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From Seepages to Oilfields: Technology, Institution Building, and China's Early Petroleum Enterprises, 1914-1945*

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ABSTRACT

This empirical study of the application of the developmental state thesis to history of the Nationalist government of China before 1949 explores how technology might have played a crucial role in shaping China's early state-owned enterprises. It begins with an analysis of how an unfavorable petroleum geological assessment and the small petroleum market gave little incentive to entrepreneurs to invest in oil exploration. It also discusses how technology continued to hamper the Nationalist government's efforts in oil prospecting. Then, it considers the history of China's first large-scale oilfield, the Yumen Oilfield, which was established in 1939 at the height of the Sino-Japanese War (1937-1945). It argues that the Nationalist government shared some features of the developmental state, yet, despite the aspiration of economic nationalism, technology played a crucial role in the birth of China's petroleum enterprises.

Key words: Yumen Oilfield, National Resource Commission, Weng Wenhao, Qian Changzhao

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1. Introduction

Historians of modern China have recently found the developmental state thesis an effective tool for understanding the role of the Nationalist government in the country's economic development in the 1930s and 40s. The thesis, which rose to prominence in the 1980s because of its power in explaining the fast economic growth of East Asian economies such as Japan and most recently China, argues that the state, often inspired by economic nationalism, intervenes in the economy by extensive regulating and planning in order to pursue economic growth.[1] In light of this thesis, William Kirby contends that the Nationalist government, which aimed at reconstruction (*jianshe* 建設), in other words, rebuilding a rich and strong China, took great efforts in setting industrial policies, establishing central government agencies, expanding state-owned industrial enterprises, and training engineers, was a developmental state.[2] Morris Bian and J. Megan Greene also characterize the Nationalist government as a developmental state.[3]

Such a general characterization requires detailed empirical study. The Nationalist government did exhibit some features of the developmental state: state control of finance, diligent economic bureaucracy, extensive regulation and planning for industrial development, and, particularly, high mobilization for war. While historians have focused on either government policies or state-owned enterprises' governance structure, they have not paid enough attention to the central issue of the developmental state thesis: obtaining advanced

1 The term "developmental state" was coined by the political scientist Chalmers Johnson in his study on the Japanese government's role in the country's economic miracle. Chalmers Johnson, *MITI and the Japanese Miracle: The Growth and Industrial Policy, 1925-1975* (Stanford: Stanford University Press, 1982); Meredith Woo-Cumings (ed.), *The Developmental State* (Ithaca: Cornell University Press, 1999).

2 William C. Kirby, "The Chinese War Economy: Mobilization, Control, and Planning in Nationalist China," in Steven I. Levine and James C. Hsiung (eds.), *China's Bitter Victory: The War with Japan, 1937-1945* (Armonk: M.E. Sharpe, 1992), pp. 185-213; William C. Kirby, "Engineering China: Birth of the Chinese Developmental State, 1928-1937," in Yeh Wen-hsin (ed.), *Becoming Chinese: Passages to Modernity and Beyond* (Berkeley: University of California Press, 2000), pp. 137-160.

3 Morris L. Bian, *The Making of the State Enterprise System in Modern China* (Cambridge, Mass.: Harvard University Press, 2005); J. Megan Greene, *The Origins of the Developmental State in Taiwan* (Cambridge, Mass.: Harvard University Press, 2008).

technology to achieve economic development.

Modern industry is technically demanding, capital intensive, and organizationally challenging. How might the Nationalist government have obtained advanced foreign technology to achieve its ideal of reconstruction? The answer to that question lies in examining the early history of China's petroleum enterprises through an institutional perspective. The early history of the Chinese petroleum industry emphasizes that the complex technology of oil prospecting, drilling, and refining that necessitated the Nationalist government's direct intervention into the petroleum industry. This early history reveals how technology played the key role in the formation of the China's early petroleum enterprise. Beginning with an analysis of how an unfavorable petroleum geological assessment gave little incentive to entrepreneurs to invest in oil exploration, an analysis of the early events also discusses how technology continued to hamper the Nationalist government efforts in oil prospecting. Then, technical details support a careful consideration of China's first large-scale oilfield, the Yumen Oilfield (*Yumen youkuang* 玉門油礦), which was established in 1939 at the height of the Sino-Japanese War (1937-1945).

2. Petroleum Market and Geology

China is now one of the major oil producing countries in the world. For centuries before modern times, crude oil had been collected from seepages as a lubricant, fuel, or medicine by local people in north-western provinces of Shaanxi 陝西 and Gansu 甘肅. Nevertheless, when oil prospectors rushed to Pennsylvania, United States and the Caspian Sea in the second half of the nineteenth century, few took the effort to explore China's underground oil reserves, mainly due to the nature of the world's energy market.

Before the early twentieth century, petroleum was mainly used as the base of kerosene, a liquid fuel for domestic lighting and heating that triggered the oil rush of the mid-nineteenth century. Gasoline, a more volatile fraction of petroleum that was distilled before kerosene could be produced, was considered low value and was usually discarded. Yet, the technologies of domestic lighting and motive force were both going through a transformation in the West. The fast-growing electricity industry, which offered cheap, convenient electricity to households to power light bulbs, quickly replaced oil and gas lamps and transformed urban life.[4] The falling demand for kerosene coupled with the rise of the internal combustion engine to provide an alternative source of motive force in factories and, particularly, the automobile. The popularity of the affordable mass-produced automobile revolutionized road transportation, and hence its fuels, gasoline and diesel, became the dominant petroleum products and a necessity of modern transportation.[5] Besides, the government of nineteenth-century China paid no attention to petroleum because, in the age of steam, it was concerned with how to import the technologies of firearms, steam warships and mining in order to defend against foreign incursions.

