HISTORY, PRESENT STATUS AND CONTEMPLATED USE OF NAVAL OIL SHALE RESERVES

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At the turn of the century it became clear that petroleum would play an increasingly important role in the national economy in the years ahead. It became equally apparent that the rapid conversion of the Navy's fleet from coal to oil-burning vessels would require a readily available supply of domestic fuel oil in order to assure satisfaction of military requirements in any national emergency. This was also a time in which the public lands of the United States were rapidly passing into private ownership. It was within this climate that the United States Geological Survey suggested that certain potential oil bearing lands within the public domain be withdrawn from entry and private exploitation.

The Navy's Petroleum Reserves were set aside by a series of Executive orders in 1912, 1915, and 1923. In 1916, Franklin D. Roosevelt, then Assistant Secretary of the Navy, requested the Department of Interior to set aside sufficient lands containing oil shale to be "capable of yielding, at a conservative estimate, at least five hundred million barrels of fuel oil, this amount being only two and one half percent of the estimated yield of oil from the known shale deposits upon the public domain." The shale deposits of the nation were estimated to contain 20 billion barrels at that time. Although Secretary Roosevelt's estimate of the amount of oil locked up in the shales of Colorado, Wyoming and Utah, certainly has turned out to be more than "a conservative estimate": to use his words, his estimated fraction of that shale oil underlying Navy lands of about 2 percent is not too far off from current predictions. I would like to point out (parenthetically) that shale beds of less than three feet in thickness were not being included in the estimated yield since such thin beds were not considered capable of being "mined and retorted profitably." These shale lands were set aside because it was thought that the oil deposits in the existing Naval Petroleum Reserves might be materially reduced, down through the years, by drainage from existing wells in tracts held by private owners both within and adjacent to the Reserves. An assured and adequate supply of fuel oil for the Navy was considered the vital and impelling military need of the day, so Naval Oil Shale Reserves Nos. 1 and 2 were thereupon set aside in 1916 and Naval Oil

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Shale Reserve No. 3 was established in 1924.

The concept that the Reserves are intended solely for Naval purposes has become clearly outmoded and it is generally recognized that such a national petroleum stockpile is intended for use by the Defense Establishment as a whole.[1] With the distinction between the purely military and civilian requirements somewhat obscured in a total war situation, perhaps even this concept is not entirely accurate. The Naval Petroleum and Oil Shale Reserves might be used to bolster the resources available to industry during a crisis. Probably the oil from our reserves would be thrown into the pool of liquid fuels available to the refining capacity of the nation and the products produced therefrom committed to use as designated by those responsible for the total national defense of the country. Along with the Naval Reserves we would expect the other reserves of the Nation to be made available: the shut-in capacity of the great oil fields of the South and Southwest and full utilization of the great coal resources of the East. Until a decision that oil from the Naval Reserves is necessary for the "National Defense" during a time of crisis, production is limited to that necessary for protecting, conserving, testing, and maintaining this oil in the ground.[2]

Oil Shale Reserves Nos. 1 and 3 contain 55,000 acres, more or less, of the public lands in Garfield County, Colorado, while Reserve No. 2 contains 91,000 acres of shale lands in Uintah and Carbon Counties in Utah. Estimates of recoverable shale oil from these Reserves has varied widely, and frankly, we don't know precisely how much oil is in place beneath these lands. Our current estimate, and one which is believed conservative, is that 12 billion barrels of shale oil could be economically produced from the Colorado reserves and an additional 3.8 billion barrels could be retorted from the shales in Utah. These estimates do not include shales known to have a richness of less than 15 gallons per ton nor do they consider beds thinner than 15 feet.

Fairly recent discoveries of ultra-rich shales across large areas of the North Slope of Alaska seem to indicate that Naval Petroleum Reserve No. 4 may become important as another Oil Shale Reserve.[3] In a research project sponsored by the Navy, shales containing over 140 gallons per ton have been recovered from the North Slope of the Brooks Range but unfortunately the mother-lode of these deposits has not yet been pin-pointed. A complicated geology of the area has us baffled at the moment with regard to where next to look, but it is hoped additional exploration will unlock some of the secrets surrounding the source of these Tasmanite samples. An interesting point worthy of note is the existence of important quantities of minor minerals, notably mercury, silver, copper, and other metals that may provide a key to the economic recovery of the shale oil.

