OIL & GAS JOURNAL 61 (JUNE 17, 1963): 131-136,

Opinion

Is the "Song of Plenty" a siren song?

This appraisal of our future oil and gas resources is, as clearly labeled here, one man's opinion. He is a geologist, lawyer, realist, and thinker, with a solid background of experience. He supports his commentary with some hard facts that make for interesting reading and stimulating thought. Here is "must" reading for all who would deal in futures, for if the "Song of Plenty" is truly offkey, the industry must be made aware of it.

BY H. K. HUDSON

H. K. Hudson earned an AB degree in geology from University of Oklahoma and was a practicing petroleum geologist before returning to the university to study law. He joined Phillips Petroleum Co. as a lawyer after obtaining his LLB degree in June 1926.

Throughout his legal career he has been intimately associated with matters related to oil and gas reserves, including several important Federal Power Commission natural-gas-certificate cases dealing with the adequacy of present and future gas reserves.

DURING the 6-year period since 1956, the number of exploratory wells drilled in the search for oil and gas has declined to only about two-thirds of the 1956 high; the number of drilling contractors that have gone out of business and the number of rigs that have been cannibalized to make repairs on other rigs have been tremendous; and the number of students studying to be petroleum engineers and geologists has declined at an alarming rate. During this same period gas reserves added annually have been far below the highs of 1955 and 1956; and last year, for the second time, oil reserves added (including secondary recovery) in the U.S. were less than production.

It is well known that the U.S., in making its tremendous industrial strides, has already exploited many of its mineral resources (iron, copper, lead, zinc, etc.) to a point where we are now mining low-grade ores in the U.S. and importing high-grade ores from other countries. In the face of that history with respect to our solid minerals, and in the face of the trends above referred to with respect to the exploration for and finding of crude oil and natural gas, some supposed experts still try to assure the Government and the people of the U.S. that there are far greater volumes of crude oil and natural gas still to be found in the U.S. than we have found to date; that, indeed, we have barely scratched the surface.

This "Song of Plenty" unavoidably creates an impression in many circles that oil and gas should be relatively easy to find. The fact that it has made an impression is shown by a recent statement by the chairman of the Federal Power Commission of his conclusion that we need have no concern over our gas supply for 15 or 20 years or perhaps before the year 2000.

Contrary to this easy assurance of great supply, Dr. M. King Hubbert, of the National Academy of Sciences, and Ralph E. Davis, one of the most highly respected gas geologists in the U.S., in separate studies, calculate that volumes remaining to be found are of about the same magnitude as those which have been found and that our finding rate has passed its peak. Hubbert's estimates cover both oil and gas; Davis's cover gas. Some of the high estimates of the crude oil and natural gas still to be found in the U.S. are as much as 4 or 5 times as great as the estimates of Hubbert and Davis.

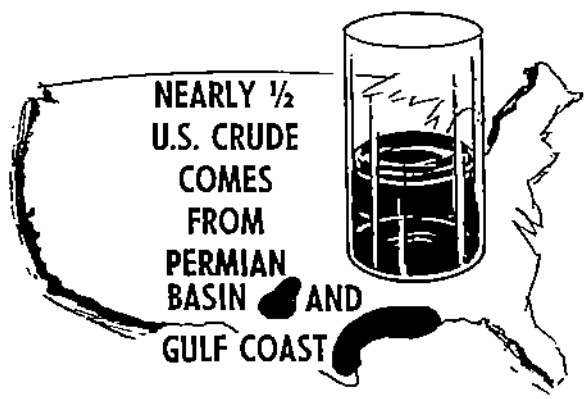
Extrapolations and assumptions not valid. How are these high estimates made? Using estimates of proved reserves of crude oil already found, the forecasters make extrapolations for crude oil to be found in the future based upon the assumption that the sedimentary deposits as yet unexplored will have crude-oil-bearing characteristics similar in some manner to those which have been explored. They then use an assumed (but unsup-

portable) historical ratio of the rate of finding of crude oil to the rate of finding of natural gas and calculate the volumes of natural gas still to be found. Demonstrably, these assumptions and these extrapolations have absolutely no validity.