However, the increasing importation and consumption of kerosene prompted some interest in exploring the country's own oil reserves by the twentieth century.[6] A handful of foreigners gained permission from the local officials of the Qing government to build small-scale drilling and refining facilities in northern Taiwan and northern Shaanxi in 1874 and 1907 respectively. These were small-scale explorations that involved a few foreign technicians, and no more than ten wells were drilled. Due to their small outputs, both ventures were soon abandoned.[7]

Foreign entrepreneurs resumed their interests in the 1910s. In 1914, the American firm Standard Oil Company of New York (SOCONY), one of the major suppliers of kerosene to China, was seeking opportunities to improve its business competitiveness and

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4 Thomas Parks Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: The Johns Hopkins University Press, 1983).

5 In the late nineteenth century, crude oil produced 61.2 percent of kerosene and 28.8 percent of petrol and fuel oil. Yet, in the 1910s, kerosene fell to 25.4 percent and motor fuels increased to 67.7 percent. In 1939, kerosene accounted for only 5.7 percent of petroleum products. Petrol and fuel oil shared the dominating 91.5 percent. Charles Singer (ed.), *A History of Technology vol. 5: The Late Nineteenth Century, c. 1850 to c. 1900* (Oxford: Oxford University Press, 1984), p. 187.

6 The quantity of imported kerosene rose from 2,100 gallon in 1863 to 3, 429, 423 in 1880. Wu Ling-jun 吳翎君, *Meifu Shiyou zai Zhongguo (1870-1933)* 美孚石油在中國 (1870-1933) (Taipei: Daw Shiang Publishing, 2001), p. 279.

7 Shen Lisheng 申力生, *Zhongguo Shiyou Gongye Fazhanshi: Jindai Shiyou Gongye* 中國石油工業發展史：近代石油工業, vol. 2 (Beijing: Petroleum Industry Press, 1988), pp. 61-65, 69-72; Zhongguo Shiyou Zhi Bianji Xiaozu 中國石油志編輯小組 (ed.), *Zhongguo Shiyou Zhi* 中國石油志, vol. 2 (Taipei: Chinese Petroleum Corporation, 1976), pp. 785-787.

to develop possible sources of crude oil in China. It earned a concession from the newly established republican government of China, which was suffering financial difficulties, to explore for oil in northern Shaanxi in exchange for a share in the firms' kerosene business.[8] In 1915, SOCONY geologists conducted surveys in northern Shaanxi, where oil seepages had long been known. However, the potential oilfield was in a remote area and SOCONY technicians had to overcome transportation difficulties by building roads and recruiting a large army of Chinese labourers to transport the equipment.[9] They drilled seven test wells, which produced a small amount of oil. In 1916, the company determined the operation economically unviable and terminated the project. Probably due to costly and difficult transportation, the company did not even withdraw the equipment, part of which was retained by the local government for the production of a small amount of kerosene and paraffin wax.[10] SOCONY also tried to explore possible petroleum deposits in Guizhou 貴州 in southwest China, where natural gas was often discovered in the process of digging water wells, but failed to find any oil.[11]

As Grace Shen has pointed out, after those explorations, SOCONY geologists strongly doubted that China's geological conditions could produce oil. The doubt originate from the widely accepted geological theory on petroleum at the time which maintained that oil, formed by the decomposition of marine life, could only be found in the geological folds such as anticlinal structures of marine strata. They argued that either the nature of the rock that formed the potential oil producing strata in China had allowed oil to leak away or oil could not accumulate in the geological folds. Other geologists further contended that Chinese geology, which was predominately a continental formation, could not possibly bear oil. Such a geological conclusion made a negative impact on entrepreneurs' willingness to invest in oil prospecting.[12]

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8 Noel Pugach, "Standard Oil and Petroleum Development in Early Republican China," *The Business History Review*, 45.4 (1971), pp. 452-473.

9 Dong Weqiao 董蔚翹, "Shanbei Tanyou de Huiyi 陝北探油的回憶 (Reminiscence of Oil Drilling in Northern Shaanxi)," in Shiyouren Bianji Weiyuanhui 石油人編輯委員會 (ed.), *Bilu Ji* 篳路集 (Publication location unknown: Shiyouren Chuban Weiyuanhui, 1967), pp. 4-6.

10 Shen Lisheng, *Zhongguo Shiyou Gongye Fazhanshi*, vol. 2, pp. 8-9.

11 Yan Chang-jin 顏昌晶, "Jindai Zhongguo Shiyou Gongye Fazhan zhi Yanjiu (1932-1949) 近代中國石油工業發展之研究 (1932-1949)," Master thesis (Taoyuan: National Central University, 2001), p. 20.

12 Grace Yen Shen, *Unearthing the Nation: Modern Geology and Nationalism in Republican China*

Although that argument was later falsified by oil discoveries after the late 1930s, Chinese geologists at the time did not challenge these conclusions, because the discipline requires extensive empirical studies to backup or rebuke existing theories. Geology was the most advanced science in early twentieth century China and the number of Chinese geologists constituted one of largest scientific communities in the country. However, what Chinese geologists lacked were human and financial resources. First of all, geological research institutions were just starting to be established. China's foremost geological research institution, the Geological Survey (*Dizhi diaochasuo* 地質調查所), was set up by the Ministry of Industry and Commerce in 1916. Through the 1920s, three provincial institutions were set up and, by 1935, five universities had established geology departments. The pioneering Chinese geologists, such as Weng Wenhao 翁文灝, who gained a PhD from Belgium and headed the Geological Survey since 1921, were foreign-trained. Along with foreign geologists, they trained more Chinese geologists. The Geological Survey had only 30 geologists in 1926 but that number doubled by 1935.[13] Unfortunately, although they were undoubtedly diligent researchers, surveying the vast territory of China was extremely challenging.[14] Nor did they employ sophisticated gravitational, seismic, or electric methods, which would have greatly increased the accuracy of the petroleum geology survey.