The Navy is actively encouraging and maintaining interest in research and

development of shale oil retorting processes which may lead to economic methods of recovery and ultimately to establishment of a shale oil industry in being. Shale from the Naval Oil Shale Reserves is being provided for the experimental work being carried on at the Anvil Points Plant near Rifle, Colorado. Research in the various aspects of mining, handling and retorting the shale is being carried on under the technical and financial sponsorship of Mobil and Humble through a lease arrangement with the Department of the Interior and the Colorado School of Mines Research Foundation. The Continental Oil Company, Pan American Petroleum Corporation, Phillips Petroleum Company, and Sinclair Research, Incorporated, have also joined in the venture, to share in its costs and receive all information from the program. Since the lease agreement was signed 13,790 tons of oil shale have been removed from the Navy lands, of which 7,540 tons have been retorted. Shale oil recovered amounts to 3,394 barrels, most of which has been burned in the boilers at the facility.

We are cooperating with the Bureau of Mines in a research project to develop techniques for improving permeability in oil shales with high explosives. It is believed that if an extensive secondary fracture network can be established between distant wells in oil shale by the injection and detonation of a liquid explosive or by some other method, the air permeability thus established would permit in-situ oil shale retorting. Near-surface tests conducted in limestone formations have encouraged the furtherance of the program and it is planned to move into oil shale formations first with a shallow test and later with a deep test in the Naval Oil Shale Reserve. The shallow test is to take place this spring near Green River, Wyoming, in a 125-foot deep horizontal electrolink fracture created by the research group from the Laramie Petroleum Research Center. The deeper test is scheduled to take place this fall. Consideration is also being given by our Office to strip mining by explosive casting, high explosive fracturing, underground retorting and to combinations of these techniques.

It appears obvious that if a significant break-through can be made in the in-situ recovery process, many of the disadvantages of the surface retorting can be eliminated; the cost of mining and handling tons of feed shale daily, the disposition of the spent shale, the tremendous initial investment in plant facilities, and the waste from shale pillars required for support of the mine roof. If heated natural gas can be used to retort this oil in place, an additional advantage gained may be the reduction in viscosity of the recovered product and the upgrading of the crude in the underground retorting process.[4] The gas reservoirs located in the shale lands may provide the vehicle not only for recovery of the oil but also the hydrogen source for possible hydrogenation of the product. Research in this direction is also indicated.

During the last 20 years the strategic position of the United States in oil

reserves has changed drastically. Prior to World War II, 10 percent of United States petroleum production was exported and through the tremendous response of the oil industry wartime demands were successfully met. Since 1945, however, domestic demand for oil has doubled while domestic crude oil production has increased only 63 percent.[5] Our success at finding oil has not been able to keep pace with the growing requirements of an oil-based economy. Imports since World War II have increased five-fold until at the present time 20 percent of the petroleum consumed in the United States is imported. As dependence on these water-borne imports increases, the strategic value of reserve domestic capacity to replace them is enhanced. The entire industry is becoming increasingly aware of the widening supply-demand gap in this country. A good hard look is being had at the decrease in exploratory drilling of late and the current oil-finding success ratio. The alarming fact here is that when fewer holes are drilled one would expect the drilling of only the best prospects would be undertaken and that the ratio of new discoveries to wildcats would increase. Such has not been the case. Everyone is trying to estimate recoverable reserves: proven, unproven, and yet unfound. Geologists and geophysicists are encouraging new techniques for finding all sorts of traps possibly productive of oil. It has been stated that the United States will become a net importer of petroleum; that is, the demand can be expected to exceed productive capacity, within ten years.

Unless our skill, or luck if you please, at finding new reserves is vastly improved, this gap will have to be filled with liquid hydrocarbons converted from coal or gleaned from tar sands or oil shale.

I would like to depart here from the past and present and look to the future, but first I want to cite some pertinent facts upon which to premise my observations.

1. The United States, while perhaps not critically short, is certainly not in long supply of indigenous crude oil—with the ratio of total reserves to total demand showing a so-called "number of years supply" something under ten years and decreasing steadily during the recent past.
2. The present rate of consumption is about 11 million barrels a day with an estimated consumption in 1985 of some 18 million barrels per day.[6]
3. To maintain the present reserve to production ratio, it has been estimated an additional 83 billion barrels of reserves will be required in the next fifteen years, which is over 5 billion more than we have produced to date.[7]
4. The cost of finding and developing new reserves is increasing each year.
5. Somewhere, there is a lid on the increasing price of crude oil placed

there by shale oil which is available in overwhelming quantities, at least on paper.

6. Imported oil will probably continue to be restricted to promote self-sufficiency for national security reasons.
7. The Federal Government controls 90 percent of the more prolific shale lands and is reluctant to lease them out at a time when these lands have no immediate income value and the magnitude of their future worth is in question.
8. The most assured way of researching the degree of competitiveness of shale oil products with liquid petroleum is to build an integrated complex of sufficient size and rated output to be able to place an adequate amount of finished products in the market place. These findings would help the establishment of shale land values.
9. Industry is reluctant to invest heavily in shale development without profit motive and does not believe it is in the public interest for Government to do it.
10. As it would require several years lead time to effectively develop a "going" oil shale industry, it is idle and dangerous to count on this production as an immediate contribution to national defense.

