100 barrel well will pay out in approximately 7 months, a 200 barrel well in just over 3 months, etc. As to the profit derived in relationship to the total investment made in the play, it should be necessary to consider that if one follows the average discovery frequency, the total investment costs charged to a producing well would be the cost of the producer equipped, plus the cost of two dry holes drilled with it in the exploration program. This would amount to a total of $85,000 spent, $45,000 for the producer, and $20,000 each for two dry holes. The cost per barrel developed would be 68¢, considering 125,000 barrels of recoverable oil for the average well. The 7/8ths working interest should receive $319,000 from pipeline runs of this reserve. If the overall lifting cost and local taxes (the latter being about 1% of gross production) total 50¢ per gross barrel or $62,500, then about $257,000 of net operating revenue should be derived per well. The ratio of net revenue to development cost would then be $257,000 divided by $85,000, or three to one.

There is a remarkably widespread viewpoint and disparity in final conclusions as to whether or not to enter into an exploration program in Ohio. The individual or small independent has been tremendously impressed with rapid payout of investment when being fortunate enough to find production. The risk in the amount of dollars spent seems to this group to be fairly small, because the shallow drilling depthhs result in cheap dry holes. The individual or small independent then is able to continue in the position of being wounded but not dead, as he would have been when taking even a relatively small interest in an 8,000- to 12,000-foot well. This prospecting group has found a great deal of oil in Ohio, whether or not the decision to drill a well was made on sound exploratory knowledge and judgment, or whether the location was made just because one could drill a cheap hole on a small amount of acreage available. This practice has resulted in operators with a great deal of acreage being able to give up a minimum acreage position and even impose high overriding royalties on the earned acreage.

Major oil companies seeking larger pools might be aware that there is an excellent chance, grading to reasonable certainty, that erosional remnants will not be the only available trap for accumulation of Cambrian oil in Ohio. The Beekmantown wedge of post-Cambrian and pre-Ordovician sequence offers a splendid opportunity for a stratigraphic trap in its updip limit of deposition in southern and central Ohio. Certain geophysical exploration has indicated structural features, possibly basement included, in east-central Ohio, deeper in the Appalachian basin. Northern Ohio offers the possibility of the truncation of the Trempealeau and occurrence of Franconia (the next oldest Cambrian bed) as the unconformable surface of the Cambrian. Facies change of the Glenwood Shale to a dolomite section is a fact in certain areas, and production has been found in this formation.

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November 2, 1964
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"Stratigraphy of the Moon"

The U. S. Geological Survey is currently preparing a geologic map of the earthward hemisphere of the Moon at a scale of 1:1,000,000, using direct visual and photographic observations through large telescopes, and more recently, images transmitted by Ranger spacecraft. The purpose of the mapping is to develop and portray our understanding of the history of the Moon, to provide a basis for selection of favorable sites for lunar missions, and to serve as a framework for the much fuller geologic survey that will be carried out when manned landings are made. For this purpose a lunar stratigraphy is used that is closely analogous in principle to that used on Earth.

Both rock-stratigraphic and time-stratigraphic units are used. The fundamental rock-stratigraphic unit is the formation. In the absence of direct information on lithology, formations are characterized by homogeneity of physiographic expression and albedo. Some formations have been given formal binomial names; for others only the age designation and characterizing features are used. Related formations are assembled into groups, and facies within formations are distinguished, corresponding to members on Earth although not formally designated as such.

Although each formation has a distinctive composition and mode of origin, hypotheses concerning these can form no part of the definition of the formations. On the contrary, the stratigraphic assignments, based on observed appearances and relationships, should aid in formulating such hypotheses.

Time-stratigraphic classification is based on the laws of superposition and intersection. These may be applied to the formations directly, or they may be used to develop secondary criteria of age, as in the case of certain fresh-appearing craters which are surrounded by rays (radial streaks of bright material). Whenever a relationship of superposition between two craters or their ray systems can be determined, the crater with the brighter rays is younger than the crater with the fainter rays or with none at all. It thus appears that rays fade with time, eventually reaching the point of invisibility, so that a ray system indicates that its central crater is relatively young. Another useful index of age is the spatial frequency of small impact craters on a unit, which is higher the longer a surface has been exposed to meteorite bombardment.

The fundamental time-stratigraphic unit is the system, comprising the formations deposited during a period. Three systems are now recognized, one of which has been subdivided into two series. Older rocks have not yet been formally classified. In descending order the systems are:

Copernican System

Eratosthenian System

Imbrian System $\begin{cases}\text{Archimedian Series}\\ \text{Apenninian Series.}\end{cases}$

The Copernican System includes the deposits associated with ray craters, such as the crater Copernicus itself. In addition, formations of volcanic or other origin that can be shown to be stratigraphically above a ray center are included in the Copernican System.

Erastosthenes, a fresh-appearing crater without bright rays, serves as the type locality for the Eratosthenian System. Most fresh appearing craters without rays are mapped as Eratosthenian, but since other factors than age, such as the albedo of the background, have some effect on the visibility of rays, a degree of uncertainty in the Eratosthenian-Copernican boundary is inevitable. Aside from the rays, Eratosthenian and Copernican craters are similar, although the effects of erosion (presumably by meteorite bombardment) are typically more developed in Eratosthenian craters. Crater formation was the dominant, but not exclusive, process active during the Eratosthenian Period, as in the Copernican Period.