Some of the facts uncovered by the oil and gas industry in recent years demonstrate the invalidity of those assumptions and extrapolations as well as the invalidity of broad, unsupported statements about the enormous volumes of crude oil and natural gas still to be found in the U.S. Why won't these forecasters face those facts?

Disappearing crude oil with depth

In the last 25 or 30 years, the oil and gas industry has been finding that, beginning at depths of about 8,000 ft, as we drill deeper and deeper, more and more of the hydrocarbon reservoirs are gas reservoirs and fewer are crude-oil reservoirs. In some manner, heat and pressure at great depth, together with the passage of geologic time, have done something to the crude oil. It simply isn't there in the same degree as at shallower depths.



Consider the facts that have been disclosed concerning the Permian basin area of West Texas and southeastern New Mexico and the Gulf Coast area of Mississippi, Louisiana, and Texas. These two areas account for nearly half of the total crude-oil production of the United States. As Dr. Frank J. Gardner, Exploration Editor of The Oil and Gas Journal, shows in an article in the Mar. 18, 1963, issue of the Journal, entitled "Deep Oil: Is It Only a Mirage?" these two areas also contain a large part of all the sedimentary beds in the United States below 20,000 ft.

In a current FPC area rate hearing, evidence has been introduced that in the Delaware - Val Verde basin, which is the deepest part of the Permian basin area, there is virtually no oil at depth—only gas. Although geophysics shows that the sedimentary beds in that area extend to a depth of 35,000 ft or more, enough exploration at depth has already been done to show that there is very little likelihood of commercial crude-oil reservoirs anywhere in the Permian basin area below 15,000 ft.

Now look at the Gulf Coast area. In the same FPC hearing, it was pointed out that, although at shallower depths a very large part of the producing reservoirs are crude-oil reservoirs as compared to gas and gas-condensate reservoirs, below 8,000 ft they constitute only 46%; below 10,000 ft it becomes 37%; and below 12,000 ft it is only 30%. Anyone can see that that trend comes to 0% at about 19,000 or 20,000 ft. In his article, Gardner points out that, out of a total of 15 record-setting wells drilled below 17,000 ft in the United States, only 3 have been productive and only 1 of those (a well in South Louisiana) produced crude oil in small quantities below 20,000 ft. That well was abandoned after producing for a relatively short time, obviously before it paid for itself.

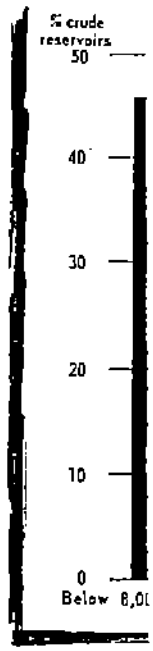
None below 16,000 ft? As a matter of fact, after a considerable amount of exploratory drilling and some crude-oil production below 15,000 ft, no really significant crude-oil discovery has been made below 16,000 ft anywhere in the United States. The depth below which crude oil in commercial quantities will not be found may well be about 16,000 ft instead of 19,000 or 20,000.

With such facts facing us indicating that there may be little or no commercial crude below 20,000 ft, or perhaps even below 16,000 ft, how can any one make a valid assumption based upon the oil-bearing characteristics of known producing sedimentary beds at shallow depths to calculate any substantial volumes of crude oil in unexplored sedimentary beds at great depths? Instead of such pointless extrapolations, why don't the forecasters face this evidence that crude oil will not be present at great depth as it has been at shallower depths?

The phony "finding ratio." Since, as indicated above, the calculations by extrapolations of the volumes of crude oil to be found at great depth have no validity, then certainly any calculations of the volumes of natural gas remaining to be found at depth, based on the crude-oil calculations, are equally suspect.

Furthermore, the so-called "finding ratio" between the finding of natural gas and crude oil is completely phony. Since much of our crude oil and natural gas occurs in separate "nonassociated" reservoirs, and since in some areas we find mostly gas and in others mostly oil, the so-called finding ratio makes no more sense than a finding ratio between crude oil and lead. As a matter of fact, if the forecasters had included Canada in their studies and had counted the 300 billion bbl of Alberta tar sand as crude oil (which it is), their finding ratio for gas would have been so low that their calculated volumes of natural gas still to be found in the U.S. would have had to be far less than those of Hubbert or Davis—even when based on the invalid high calculations of crude oil still to be found.