Furthermore, none of the geologists were specialized in petroleum geology. As Zhang Jiuchen has pointed out, the majority of Chinese geologists focused on theoretical research.[15] Those who studied economic geology, which is sub-discipline concerning the

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(Chicago: Chicago University Press, 2014), pp. 167-168. More details about early twentieth century petroleum geology, see Brian Frehner, *Finding Oil: The Nature of Petroleum Geology, 1859-1920* (Lincoln, Nebraska: University of Nebraska Press, 2011); William Harvey Emmons, *Geology of Petroleum* (New York: McGraw-Hill Book Co., 1921).

13 There were geological institutions in Henan 河南 (1923), Hunan 湖南 (1927), Guangdong 廣東 (1927, later was incorporated into Sun Yat-sen University in 1929), and Sichuan 四川 (1932). Academia Sinica, China's foremost scientific research institute, set up its Institute of Geology in 1928. Yang Tsui-hua, "The Development of Geology in Republican China, 1912-1937," in John Z. Bowers, J. William Hess and Nathan Sivin (eds.), *Science and Medicine in Twentieth-Century China: Research and Education* (Ann Arbor: Center for Chinese Studies, The University of Michigan, 1988), p. 69.

14 For more details about the history of geology in Republican China, see Zhang Jiuchen 張九辰, *Dizhixue yu Minguo Shehui: 1916-1950* 地質學與民國社會：1916-1950 (Jinan: Shandong Education Press, 2005).

15 Ibid., p. 93.

study of earth materials for industrial purposes, mostly worked on coalmines and iron ores to meet China's industrial demands.[16] In the Geological Survey's publications, petroleum took up only a very small section. Chinese geologists, probably motivate by nationalistic sentiments, gave overly optimistic estimates of China's oil reserves. They contended the area that stretched across northern Xinjiang 新疆, Gansu, northern Shaanxi and Sichuan basin could hold 3,274 trillion barrels of oil underground, making up 7.29 percent of the world reserve and would have been the seventh largest oil reserve in the world.[17] However, no realistic finds could confirm the Chinese geologists' hypothesis. Before any changes would occur in geological theory of petroleum, though, the Chinese petroleum market would evolve.

3. Changing Environment

China of the early twentieth century was going through industrialization, and the major source of motive force was the coal-powered steam engine.[18] The internal combustion engine was already a minor source of motive force in China. According to an industrial survey completed by the government in 1937, in terms of horsepower, steam engines made up 86 percent of the motive force in China's factories, and diesel engines just 12 percent.[19]

Hence, the country consumed very little petroleum. As Table 1 shows, in 1927, the country imported 276 million gallons of petroleum products, and, by 1936, only 346 million gallons (excluding Manchuria). Compared with contemporary industrialized countries, that level of import was insignificant. For example, the United States' demand for crude oil was 483 million barrels (20,290 million gallons, 1 barrel= 42 gallons) in

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16 Yang Tsui-hua, "The Development of Geology in Republican China, 1912-1937," pp. 65-89; Yang Tsui-hua 楊翠華, "Jingji Dizhixue zai Zhongguo de Fazhan, 1912-1937 經濟地質學在中國的發展，1912-1937," *Thoughts and Words* 思與言, 24.2 (1986), pp. 72-75.

17 Xie Jiarong 謝家榮 (ed.), *Dierci Zhongguo Kuangye Jiyao (1918-1925)* 第二次中國礦業紀要 (1918-1925) (Beiping: Nongshangbu Dizhi Diaochasuo, 1926), p. 107.

18 Thomas G. Rawski, *Economic Growth in Prewar China* (Berkeley: University of California Press, 1989).

19 Liu Dajun 劉大鈞, *Zhongguo Gongye Diaocha Baogao* 中國工業調查報告, vol. 2 (Publication location unknown: Jingji Tongji Yanjiusuo, 1937), pp. 96, 128, 160.

1920 and rose to 1,009 million (42,369 million gallons) in 1929. Even during the Great Depression, the country still consumed between 850 million barrels (35,700 million gallons) and 900 million barrels (37,800 million gallons) of crude oil a year after 1929.[20] Comparatively, in 1925, all of China made up merely 0.7 percent of the world petroleum market.[21]

Table 1: Importation of petroleum products from 1927 to 1936 (unit: gallon)[22]

Year	Gasoline	Diesel	Lubricants	Kerosene	**Total**
1927	13,203,446	91,145,778	8,099,514	163,969,139	**276,417,877**
1928	20,041,590	129,061,760	12,384,563	262,792,609	**424,280,522**
1929	28,644,358	107,077,337	13,767,104	239,263,293	**388,752,092**
1930	29,725,052	87,970,877	13,029,535	185,608,596	**316,334,060**
1931	29,754,655	132,361,839	10,394,293	171,140,380	**343,651,167**
1932	24,114,506	136,626,092	8,227,167	145,918,794	**314,886,559**
1933	31,281,601	195,665,546	11,156,051	187,261,165	**425,365,360**
1934	39,659,994	237,953,908	11,714,961	119,021,792	**408,350,655**
1935	40,996,200	231,825,937	10,384,421	102,180,729	**385,387,287**
1936	45,508,632	182,517,460	13,122,962	104,426,849	**345,575,903**

It is worth noting that China was mainly importing kerosene. Table 1 shows that, by 1930, China imported 186 million gallons of kerosene *per annum*, which was 59 percent of all imported petroleum products. It shows that motorization was still at a low level in China at the time.

Nevertheless, China's source of motive force was slowly giving way to the internal combustion engine. Automobiles were imported, and hard-surfaced roads were built. Motorized road travel gradually became part of life among the urban elite.[23] The Chinese

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20 Douglas R. Bohi and Milton Russell, *Limiting Oil Imports: An Economic History and Analysis* (Baltimore: The Johns Hopkins University Press, 1978), p. 22.

21 Joel Darmstadter, Perry D. Teitelbaum and Jaroslav Polach, *Energy in the World Economy: A Statistical Review of Trends in Output: Trade, and Consumption since 1925* (Baltimore: The Johns Hopkins Press, 1971), p. 91.

