, sand pinch-outs, permeability barriers, and erosional remnants below the Knox unconformity may be present in all parts of Ohio. Lack of information concerning structure in the Sauk Sequence does not rule out the possibility of structural accumulations. To the present time, the great bulk of Cambrian production has been from erosional remnants in Morrow County. Extensive exploration in Ohio is expected to continue for at least several years.

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April 7, 1964

UMBERTO COLOMBO, Donegani Research Institute, Italy
"The Evolution of Petroleum"

"The idea of a 'metamorphic' evolution of petroleum arose from the consideration of differences existing in chemical structure of crude oils within each sedimentary basin, and from certain regularities, which seem to indicate a relationship between the structure of oils and such geological parameters as age and depth of their reservoirs. This concept of evolution of petroleum was strictly connected with the classical hypothesis of the origin of oil in 'source rocks,' through complex transformations of biologic matter. Recent studies on migration of hydrocarbons and on the composition of crude oils have led to a substantially new picture of origin and alteration of oil deposits. The new ideas are reviewed, with particular reference to their implications in the problem of evolution of petroleum."

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April 13, 1964

ED BARRETT, Continental, Oklahoma City "Origin of Mobile Belts—Ouichitas Emphasized"

No one, to the present writer's knowledge, has satisfactorily explained the underlying reason for the continent-bordering mobile belts, and the following hypothesis may fall in the same category. It is thought reasonable, however, to assume that the thermal, and therefore density, differential between the sub-continental and sub-oceanic basaltic layer, is responsible for the turbulent zones referred to as the mobile belts.

Conflicting evidence points to a difference of temperatures between the basaltic layer beneath the ocean floor and the subsurface of the continent. It is argued, convincingly, that sub-continent basalts are cooler than those beneath the oceans. It is just as convincingly argued that sub-continent basalts are warmer than those beneath the oceans.

Inadequacy of measuring devices and difficulty in obtaining sufficient coverage of data is the present barrier to proof in either direction. It appears, to the writer, more logical to assume warmer sub-continent temperatures for several reasons. The material of the continents is less dense and less apt to lose its heat. Also, the oceanic cover of water would appear to act as a reflecting shield to prevent the degree of heating of the submarine surface by solar radiation as that being absorbed by the continents. In any case conclusive evidence is still lacking, and it fits the general hypothesis to follow the latter view.

Attention is called to the fact that oceanic waters, subjected to flow by various factors, the principal of which is the earth's rotation, seek levels based upon their temperature and density differentials. Although there is some mixing, the major feature observable is the fact that bodies of water of even slightly different temperatures and densities collide with the result that the warmer or lighter current overrides the cooler or denser. At their zone of collision a surface of discontinuity is set up much like that of an overthrust fault zone, and the ensuing upwelling creates a pronounced zone of turbulence.

A generalized diagram of a cold front in the atmosphere is illustrative of the same principle. As in the case of ocean currents, the triggering mechanism is, in the main, a great and extensive force—the earth's rotation. The warmer and lighter air overrides the cooler and denser along a surface of discontinuity between two air masses of only slightly different temperature and composition. It is along, and in proximity to, that surface of collision that a zone of turbulence with its ensuing thunderstorms is created.

It is therefore postulated that an analogous situation occurs between the warmer, lighter continental mass and that of the cooler, denser sub-oceanic mantle, thus creating a zone of turbulence in the form of volcanoes and mobile belts. Although the specific differences between air, earth, and water are great, there exists a much lesser difference in the principles involving two masses of the same media. It is considered less than reasonable to deny the existence of the subjacent and superjacent relationships between contrasting masses in all three media. In each case there is a major cause which is not immediately apparent upon specific or particular examination. In all cases temperatures and densities are involved, and the major intermediate cause of overriding in air and water is the earth's rotation. A major, intermediate cause for overriding in the earth's crust is held to be the crustal shrinkage as diagrammed. The only apparent, great difference between the three cases of turbulence is one of time and the time required is apparently proportional to the density and friction of the medium involved.

That an overthrusting relationship exists between continent and ocean, is indicated by the depth of earthquake foci which are most shallow at the island arcs and progressively deeper toward, and beneath the continents. Diagrams are constructed to illustrate this concept of how the continents have grown by accretion due to encroachment of auxiliary welts and subsequent marginal mountain building. The bordering geosynclines are thus formed, primarily by compressional forces oriented horizontally, and are filled with sediments the character of which mainly depends upon source—cratonal or extra-cratonal.

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May 4, 1964

MERRILL J. REYNOLDS, Oliphant Co.
Tulsa

"Geothermal Energy Exploration"

The search and utilization of geothermal energy as a new source of power commenced in Italy in the early 1900's. The first light bulb to be lit by power produced from the natural heat of the earth occurred in 1903. Today, Italy produces sufficient power from geothermal energy to operate its entire network of electric railroads which amounts to approximately 300,000 kw.

Iceland followed Italy in its search for geothermal energy after World War I. Today, domestic and industrial heating is quite common; there is a prospect of a 25,000 kw plant soon to go into operation.

New Zealand produced their first power from geothermal energy in 1958. Their present capacity is approximately 102,000 kw.

In the U. S., between 1921-1925, eight steam wells had been drilled at the Geysers, 75 miles north of San Francisco, California. The project was unsuccessful because abundant, relatively low cost water and fossil fuel generated electric power was available. Between 1956-1958, several of the original wells were reworked and several new wells were drilled. In 1958 the first power plant, with a capacity of 12,500 kw, was installed.