Smaller reservoirs with depth. Now consider some facts that we have available to us with respect to the probable volumes of natural gas,



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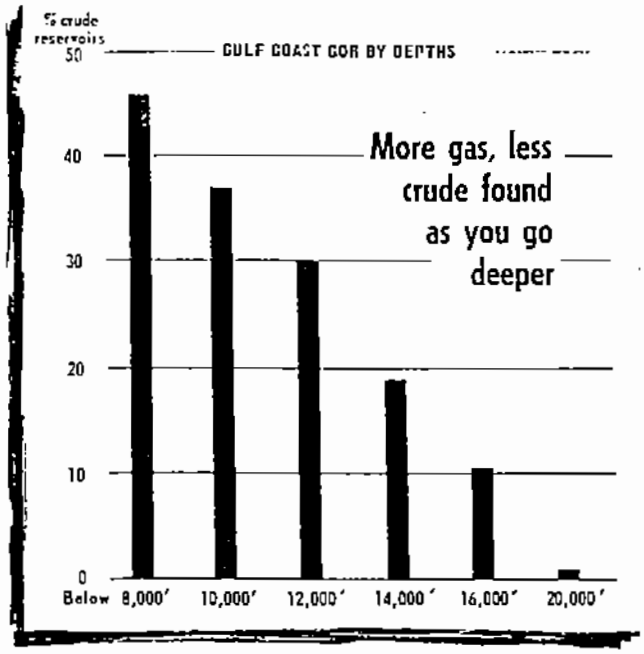


as well as crude oil, at great depths. As Gardner shows by the map accompanying his article, the sedimentary beds lying below 20,000 ft have a relatively small areal extent, compared to the hundreds of thousands of square miles of sedimentary beds in the U.S. above that depth which have been fairly well explored. So, the available sedimentary beds at great depth will necessarily be far less extensive than the beds above that depth.

However, there is another fact of even greater importance than the limited areal extent of the deep sedimentary beds. This is the very considerable evidence that, as we drill deeper and deeper, the individual reservoirs encountered are smaller and smaller. This seems to be true for both oil and gas.

- The largest known single accumulation of hydrocarbons in the world is the shale oil of Colorado and Utah. The volume of this oil has been estimated to be 3 or 4 times as great as all of the proved reserves of "conventional crude oil" (i.e., producible from wells) in the entire free world. This vast accumulation of hydrocarbons lies at and slightly below the surface.

- The next-largest known accumulation of hydrocarbons in the world is the Athabasca tar sands of Canada, the volumes of which have been estimated to be about equal to the total proved reserves of conventional crude oil in the free world. The tar-sand oil also occurs at and slightly below the surface.

- By far the largest known single accumulation of natural gas in the free world is the Panhandle-Hugoton reservoir with original reserves of 70 trillion cu ft at a depth of approximately 3,000 ft.

- By far the largest known accumulation of conventional crude oil in the Western Hemisphere is East Texas field with an original reserve of some 5 or 6 billion bbl at slightly below 2,000 ft.

- The next-largest known single accumulation of conventional crude oil in the United States is the old, shallow Panhandle field oil reservoir with an original reserve of more than 1 billion bbl at about 3,000 ft.

- Next in size to the Panhandle-Hugoton gas reservoir is the San Juan-Mesa Verde reservoir in northwestern New Mexico and southwestern Colorado with an original reserve of about 8 trillion cu ft and at depths of 5,000 to 6,000 ft.

Nowhere in the U.S. below 5,000 ft have we found any single crude-oil reservoir remotely comparable in size to the shale-oil deposit, the Athabasca tar sands, or even East Texas field; and nowhere below that depth have we found any natural-gas reservoir remotely comparable in size to the Panhandle-Hugoton reservoir. And nowhere below 10,000 ft have we found any single crude-oil reservoir equal in size to the shallow Panhandle field oil reservoir or any single gas reservoir equal in size to the San Juan-Mesa Verde or even to the old, shallow Monroe reservoir of North Louisiana, which had a gas reserve of about 6 trillion cu ft.