22 Kong Qingtai 孔慶泰, "Guomindang Zhengfu Shiqi de Shiyou Jinkou Chutan 國民黨政府時期的石油進口初探," *Historical Archives* 歷史檔案, 1 (1983), pp. 111-112.

23 Frank Dikotter, *Exotic Commodities: Modern Objects and Everyday Life in China* (New York: Columbia University Press, 2006), pp. 89-97.

government estimated that in the mid-1930s China would need around 41 million gallons of gasoline to meet the demand of road transportation.[24] Also, factories started to use the diesel engine. The Chinese newspaper *Shenbao* 申報, reporting on the first diesel engine manufactured in China in October 1929, stated in passing that tens of thousands of diesel engines were being employed in China.[25]

Hence, China's petroleum market was also following the trend of technology in the West. The amount of imported kerosene steadily declined, until by 1936, it amounted to only 104 million gallons, much less than the 186 million by 1930. The change might have reflected the growth of the electric industry, the fastest growing industry in China in the 1920s and 1930s. Tim Wright estimates that from 1923 to 1936, electric output grew by 11.7 percent *per annum*, from 46 million kilowatt hours to 2,732 million kilowatt hours.[26] There was considerable scope for the expansion of electric supply. Notably, China's electric generators operated largely on coal, and hence the major source of motive force was still the steam engine.

Some noted the change in the Chinese petroleum market. In 1931, Weng Wenhao set up the Qinyuan Fuel Laboratory (*Qinyuan ranliao yanjiushi* 沁園燃料研究室) under the Geological Survey, appointing Jin Kaiying 金開英, a Columbia University trained chemical engineer, as its director. Young university graduates from chemistry or physics were recruited into the lab to study how to convert coal or vegetable oil into liquid fuel.[27] Later, Jin and his fellow chemists of the lab would play an important role in China's state-owned petroleum enterprise. Their research would also become a crucial method of producing liquid fuel in wartime China.

In short, China's petroleum market was small, but the trend of technological

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[24] The Second Historical Archives of China 中國第二歷史檔案館, "1927-1936 Nian Diguozhuyi Guojia zai Hua Qingxiao Shiyou Shiliao 1927-1936 年帝國主義國家在華傾銷石油史料, " *Historical Archives* 歷史檔案, 1 (1983), p. 61.

[25] "Xinzhong Goncheng Gongsi zhi Chengji 新中工程公司之成績," *Shenbao* 申報 (Shanghai), 8 October 1929, p. 15.

[26] Tim Wright, "Electric Power Production in Pre-1937 China," *China Quarterly*, 126 (1991), p. 362. In effect, in 1933 and 1934, less than 10 percent of the Chinese population had access to electricity and 77 percent of the electricity was consumed by industry. William Hausman, Peter Hertner and Mira Wilkins, *Global Electrification* (Cambridge: Cambridge University Press, 2008), p. 25, Figure 1.5; p. 29, Table 1.3.

[27] Lu Bao-qian 陸寶千 and Huang Ming-ming 黃銘明, *Jin Kaiyin Xiansheng Fangwen Jilu* 金開英先生訪問記錄 (Taipei: Institute of Modern History, Academia Sinica, 1991), pp. 35-37.

development was moving slowly towards the internal combustion engine. Prospecting for oil was only attractive in the light of long-term interests, which would have to be confirmed by the Chinese government.

4. Institution Building, Oil Prospecting, and War

The Chinese government's attitude towards industrial development and, in our case, the petroleum industry, became more assertive when the Nationalist party set up a credible government in Nanjing 南京 in 1927. The Nationalists called for national reconstruction, by which the ideal was to build a wealthy, self-sufficient, and strong nation under the strong leadership of a highly centralized government. The basics of the reconstruction ideal was laid down by the Nationalist party founder Sun Yat-sen, who dreamt of building railways, roads, and ports, as well as developing heavy industries.[28] Sun himself did not spell out how his dream might be realized, yet his economic ideas roughly followed an policy trend that considered direct or indirect state-interventions into economic activities an effective means to tackle post-World-War-I economic concessions in Western Europe. "Controlled economy" (*tongzhi jingji* 統制經濟) became the catch phrase used by Chinese politicians and scholars when discussing how to develop China's economy.[29] Yet, Margherita Zanasi has shown that Nationalist politicians bitterly disagreed with each other about how to achieve this ideal. Factional struggles were rife; government agencies were formed under different party leaders' aegis; and the records of their achievements varied.[30]

As for petroleum, the Nationalist government did pay some attention to its markets and production. A ministry-level government agency, the National Reconstruction Commission (*Jianshe weiyuanhui* 建設委員會), which was formed in 1928 by Hu Hanmin 胡漢民, a senior party leader who had been a loyal follower of Sun Yat-sen, for researching, planning, and regulating the industries of water management, electric power,

28 Sun Yat-sen, *International Development of China* (New York: Putnam, 1953, reprint of 1920 edition).

29 William C. Kirby, *Germany and Republican China* (Stanford: Stanford University Press, 1984), pp. 87-88.

30 Margherita Zanasi, *Saving the Nation: Economic Modernity in Republican China* (Chicago: University of Chicago Press, 2006).

and mining, drew up a rough proposal for developing the economy of north-western provinces of Shaanxi, Gansu, and Xinjiang. Oil exploration was included. Song Ziwen 宋子文, another senior party leader and then concurrently both Minister of Finance and the Acting President of the Executive Yuan, established the National Economic Council (*Quanguo jingji weiyuanhui* 全國經濟委員會) in 1931 for research on and development of the national economy through road construction, water conservancy, public health, education, rural economy, and the cotton industry. It also considered proposals for exploring petroleum in Sichuan, Shaanxi, and Zhejiang 浙江.

