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public forget, that oil and gas are the prime requirements for fuel and petrochemicals.

At the turn of this century, U. S. developed reserves were less than 3 billion bbls. of oil and we had produced less than 1 billion bbls. Total accumulated production and reserves were less than 3.4 billion bbls. This figure had only doubled by the end of 1910, when the professional petroleum geologist was beginning to make his presence felt. During the next 52 years, it rose 16 times to more than 113 billion bbls, over half of which has been developed during the past 20 years. The years 1957, 1962 and 1963 were the only years since 1943 in which newly developed reserves of liquid hydrocarbons did not equal production.

On the other hand, by 1910 we had only recorded production of some 35 trillion cu. ft. of natural gas. During the next 52 years, gas production amounted to over 200 trillion cu. ft. and reserves stood at 274 trillion.

Although the professional petroleum geologist can take a reasonable share of the credit for the discovery and development of these reserves, they represent the teamwork of invested capital, proficient management, diverse professions, and labor.

It appears that in this country we may have reached or neared the peak of petroleum productive capacity following some 30 years of very efficient discovery capacity. You can hear estimates of ultimate recoverable oil reserves for the U. S. running from 140 to 2,000 billion bbls. Future gas reserves have been estimated at from twice to eight times the present reserve (274 trillion cu. ft.).

It can be reasoned that the shallower and more cheaply found and developed reserves have largely been discovered. Not all, but most, future discoveries of importance must come (a) from the deeper portions of known basins, (b) obscure stratigraphic traps, (c) costly offshore exploration, and (d) remote unexplored areas. The petroleum geologist need have little worry about his place in the scheme of things. He will be, in increasing quantity and quality, an operating necessity to the well being of the petroleum industry and the nation. There are certain clear signs for his future. First, he can rest assured there will be an increasing demand for energy from hydrocarbons. The percentage increase is not important—there will be a market for an ever-growing supply of energy.

Secondly, the geologist must find these hydrocarbons under deeper and more hazardous drilling conditions, in remote and inaccessible areas, and in obscure stratigraphic traps. This will require a large number of holes. All of this can only add up to larger exploration costs.

Thirdly, no relief can be expected in the price situation for liquid hydrocarbons. The excess supply outside our borders within the next decade will be a strong deterrent to any domestic price increases. A rise in price would make competitive the vast quantities of hydrocarbon liquids in the tar sands, oil shales, and coals. The price ceiling which we have now must be lived with for some time.

Since we can't expect an increase in the price received for oil, and no decrease in the costs to develop and operate, where will the exploration money come from? There remain two ways to obtain the necessary increased exploration funds.

1. Obtain gas prices in line with the cost of finding, developing and producing gas and commensurate with its value as a fuel compared to other fuels. This is a political and consumer relations problem, requiring a great effort on the part of industry employees in educating others.

2. To compete successfully with foreign oil, we must develop our fields at a lesser cost by drilling fewer holes. It behooves us as geologists to continually strive for regulations and legislation that will allow wider development spacing, and allowable production rates which will provide economic incentive for wide well spacing.

Geologists have paid court to the words "stratigraphy," "sedimentation," and "lithology" for years, but only recently has the profession started to tie them together in a bundle and use this to develop knowledge that is understandable and useful in searching for the elusive "stratigraphic trap." The industry and the profession now have the tools and know-how to organize as concerted a search for "strat traps" as has been the hunt for structures the past 30 years. These two requisites can be combined to find ample hydrocarbons on this continent during the next generation to fill the needs of the following generation. The will-o-the-wisp "little black box" is in our head, and is not the gadget modern alchemists are searching for.

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December 9, 1963

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"Advances in Logging Technology"

Since 1950 new well logging tools have been developed at an accelerated rate. During this interval the oil industry has seen the introduction of density, continuous dipmeter, sonic (velocity), induction, electric, salinity (chlorine), nuclear magnetism, acoustic amplitude (microseismogram) and spectral logging. These tools provide measurements of rock properties previously unavavilable.

This has not only sharpened the ability of using logs for formation evaluation (determining porosity fluid saturation and pay thickness) but also has increased the possibility of obtaining accurate lithologic information from logs. A wealth of valuable geological information is available to the geologist who demands more from logs than depth control and correlation information.

Formation evaluation from logs has been very much refined and improved during the last years. A series of new instruments, laterologs and induction logs, measure rock resistivities and conductivities at different distances from the borehole. This variety of radius of investigation allows running the log combination most adequate for the best results in a given problem. These different tool combinations have made interpretation of the results more accurate but, at the same time, more complex.

Acoustic logging has caused quite a revolution in formation evaluation in recent years. The first available instrument (sonic log or continuous velocity log) just measures travel times, first arrivals of the sonic pulse. This log has become an excellent porosity tool because there are definite relationships between acoustic velocity and porosity. However the velocity log utilizes only a very small portion of the available information. During the last few years there has been a great deal of interest in utilizing the information contained on the whole acoustic wave train. Thus, the amplitude log was developed to determine cement bonding. Later developments include the recording of arrival times and amplitudes not only of the compressive wave but of the shear wave. Indications are that a complete study of the wave train will give better information on porosities, lithologies and fracturing of the rocks surveyed. Some companies, like Welex and Birdwell, are attempting to present the wave train in variable density form—the microseismogram.

Advances in logging technology permit the determination of gross lithology by combining various logging surveys. Thus the lithology can be descriminated by using logging combinations such as density-sonic, density-neutron, and sonic-neutron. Several papers have been published showing that there are enough differences between the responses of the main types of sedimentary rocks to these tools to enable us to differentiate them.

Radiation logging also has shown promising advances. The trend is to record either desired portions or the whole spectrum of gamma rays produced by bombardment of the formation with neutrons. The standard tool still uses low-energy neutrons, but several prototypes have been constructed for high-energy neutron tools. Spectral logging is a future hope for obtaining accurate lithologic information from logs.

From the remarks made above it is clear that log interpretation has become a highly technical activity, an obvious area for automation. Industry has been very interested in the possibility of recording logs digitally on magnetic tape and processing them in electronic computers. This trend opens new possibilities for improving log interpretation and creates a new challenge for the log analyst. New tools, new parameters to measure, refined log interpretation methods, and modern data processing techniques are the present and future aspects of log analysis. Geologists should keep abreast of these developments—after all, logs are the only continuous records of a well. Advances in logging technology are making it possible to obtain from logs important geologic information.

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January 6, 1964

ALFRED JAMES III, Walters Drlg. Co.

Wichita

"A Study of the Aldrich and Arnold Oil Producing Trends of Northwestern Ness County, Kansas"

This report covers an area in west central Kansas of 252 square miles from which cumulative production in mid 1963 totalled over seven million barrels of oil. There are at present over 120 producing oil wells in twelve pools. During 1962 and 1963 there has been considerable interest and activity in the area flanking the Central Kansas Uplift to the west, and this report gives a detailed look at a portion of this area which has been producing for over three decades.

Principal production is from Mississippian dolomites of the lower Meramec Stage on structural closure, with minor oil production from basal Pennsylvanian limestones. Maps presented include structure contours on Cretaceous, Permian, Pennsylvanian, and Mississippian datums, as well as two isopach maps; all are contoured on ten foot intervals for easy comparison. An electric log cross section is included.

Emphasis is on the maps and cross section, but also discussed are reservoir character, reserves, lithology, development history, probable ages of structural growth and oil migration, and exploration methods.