The Imbrian System includes units associated with the formation and the filling of the Mare Imbrium basin, and correlative units elsewhere on the Moon. The base of the Imbrian System is defined by the base of a widespread blanket of material surrounding Mare Imbrium. The deposition of this blanket is believed to have resulted from a single catastrophic event (apparently impact) by which the basin occupied by Mare Imbrium formed (Shoemaker, 1964). A system of lineaments, probably faults, known as Imbrian sculpture, apparently developed at the time of this event. The presence of Imbrian sculpture in a rock unit serves as a criterion of pre-Imbrian age.

The Apenninian Series, named for the Apennine Mountains on the edge of Mare Imbrium, includes the blanket mentioned above and other widespread formations apparently symmetrically distributed around Mare Imbrium. It is uncertain whether the entire series is composed of material deposited in a brief period of time as a result of the Mare Imbrium event or whether it includes genetically unrelated materials deposited over a longer span of time.

The Archimedian Series begins with deposits from the oldest craters superimposed on Apenninian material, such as the crater Archimedes, and extends to the top of a widespread unit of extensive smooth dark mare materials, named the Procellarum Group after Oceanus Procellarum. When the first maps were prepared, it was thought that deposition of all the mare material took place in a brief period, which was distinguished as the Procellarian Period, between the Imbrian and Eratosthenian. Further mapping, however, has shown that deposition of mare material occurred over a lengthier span of time, simultaneously with continued crater formation. The time significance of the mare material is thus less and the Procellarum Group is now regarded as a rock unit of Archimedian age. The spatial frequency of small craters is approximately uniform over the surface of the Procellarum Group, suggesting that deposition terminated at roughly a single point in time. This surface is consequently used to define the Imbrian-Eratosthenian boundary.

Work is in progress on the division of pre-Imbrian time, primarily on the basis of deposits and structures related to the formation of basins older than Mare Imbrium. Local stratigraphic columns have been developed, but as yet none are sufficiently certain for incorporation into a Moonwide stratigraphic system.

The absolute length of the periods can be estimated only crudely. An assumption that the majority of craters are of impact origin allows the spatial frequency of craters on surfaces of different ages to be compared with the flux in space of potential crater-forming objects and the spatial frequency of presumed impact structures on Earth. Such comparison suggests that, if the present rate of flux prevailed through the Copernican and Eratosthenes Periods, these periods occupied the greater part of time since the origin of the planets. If so, the pre-Imbrian and Imbrian must have been periods of short duration during which the rate of impact of crater-forming objects exceeded that in subsequent time.

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November 9, 1964

W. M. HAAS, Humble, Houston

"What Is Our Geologic Image?"

The image the geologist portrays to the public is generally indistinct. Few people have a clear understanding of the geological profession and its contributions to society. The capabilities, talents, and potential leadership of the geologist are generally overlooked. The image must be brightened by aggressive actions. The public should be informed and educated to the qualities of the geologic profession. Students need to be encouraged to study geology; to recognize that geology as a science is not only rewarding as an avocation but also as a vocation; that the economic geologist has almost unlimited opportunities to advance his ambitions.

During 1966, the Semi-Centennial Year for the American Association of Petroleum Geologists, petroleum geology will be publicized. Through its theme "Petroleum Geology—The First Fifty Years" the public will be informed on the contributions that petroleum geology has made to mankind. Both national and local publicity campaigns will take the geological message to the people in an effort to enhance and enlighten the geologic image.

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November 16, 1964

D. M. TRIPLEHORN, Sinclair Research, Tulsa

"Origin and Significance of Glauconite in the Geologic Sequence"

Glauconite is defined as any sand-sized, earthy, greenish pellet found in sedimentary rocks. This definition has no specific implication regarding chemical or mineralogical composition. However, most glauconite pellets are composed primarily of a randomly interlayered 10-Angstrom non-expandable (illitic) material and expandable (montmorillonitic) material. Much of the variation in glauconite properties is related to variation in the amount of expandable layers present.

Glauconite pellets reveal much variety in external appearance (morphology) and internal structure (as seen in thin section). These characteristics can be used to interpret the origin and/or subsequent history of pellet types. Suggested origins include (1) chemical precipitation, (2) expansion and alteration of detrital mica, (3) alteration of fecal pellets, (4) alteration of clay fillings of fossil tests, (5) mechanical aggregation, and (6) chemical replacement. Original morphologies may be obscured by abrasion (reworking) and internal structures changed by recrystallization.

Glauconitization apparently requires four essential factors: (1) parent material (generally an expandable layer lattice silicate), (2) a source of iron and potassium (sea water), (3) local reducing conditions, and (4) time. The last factor emphasizes the progressive nature of glauconitization, which may be terminated at any stage (most likely by burial).

The progress of glauconitization results in certain interrelated changes in glauconite pellets:

(1) An increase in iron and potassium, (2) a decrease in the amount of expandable material, (3) an increase in crystallinity (degree of ordering), (4) a change from light green to dark green color, and (5) an increase in rounding and sorting of pellets. There are only general trends and exceptions may be common.

Glauconite is a reasonably safe criterion for a marine, shallow water environment and slow rates of deposition. It is most abundant at unconformities; e.g., at the base of marine transgressive sequences. Redeposition in terrestrial environments is unlikely. Transportation of glauconite after its formation inhibits its use as a more spe-