Unfortunately, none of these proposals were carried out.[31] The two agencies did not coordinate their works, and the confusion over which one had authority for oil exploration did not help either. Yet, technology, not political wrangling or ineffective government agencies, was the core problem. No politicians or agencies had enough geological knowledge of petroleum, technicians, equipment, or funds to make the proposals practical.[32]

The lack of progress was soon changed, not because of ideals or politics but because of the immediate military challenge from Japan. In late 1931, the Japanese army occupied Manchuria, northeast China, and created a puppet state of Manchukuo in the following year. Meanwhile, the Japanese navy attacked Shanghai 上海, China's greatest port-city in which the largest foreign settlements in China located. After international intervention, Japan forced the Nationalist government to accept the city's demilitarization. Then, the Japanese army further pressed China to accept a demilitarized zone in eastern Hebei 河北 province, north China, which in effect opened to the former capital Beiping 北平 (now Beijing 北京) to Japanese attack.

The crises created a huge pressure on the Nationalist government. To prepare for war, the issue of increasing the heavy industrial capacity to boost defense became urgent. Chiang Kai-shek 蔣介石, who had been the government's political and military leader

[31] Song Ziwen was Sun Yat-sen and Chiang Kai-shek's brother-in-law, and his father was one of the major financial contributors to the Nationalist party from the early times. For more details about the regulatory role of the council, see Tim Wright, "The Nationalist State and Regulation of Chinese Industry During the Nanjing Decade," in David Pong and Edmund Fung (eds.), *Ideal and Reality: Social and Political Change in Modern China, 1860-1949* (Lanham: University Press of America, 1985), pp. 127-152; Margherita Zanasi, *Saving the Nation*, pp. 81-101.

[32] Yan Chang-jin, "Jindai Zhongguo Shiyou Gongye Fazhan zhi Yanjiu (1932-1949)," pp. 40-41.

since 1927 but lacked the credibility to shape economic policies, took the initiative. In late 1932, Chiang recruited a group of natural and social scientists as well as industrialists, who were usually critical of the Nationalist party, into the National Defense Planning Commission (*Guofang sheji weiyuanhui* 國防設計委員會), which undertook the drafting of a plan for building a militarily-oriented heavy industrial economy.[33] The commission was secretly organized under the General Staff and its budget was drawn from special funds under Chiang's control as the chief of the General Staff. Chiang himself headed the commission as the chief commissioner but appointed the geologist Weng Wenhao as its secretary general, with Qian Changzhao 錢昌兆, a British trained economist, as deputy.

The fundamental difference between the National Defense Planning Commission and the other agencies was that, in order to avoid impractical or unrealistic planning, it began with an effort to obtain better knowledge of China's industrial capacities.[34] They organized teams of specialists and technicians to conduct surveys of China's engineering, mineral, agricultural, and human resources, and later compiled statistical data. Particularly, Weng Wenhao brought his own geological expertise and that of his geologist colleagues, who would soon play an active role in the development of the petroleum enterprises.

Another departure from the earlier planning was that, unlike the earlier regulatory approach, the commission aimed at directly intervening in industrial development by establishing state-owned enterprises, particularly in oil exploration.[35] Hence, while conducting industrial surveys, it turned its eyes on the already-known oil deposits in northern Shaanxi, where, after SOCONY had abandoned its exploration, the Shaanxi provincial government had continued oil production with limited output.[36] Weng Wenhao sent geologists from the Geological Survey to survey the lands of northern Shaanxi between 1931 and 1933. They found geological structures resembling anticlines

33 William C. Kirby, *Germany and Republican China*, pp. 91-94.

34 Morris L. Bian, *The Making of the State Enterprise System in Modern China*, pp. 45-53; Xue Yi 薛毅, *Guomin Zhengfu Ziyuan Weiyuanhui Yanjiu* 國民政府資源委員會研究 (Beijing: Social Sciences Academic Press, 2005), p. 72.

35 Morris L. Bian, *The Making of the State Enterprise System in Modern China*, pp. 53-54.

36 Shen Lisheng, *Zhongguo Shiyou Gongye Fazhanshi*, vol. 2, pp. 74-77.

in locations which the SOCONY geologists had not previously discovered.[37] The discovery was encouraging and, in 1934, the commission decided to take a step further to take over the area and form the Northern Shaanxi Oil Prospecting Office (*Shanbei Youkuang tankanchu* 陝北油礦探勘處), which was the commission's first enterprise.

At that time China had no domestically trained petroleum engineers. Probably due to lack of funds or its unwillingness to disclose its petroleum exploration activities to the outside world, the commission did not recruit any foreign technicians. To prospect for oil without direct foreign technical assistance, Weng recruited engineers from the coal-mining industry, with which he kept close association since his days at the Geological Survey, into the hundred-man workforce.[38] He appointed Sun Yueqi 孫越崎, a coal-mining engineer, as the enterprise's director and Yan Shuang 嚴爽, another coal-mining engineer, as the drilling engineer. The prospecting office, which was organized as an extension of the commission's bureaucracy, was divided into the offices of accounting, general administration, engineering, and mining. It had a radio station to communicate with Nanjing.[39]

The commission did not obtain state-of-art drilling equipment. Instead, it took over one old cable-tool rig, which had been abandoned by SOCONY's earlier operation in 1914, and purchased two new cable-tool rigs from the United States, and a steam engine from Germany. The cable-tool rigs worked by raising and dropping a heavy drill-bit on a drilling cable so that its percussion could break through rock. This technology was slightly outdated and, in the West, had been replaced by the more efficient rotary rig driven by the diesel engine. Other equipment was ordered from machine shops in Shanghai.[40]

With such simple drilling equipment, the technicians of the oil prospecting office drilled seven test wells before 1935. Only two were producing wells and their output was less than ten barrels of crude oil a day. Probably because of a lack of training in oil

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37 Ibid., pp. 23-24.

38 Dong Weiqiao, "Sashiqi Zai Shiyou Shengya 卅七載石油生涯 (My Thirty-seven-year Career in the Oil Industry)," in Ling Hong-xun 凌鴻勛 et al., *Shiyouren Shihua: Qingzhu Zhongguo Shiyou Gongsi Chengli Ershiwu Zhounian Jinian* 石油人史話：慶祝中國石油公司成立二十五週年紀念 (Publication details unknown), pp. 40-52.