From the above, it could be concluded that an oil shale industry will emerge, but the timing is an enigma. The defense planners would like to see it now to bolster national self-sufficiency. Industry wants it only when the profit ratio is right. Industry has suggested that the Government do more by making its land available for competitive fixed-royalty leasing. On the other hand, it might be asked by Government why industry, who will be confronted with enormous demands for liquid hydrocarbons, has not done more in the way of large-scale and effective research to develop the answers that might generate these new sources of productive capacity.

It is agreed that private industry should take the lead. The oil industry has the technical know-how and market control to be the principal developer of the shale oil industry. These private interests could join hands and develop a full scale integrated research project of sufficient magnitude to determine the competitiveness of shale oil products.

An example of such a cooperative venture is the research program at Rifle. The research could be in either the in-situ combustion or in surface retorting or both. Government could be expected to cooperate in obtaining the appropriate answers from this research after which optimum decisions could be made with respect to both leasing the land by Government and acquisition of the leases by industry.

With regard to adequate domestic supplies of liquid petroleum products, the objectives of industry and Government are alike except for degree. Both are charged with responsibility of maintaining a strong, vigorous, prosperous,

domestic industry capable of rapid expansion to meet the needs of any crisis. However, the national defense planners also would like included in these capabilities a substantial reserve productive capacity in strategic areas. Certainly this country is capable of both these tasks, lest we actually let ourselves become in short supply of liquid petroleum products.

In closing, I should like to point out that the Congress, as far back as 1948, in a report of a special Subcommittee of the Committee on Armed Forces of the House of Representatives, stated "it behooves the Nation . . . to expedite research in this new industry and to establish a program that will move consistently forward to encourage synthetic development without impeding presently used processes of producing our national petroleum." It has been estimated that 8 to 10 years will be required for design and construction of a commercial shale oil plant.[7] Since it is statistically possible for the United States to experience a dearth of oil some 10 to 15 years hence, a vigorous effort is required today to initiate the research and development of the processes which will ultimately be required for the economic production of shale oil. In order for the Naval Oil Shale Reserves to be a true source of reserve energy, the techniques and procedures for shale oil production must be known and proven, and an industry must be alive and capable of rapid expansion to meet emergency requirements for fuel.

The opinions and conclusions expressed in this article are those of the author and do not necessarily represent the views of the Navy Department, the Office of Naval Petroleum and Oil Shale Reserves, or any other governmental department or agency thereof.

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Commander Ossian R. Butterfield, CEC, USN, entered the U.S. Navy in June 1944, was enrolled in the Navy V 12 College Training Program and attended Williams College in Williamstown, Massachusetts. In November, 1945, he was transferred to the U.S. Naval Reserve Officers Training Course Unit at Brown University. In 1947, he was graduated from Brown with the degree of Bachelor of Science in Engineering.

Upon graduation, he was commissioned an Ensign in the U.S. Navy Civil Engineering Corps. Duty assignments have included engineering duties at the Naval Proving Grounds, Dahlgren, Virginia; the Naval Air Station, Dallas, Texas; the Naval Stations in Argentina, Newfoundland, and in Bermuda, The West Indies; the Naval Air Station, Patuxent River, Maryland; the Naval Radio Station, Kamiseya, Japan; and the Naval Mine Warfare School, Yorktown, Virginia.

In 1955 and 1956, he attended Rensselaer Polytechnic Institute in Troy, New York, where he received the Bachelor of Civil Engineering degree in June 1956. He has served as Executive Officer and as Commanding Officer of U.S. Naval Mobile Construction Battalion Six deployed to Rota, Spain, and other bases in the Atlantic Ocean Area. He has been assigned duty in the Bureau of Yards and Docks, Navy Department, Washington, D.C., where he was Director of the Construction Division responsible for the management of projects engineered and constructed by the U.S. Navy for other governmental agencies.

He was selected for postgraduate education in petroleum engineering and entered the Graduate School of the University of Texas in September, 1963.

He was assigned to the Union Oil Company of California for a period of nine months for training in the various phases of the oil industry. This experience included exploration, production, reservoir engineering, refinery operations, research, and management within a major oil company. In June, 1965, he was assigned to duty in the Office of the Director, Naval Petroleum and Oil Shale Reserves, Navy Department, Washington, D.C.