There has to be a reason for this greater accumulation of hydrocarbons at shallower depths. In developing the science of geochemistry and geobacteriology, it has been found that the soil above a hydrocarbon reservoir contains more hydrocarbons than the soil elsewhere. They obviously got there by vertical migration through relatively impervious beds. Isn't it quite possible that, during the millions of years of geologic time, this vertical migration from the deep high-pressure zones to shallower low-pressure zones has been the cause of larger accumulations in the shallower zones and that the recoverable gas, as well as the recoverable oil, at great depth may be far less than at shallow depths?

Regardless of the reason for this phenomenon, the important fact is the evidence of smaller reservoirs of hydrocarbons at greater depths. In the face of our knowledge with respect to that lesser occurrence at great depths, how can anyone, by the extrapolation methods above referred to, possibly make any valid estimate of enormous volumes of crude oil and/or natural gas at great depth? Why don't the so-called experts face those facts honestly?

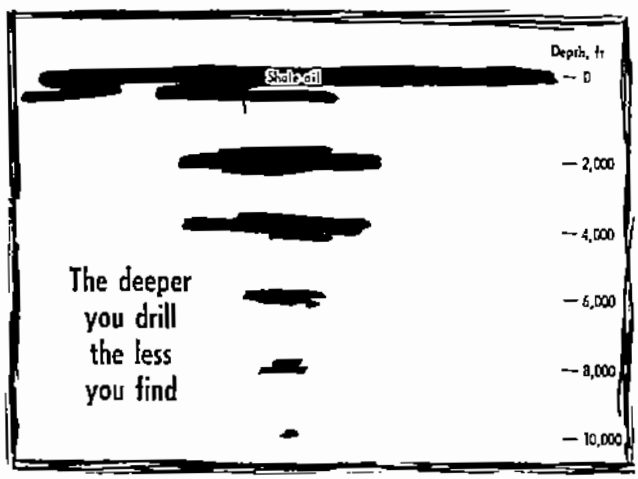
Disappointing exploration in shallower sedimentary beds

Now, how about the facts available to us which give us some indication of the probable occurrence or nonoccurrence of crude oil and natural gas in the shallower sedimentary beds which have not yet produced in large volumes?

The shelves. Consider first the continental shelf around the United States, now being looked upon as a happy hunting ground. Every geologist knows that, so far, wherever in the world we have found oil or gas on an offshore continental shelf, it has been in depositional basins which produced onshore and which extend out onto the shelf. The examples of this in the United States are the Los Angeles Basin and the

Gulf Coast of Louisiana and Texas. In both cases, discovery of oil and gas on the continental shelf has been an extension of discovery in the same basins on shore. This certainly gives us some basis for suspecting that, where the depositional beds are barren onshore, they may also be barren on the adjacent continental shelf.

The coastal plain. Now look at the Atlantic Coast. Although the Appalachian area has produced tremendous volumes of carbonaceous material (coal) and tremendous volumes of crude oil and natural gas, all of this production has been from deposits found west of the easternmost ridge of the Appalachian Mountains. The Atlantic Coastal Plains seem to be barren of fossil fuels (coal, crude oil, or natural gas). With this evidence that the sedimentary beds are barren onshore, the odds are very high that they will be barren offshore.



Now extend this inquiry around Florida and into the Gulf Coast and consider the unsuccessful exploration that has already taken place on the Atlantic Coast and Florida Gulf Coast. In the current FPC area rate proceeding above mentioned, evidence with regard to this exploration was presented which was surprising to many. It was shown that, along the entire Gulf Coast of Florida and along the U.S. Atlantic Coast, there had been a total of at least 475 exploratory dry holes drilled to depths greater than 3,000 ft (and a lot more to shallower depths), including about a dozen deep, dry holes on the continental shelf, and that the only production in that entire area is one 11-well oil field on artificial lift and one abandoned gas well, both in southern Florida. Three more exploratory dry holes were drilled in 1962: one almost 13,000 ft deep in the gulf in the Key West area; one almost 12,000 ft deep in the Florida Panhandle; and one shallower well near Tallahassee.

On the basis of that evidence, neither the onshore nor offshore areas of the Gulf Coast of Florida and the Atlantic Coast give any present indications of possible oil and gas production.