39 Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zongguo Shiyou Zhi*, vol. 2, p. 789.

40 Shen Lisheng, *Zhongguo Shiyou Gongye Fazhanshi*, vol. 2, p. 77; Dong Weiqiao, "Sashiqi zai Shiyou Shengya," in Ling Hong-xun et al., *Shiyouren Shihua*, p. 45.

drilling, the technicians simply drilled without analyzing rock samples. Nor did they do more geological studies. But they built two sets of simple retorts to distil the crude oil into gasoline, diesel, and paraffin wax. Unfortunately, the NRC's (National Resource Commisson, *Ziyuan weiyuanhui* 資源委員會) venture there was brought to an abrupt stop because, in April, the Chinese Communist Party (CCP) forces, which had been battling with government troops in northern Shaanxi since 1932 occupied the area. The commission withdrew most technicians but the CCP retained the equipment to continue small-scale production.[41]

Meanwhile, Chiang Kai-shek, who continued his campaign against the CCP and was at the same time stepping up his preparations for inevitable war against Japan, was putting into practice his ideas of military-oriented heavy-industry-based economy. In the Nationalist government's reorganization in 1935, he merged the National Defense Planning Commission and the Department of Resources (*Ziyuanchu* 資源處) of the Bureau of Ordnance (*Binggongshu* 兵工署) into the NRC, and placed it directly under the National Military Council (*Junshi weiyuanhui* 軍事委員會), the highest military organization under Chiang's personal control.

The reorganized commission continued its works of surveying and planning. In 1936, it drew up a three-year plan for establishing state-owned heavy industrial enterprises. This included steel making, mining, electricity, metallurgy, as well as electrical and mechanical engineering.[42] It planned to purchase machinery with foreign credit and signed a barter trade agreement with Germany for exporting mineral materials in

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41 Zhang Li 張力, "Shan Gan Diqu de Shiyou Gongye 陝甘地區的石油工業," in Institute of Modern History, Academia Sinica 中央研究院近代史研究所 (ed.), *Zhongguo Xiandaihua Lunwenji* 中國現代化論文集 (Taipei: Institute of Modern History, Academia Sinica, 1991), pp. 478-492; Long Nanyang 龍南陽 (ed.), *Yanchang Youkuangshi* 延長油礦史 (Beijing: Petroleum Industry Press, 1993); Long Nanyang and Ma Zhongxun 麻仲勛, "Yanchang Youkuang de Kaifa 延長油礦的開發 (The Development of the Yanchang Oilfield)," in Gansusheng Weiyuanhui Wenshi Ziliao Weiyuanhui Xibei Jindai Gongye Bianxiezu 甘肅省委員會文史資料委員會西北近代工業編寫組 (comp.), *Xibei Jindai Gongye* 西北近代工業 (Lanzhou: Gansu People's Publishing House, 1989).

42 Morris L. Bian, *The Making of the State Enterprise System in Modern China*, p. 54; Qian Changzhao 錢昌照, "Guomindang Zhengfu Ziyuan Weiyuanhui Shimo 國民黨政府資源委員會始末," in Quanguo Zhengxie Wenshi Ziliao Yanjiu Weiyuanhui Gongshang Jingji Zu 全國政協文史資料研究委員會工商經濟組 (ed.), *Huiyi Guomindang Zhengfu Ziyuan Weiyuanhui* 回憶國民黨政府資源委員會 (Beijing: Zhongguo Wenshi Chubanshe, 1988), p. 4.

exchange for German weaponry and heavy industry machinery. With a budget of 10 million Chinese *yuan*, the commission started to implement its plans by establishing power plants, and some essential heavy industrial factories such as the Central Iron and Steel works, the Central Machine Works, and the Central Electric Works, all of which exceeded in scale the technology, capital, and organization that private investors could have achieved earlier on.[43]

Petroleum was high on the NRC's agenda. After losing northern Shaanxi, the commission shifted its attention to the Sichuan basin, which Chinese geologists considered a possible oil-producing area. In 1936, it established the Szechuan [Sichuan] Oil Prospecting Corporation (*Sichuan youkuang tankanchu* 四川油礦探勘處). Through Sino-German barter trade, it imported four rotary drilling rigs, which were more advanced and were capable of drilling boreholes to greater depths and in less time. It also recruited a German engineer to instruct Chinese technicians, some of whom were former technicians of the northern Shaanxi oilfield. In 1937, the German-made equipment reached Sichuan, where technicians drilled several test wells. They found no oil, but did find some natural gas.[44] The technology in Sichuan was slightly better than the northern Shaanxi oilfield. Probably through the technical advice from the German engineer and the advantages of state of the art equipment, Sichuan technicians were able to obtain rock samples through coring and carefully analyze the samples and record their findings. This increased the technicians' understanding of the geology of the drilling locations.[45]

Meanwhile, the Sino-Japanese War broke out in 1937. Within a year, Japanese troops had occupied China's coastal areas, major river ports, and strategic cities along major railway lines, seriously hampering China's external communication and transportation. The Nationalist government moved inland to Chongqing 重慶, Sichuan province in the southwest. State-owned industrial enterprises and some private factories were relocated in south-western provinces.

After relocation in Chongqing, Chiang Kai-shek further consolidated the power of the NRC over China's heavy industrial development. In 1938, he put it under the Ministry

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[43] Morris L. Bian, *The Making of the State Enterprise System in Modern China*, pp. 59-75.

[44] Shen Lisheng, *Zhongguo Shiyou Gongye Fazhanshi*, vol. 2, pp. 81-83, 103-107.

[45] Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zongguo Shiyou Zhi*, vol. 2, pp. 800-827.

of Economic Affairs with Weng and Qian as the minister and deputy minister respectively. The National Reconstruction Commission and National Economic Commission were both abolished. In other words, there would no longer be any confusion about economic planning, and expansion of the heavy industry as the government's core economic policy.

Nevertheless, both the war effort and industrial development required sustained supplies of liquid fuel. Without seaports or major railways, the supply of gasoline and diesel became a matter of life and death. Table 2 summarizes the quantity of petroleum products imported between 1938 and 1945. The quantity did not change much between 1938 and 1941: gasoline import remained at just above 30 million gallons, but diesel imports were halved. The flat rate of gasoline imports and the reduction of diesel imports may have been related to war-time interruptions in coastal industrial cities. However, the figures dropped drastically after 1941 because of the outbreak of the Pacific War. The import of gasoline decreased from 30,878,437 gallons in 1941 to 882,339 in 1942, and to 55,602 gallons in 1943.

Table 2: Chinese importation of petroleum products, 1938-1945 (unit: gallon)[46]

Year	Gasoline	Kerosene	Diesel	Lubricant	**Total**
1938	31,902,829	66,736	96,636,206	6,962,530	**135,568,301**
1939	35,892,342	61,941	98,213,468	8,409,353	**142,577,104**
1940	34,105,469	68,688	120,702,684	8,525,356	**163,402,197**
1941	30,878,437	41,424	99,031,501	7,574,326	**137,525,688**
1942	882,339	972,139	2,858,167	613,291	**5,325,936**
1943	55,602	9,308	5,822	44,808	**115,540**
1944	634,079	935	2,911	473,529	**1,111,454**
1945	1,882,212	604,857	783,682	148,054	**3,418,805**

Because of limited supply, rationing liquid fuel became necessary. In 1938, the Nationalist government formed the Liquid Fuel Liquid Control Commission (*Yiti ranliao guanli weiyuanhui* 液體燃料管理委員會) to control the import and distribution of

[46] Kong Qintai, "Guomindang Zhenfu Shiqi de Shiyou Jinkou Chutan," pp. 115-117.

gasoline and diesel. It was also intended to increase supply by producing biofuels. From 1938, the NRC started to establish alcohol factories in south-western provinces, and the number grew to 306 in 1944.[47] It likewise established factories that produced vegetable oil fuel. In Chongqing alone, there were 12 factories that produced biofuels.[48] Notably, one such factory was Tung Li Oil Works (*Dongli youliaochang* 動力油料廠), which was jointly established by the NRC and Ministry of Military Administration and specialized in producing gasoline from tung oil. Jin Kaiying was appointed the director and its chemical engineers were the former chemists from the Qinyuan Fuel Lab, who had some experience in converting vegetable oil into liquid fuel. However, the NRC seems not to have considered biofuels a long-term solution. The search for significant oil supplies remained frustrated until NRC technicians unexpectedly discovered oil in Yumen.

5. On the Edge of the Gobi Desert

Oil seepages in Yumen county in Gansu province had been well-known among local people, who collected crude oil as fuel or lubrication near the Laojun Temple (*Laojunmiao* 老君廟), a small Daoist shrine on the foot of the Qilian Mountain on the edge of the Gobi Desert, northwest China. The location was 2,400 meters above the sea level and the nearest cities, Yumen and Jiuquan 酒泉, were both 90 kilometers away. Oil Creek, named after nearby oil seepages, flows through an environment made barren by high winds and low temperatures.

The harsh condition of the terrain did not deter either foreign or Chinese geologists, including Weng Wenhao and his Geological Survey colleague, Sun Jianchu 孫健初, from conducting some preliminary surveys in the area by 1930.[49] Private investors were also interested, and, in 1935, a prominent Chinese diplomat and his associate bankers applied

47 Yan Chang-jin, "Jindai Zhongguo Shiyou Gongye Fazhan zhi Yanjiu (1932-1949)," p. 108.

48 Chen Tirong 陳體榮, "Sanshi Nian lai Zhongguo zhi Lianyou Gongye 三十年來中國之煉油工業," in Chinese Institute of Engineers 中國工程師學會 (ed.), *Sanshi Nian lai zhi Zhongguo Gongcheng* 三十年來之中國工程, vol. 2 (Publication location unknown: Chinese Institute of Engineers, 1946), pp. 727-736.

49 Zhang Shuyan 張叔岩, *Yumen Youkuangshi* 玉門油礦史 (Xi'an: Northwest University Press, 1988), pp. 20-21; Zhang Jiangyi 張江一, *Sun Jianchu Zhuan* 孫健初傳 (Beijing: Petroleum Industry Press, 1989), pp. 62-79.

to the Nationalist government for special permission to prospect for petroleum there.[50] In 1937, the prospectors commissioned a team of Chinese and American technicians and geologists, among whom was Sun Jianchu, to conduct surveys there. Unfortunately, they did not discover any anticlines in the area and, hence, did not see any good prospects of finding oil there.[51]

Although the conclusion inferred from the 1937 survey was that it was not worthwhile exploring for oil in the area, scientists from the Soviet Union thought otherwise. The Soviet Union's interest in the area began after the war broke out, when it started to supply machinery and weaponry to China in exchange for Chinese agricultural and mineral produce. Soviet convoys travelled through Xinjiang and Gansu on their way to Sichuan and, hence, it may be assumed that Soviet geologists obtained some knowledge about the terrain in those provinces, and showed interests in prospecting oil there.

In February 1938, the Soviet ambassador to China Ivan Trofimovich Luganets Orelsky suggested to Wang Chonghui 王寵惠, the Nationalist government's Minister of Foreign Affairs, that the two countries should jointly explore the petroleum reserves in Gansu and Xinjiang, and that the Soviet government was willing to provide technicians and equipment. For the Nationalist government, the exploration would be a great opportunity to ease fuel shortages if the project succeeded. Chiang Kai-shek ordered Weng Wenhao to investigate the proposed project's feasibility.[52] The Nationalist government moved quickly nationalized the whole area and, in July 1938, the NRC began its own operation under the Preparatory Office of the Kansu Oil Mining Administration (*Gansu youkuangju choubeichu* 甘肅油礦局籌備處), appointing Yan Shuang and other engineers from the former northern Shaanxi and the current Sichuan projects into the new

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[50] The diplomat was Gu Weijun 顧維鈞, better known as Wellington Koo. In 1936, they formed "the Preparatory Office of the China Kerosene Exploration Company" (*Zongguo meiyou tankuang gongsi choubeichu* 中國煤油探礦公司籌備處). Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 1, p. 25.