The official records of Washington and Oregon show that 375 exploratory dry holes (110 deeper than 3,000 ft) have been drilled in Washington and 167 exploratory dry holes (42 deeper than 3,000 ft) have been drilled in Oregon. The only production resulting from that exploration was from one small oil well in Washington, now abandoned.

There is current exploratory leasing activity on the continental shelf off Oregon and Washington. It remains to be seen what will be found but, if anything is found, it should be kept in mind that the continental shelf of the entire Pacific Coast is quite narrow, compared to the wide shelf off Louisiana.

Oil may be found in those states, but there is certainly no present evidence of enormous accumulations there either onshore or offshore.

Now extend the same inquiry to the continental shelf off Texas. It is well known by geologists that the sedimentary beds under the continental shelf off Texas are considerably different from the sedimentary beds of the continental shelf off southern Louisiana. A substantial amount of exploration on the shelf off Texas has proved quite disappointing. See The Oil and Gas Journal article on this subject in the issue of Sept. 4, 1961, entitled "Federal Waters Off Texas Disappointing So Far." They are still disappointing.

With respect to the Atlantic Coast, the Florida Gulf Coast, Oregon and Washington, and the Texas Gulf Coast, isn't it probable that the people who drilled the unsuccessful exploratory wells in those areas made use of all the geological and scientific knowledge that they had available, and that they considered those areas to be promising for exploration? Isn't it probable that a majority of those exploratory dry holes were drilled on promising geological structures? In view of the poor results of exploratory drilling in those areas, isn't there a likelihood that the results in other unexplored areas in the United States will be equally disappointing? Why won't the "experts" honestly face the implications of all this disappointing exploration?

Prospects in the older producing areas

There is much talk about the reserves that will be added in the future in the older areas due to improved technology. Of course, there is still a lot of crude oil and natural gas to be found in the older areas that have been fairly well exploited. Some of this oil and gas will be found in "traps" still to be discovered and some will be found in the less-permeable or "tighter" formations that we formerly could not develop commercially. However, it must be remembered that, since Colonel Drake's well, almost 2 million wells have been drilled for oil and gas in the United States and, in many areas, those wells have pretty well perforated a lot of the sedimentary beds like a pin cushion down to basement rocks or to considerable depths.

With respect to the "traps" still to be found, geologists generally recognize that we have probably discovered the greater part of the important "structural" traps which can be located by surface geology and geophysics; and that from now on, the search in future must be for "strat which are the mo most costly to find. the tighter formation heretofore passed technology will let u future, won't that b nature of gleaning?

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on, the search in the older areas must be for "stratigraphic" traps, which are the most difficult and most costly to find. With respect to the tighter formations which we have heretofore passed up but which technology will let us develop in the future, won't that be at best in the nature of gleaning?

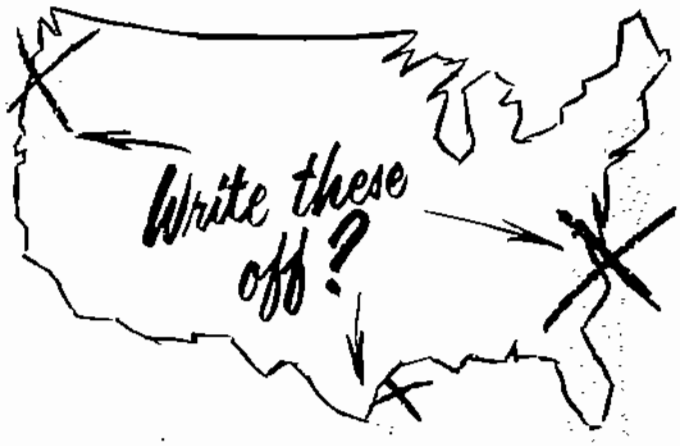
Future prospects compared to past experience

In the last 100 years, we have found in the U.S. approximately 100 billion bbl of crude oil and approximately 500 trillion cu ft of natural gas. Hubbert estimates about 75 billion bbl of crude oil still to be found, and Hubbert and Davis both estimate about as much gas to be found as we have heretofore found.

Now consider the evidence of (1) the probability of no commercial crude oil below 20,000 ft (perhaps 16,000) and of smaller gas reservoirs at depth, (2) the exploratory evidence of poor prospects, onshore and offshore, of the Atlantic Coast, the Florida Gulf Coast, Oregon and Washington, and of the continental shelf off Texas, and (3) the comparative narrowness of the Pacific continental shelf.

With that evidence in mind and remembering the hundreds of thousands of square miles that have been explored and exploited in the last 100 years by nearly 2 million wells, as well as the tremendous reservoirs that have been found and substantially produced during that period, the writer cannot imagine where the sedimentary beds could be that could contain a total volume of crude oil and a total volume of natural gas about equal to what we have heretofore found, as estimated by Hubbert and Davis, let alone the astronomical estimates of some of the other forecasters.

It is even more impossible to imagine the geological and economic climate under which such volumes of crude oil and natural gas could be found in commercial quantities. Considering this evidence, it may very well be that even the estimates of Hubbert and Davis are on the high side rather than the low side.



To say, as some do, that in a hundred years of extensive exploration and development we have found only a small part of the total volumes of crude oil and natural gas to be found in the U.S. seems absurd and extremely dangerous.

Producers are unbelieving. It is interesting to note that the activities of a large part of the producing industry show that the producers do not place much reliance on the Song of Plenty. During the last 6 years when exploration for new crude oil and natural-gas supplies has been at a very low rate in the U.S., many producers and many companies which need crude oil have, at relatively high prices, been buying proved reserves of crude oil and acquiring companies that have such reserves. Also, during this time, most of the larger producers and many of the smaller ones have been feverishly engaged in extensive and costly laboratory, pilot-plant, and development operations in the secondary recovery of crude oil in the older fields. This type of operation is limited to certain types of crude-oil reservoirs. Also, while secondary recovery increases the recoverable oil in an oil reservoir, it greatly reduces the recoverable gas in the same reservoir. And, while exploration in the United States is at a very low point, it is common knowledge that many U.S. producers are conducting extensive exploratory activities in foreign countries. The inference to be drawn from all these activities with respect to the opinion of all these producers as to volumes of conventional crude oil still to be found in the U.S. far greater than we have found to date seems fairly obvious. They don't believe it.

Possible alternatives

The discussion herein with respect to crude oil has been limited to supplies of "conventional crude oil" within the 48 contiguous United States. Even if the volumes of conventional crude oil still to be found within those states should be less than estimated by Hubbert (a distinct possibility), we can take some comfort for the future in the availability of shale oil in Colorado and Utah and the oil still to be discovered and developed in Alaska, as well as the supplies of conventional crude oil and tar-sand oil which may be available from Canada. However, some of these potential oil sources are many years away from production in volumes significant to our national requirements. So, prudence in our national economy and in our national defense would seem to lie for the present in offering the producing industry all reasonable incentives to find and develop as much conventional crude-oil reserves as possible in the U.S.

With respect to possible alternative supplies, the picture for natural gas is different from that of crude oil only in degree. The transition to alternative supplies is, and must be, much farther away but, for the distant future, the supplies are there. Physically, coal or any hydrocarbon (as from the shale oil or tar-sand oil) can be converted into gas at a price and natural gas from foreign and Alaskan sources can be liquefied and transported by tankers at a price. The gas from these sources need be no different from the natural gas that is now being transported by pipeline. So, with

these future but more distant alternative supplies for natural gas, there is no need to press the panic button and to restrict unduly the use of natural gas, as by "end-use" controls and the rejection of worthwhile pipeline projects.

However, these alternative supplies do not appear to be competitive with natural gas in any large volumes for some years to come. The enormous distance included in bringing Alaskan gas to the other states through Canada by pipeline would seem to rule out that alternative. So long as the price of oil per Btu in the field is about 3 times the price of natural gas in the field, it would seem obvious that any efforts to develop the oil shales and the tar sands will, for some years to come, be directed primarily toward the production of oil rather than gas; and no one has yet demonstrated that gas from coal or liquefied natural gas transported by tanker from available sources can compete at the city gates or elsewhere with natural gas transported by pipeline at anywhere near current price levels, except possibly for peaking purposes. At best, LNG transported by ship will be available only to coastal areas and will be subject to all of the problems of imported crude oil.

But even suppose that gas from such sources might become competitive with pipeline gas at the city gates within the next few years. None of the gas from those sources would be available to the gas pipelines in the source areas of the pipeline systems. Those pipelines that we now have represent a gross investment of about $10 billion, of which only about one-fourth has been retired by depreciation, and they have many years to go (about 24 years at current depreciation rates) to amortize that investment; and, undoubtedly, gas-pipeline expansions in the next few years will add tremendously to that gross investment and to the number of years required to amortize it. Against that required depreciation life of about 24 years for the present pipeline investment, the present proved gas reserves provide a full line deliverability of only about 12 years for average annual volumes and a shorter period for peak-load volumes.

Regardless of possible future alternatives for gas, the pipelines must, short of bankruptcy, continue to operate until they pay out their investment. Not only that, they must operate at optimum capacity to keep down the unit costs and the resulting consumer rates to repay that investment. In other words, we must keep the present and future gas pipelines full for a good many years to come. Otherwise we face the inevitable alternatives of higher pipeline costs of handling gas and resulting higher consumer prices to cover those costs or a catacylsmic period of pipeline bankruptcies with an accompanying tremendously adverse impact on the nation's economy.

So, with natural gas as with conventional crude oil, prudence in our national economy and in our national defense would seem to lie for the present in offering the producing industry all reasonable incentives to find and develop new supplies.

There is still a lot of crude oil and natural gas to be found in the U.S. but there is much evidence that we do not have the vast potential supplies that some people would have us believe—perhaps not even the volumes estimated by Hubbert and Davis. Finding and producing adequate supplies will be a hard and costly job. The vitally important point for the United States and its citizens is that we do not delude ourselves about our future supplies of conventional crude oil and natural gas or the ease of finding those supplies. The next time a so-called "expert" sings the Song of Plenty about far greater volumes of conventional crude oil and natural gas still to be found in the U.S. than we have found to date, consider the evidence and ask yourself, "Where is all that oil and gas?"

Illinois DeWitt will get second oil-producing area

DeWITT COUNTY, northern Illinois basin area, is in line for its second oil-producing area. E. H. Kaufman set casing at 900 ft and is waiting on completion tools at his 2 Albion Kirk in NW NW SW 1-20n-4e.

A core in the Lower Mississippian at 642-77 ft got 6 ft of gas sand and 25 ft of oil-saturated sand. Shows of oil were recovered in a core of the Keokuk-Burlington at 774-80 ft.

This operator is also busy at another discovery prospect in this county at 1 G. H. McKinley in NE NE SE 34-21n-4e, 1 mile northwest. Swab got 25 to 30 ft of fluid which was 50% oil from the Lower Mississippian at 671-83 ft.

Deep Wapella East test. Lloyd A. Harris is drilling at 1,802 ft at the 4 Cora Brown in S½ SW SW 21-21n-3e.

Trenton Ordovician top is 1,762 ft. This is the first deep test in Wapella East field. DeWitt County's first oil-producing area and one of the most successful new finds in the basin in some time. The top of the Devonian was called at 1,103 ft with Silurian at 1,129 ft. A core at 1,124-57 ft had 4½ ft of tan lime, 2 ft dolomite and shale, and 26½ ft of reef dolomite with an oil show. Recovery in a drill-stem test at 1,125-27 ft was 30 ft gas, 510 ft of mud-cut oil, 90 ft of mud, and no water. A core at 1,157-83 had 7 ft of reef dolomite with an oil show and 19 ft of dolomite.

Other activity. Harris completed 6 T. P. Kiley in SW SE NW 28-21n-3e making 125 bo/d from 1,115-21 ft and the 7 Kiley in SW SW NW for 145 bo/d from 1,110-18 ft. Both of these producers are open-hole Silurian wells and were not treated. The 1 W. C. Bray in NW NE SW tested 12 bbl oil hourly.

Core pulled at new Montana explorer

The confirmation try to Spring Lake field in Richland County, northeastern Montana, Williston basin, had a core pulled at 12,073-92 ft. This well is McAlester Fuel Corp. 2-B NPRR-Vaira in NE NW 35-25n-54e.

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