[51] Zhang Shuyan, *Yumen Youkuangshi*, p. 23

[52] According to Weng Wenhao's reminiscences, he made the suggestion of exploring oil in Gansu to Chiang Kai-shek in 1937, but neither of them made an actual move. Li Xuetong 李學通 (ed.), *Kexue yu Gongyehua: Weng Wenhao Wencun* 科學與工業化：翁文灝文存 (Beijing: Zhonghua Book Company, 2009), p. 643.

venture. It also recruited technicians from the mining industry. It then negotiated with the CCP, which had already entered a united-front with the Nationalist government against Japan since 1937, to transfer two cable-tool drilling rigs from northern Shaanxi.[53] The temporary headquarters of the operation were set up in Jiuquan city.

In November 1938, the Soviet government sent a geologist and an engineer to meet with Sun Jianchu and Yan Shuang, who were sent by the NRC, in Lanzhou 蘭州 City, Gansu. The Soviet experts suggested the presence of oil reservoirs more than 1,400 meters underground, requiring drilling rigs that could reach at least 1,500 meters below the surface. They suggested that geological investigations and drilling could be carried out simultaneously and promised to transport the necessary equipment to Yumen within two months after completion of negotiations between the two countries.[54]

That promise, which was never realized, encouraged the NRC, which in December, sent Yan Shuang, Sun Jianchu and an engineer to Laojun Temple to conduct surveys. They found formerly undiscovered anticlinal structures which could be associated with marine strata. This was a promising sign but test drilling had yet to be carried out. After the drilling locations were selected, they recruited workmen from nearby areas and started to build electricity and engineering workshops. They also built a simple road between the prospected oilfield and Jiuquan city.[55]

However, transporting equipment and personnel to the location was a huge challenge. Yumen was 2,500 kilometers away from Chongqing, which would take about half a month to travel. Treacherous conditions and the high altitude of the Gobi desert further complicated transportation. The preparatory office set up an office in Chongqing to help organize road transportation. It owned only five trucks so had to hire private vehicles. The government agency that managed road transport in the northwest also assisted.[56]

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53 MEA/IMH, 18-24-01-047-01; NRC/AH, 003000017028A; Sun Yueqi, "Ji Gansu Yumen Youkuang de Chuangjian he Jiefang 記甘肅玉門油礦的創建和解放 (Reminiscence of the Creation and Liberation of the Yumen Oilfield)," in *Sun Yueqi Wenxuan* 孫越崎文選 (Beijing: Unity Press, 1992), p. 37; Shen Lisheng, *Zhongguo Shiyou Gongye Fazhanshi*, vol. 2, pp. 85-87.

54 MEA/IMH, 18-24-01-047-01; NRC/AH, 003000024345A.

55 Sheng Lisheng, *Zhongguo Shiyou Gongye Fazhanshi*, vol. 2, p. 87; Zhang Shuyan, *Yumen Youkuangshi*, p. 26.

56 Zhang Yu-yan 張譽延, "Kangzhan Qijian Shiyou Qicai Yunshu Zayi 抗戰期間石油器材運輸雜憶 (Reminiscence of Transporting Petroleum Equipment During the Anti-Japanese War)," in Shiyouren

Soon after the rigs from northern Shaanxi arrived at Yumen in December 1938, the technicians started to prepare for drilling. In March 1939, while setting up the rig, crude oil seeped to the surface after the workmen hand-dug a square hole just 20 meters deep. The seepage indicated a potential oil deposit and the NRC urged the Soviet government to provide equipment and technical assistance in return for Chinese mineral and agricultural produce. Yet, while Moscow demanded a detailed plan and more negotiations, the NRC, probably sensing the Soviet government's reluctance to assist, decided to launch the exploration on its own.

The NRC's decision was bold. In hindsight, its preparation did not really provide enough geological data for evaluating the economic viability of the oil reserves, nor did its technicians have the equipment and experience to launch a large-scale exploration despite their experiences in northern Shaanxi and Sichuan. In other words, technology was the biggest difficulty. Yet, in the face of fuel shortage, the NRC had no alternative but to mobilize all the resources at its disposal and launch the operation. Financially, it allocated 2.3 million Chinese *yuan* for the fiscal year of 1939. It planned to move drilling rigs from the Sichuan oil operation and coalmines in central China. It was also prepared to purchase refining equipment from the United States.[57]

Before any new equipment could be obtained, Yumen technicians used two obsolete rigs from northern Shaanxi, which could only reach 200 meters deep. They experienced great difficulty due to lack of steel casings, which in standard drilling procedures were necessary deep into the wellbore and were cemented into position to uphold the borehole's integrity. Accidents, such as partial collapse of the wellbore walls, were frequent and progress was slow. Fortunately, the oil reservoir, located only around 100 to 200 meters deep, was within the reach of the antiquated old rigs, with which Yumen technicians drilled six wells.[58]

To do better, the commission moved rigs from the coalmines in Nationalist controlled Henan, Hunan, and Jiangxi in 1939 and 1940, despite the fact that those rigs were designed for coring in coalmines. A better drilling rig was the German-built oil

Bianji Weiyuanhui (ed.), *Bilu Ji*, pp. 52-53.

57 Morris L. Bian, *The Making of the State Enterprise System in Modern China*, p. 62; MEA/IMH, 18-24-01-047-01; NRC/AH, 003000024345A.

58 Zhang Shuyan, *Yumen Youkuangshi*, pp. 45-46

drilling rotary rig that could reach 1,200 meters deep, which was moved from Sichuan.[59] However, the new German rig posed a great challenge due to lack of training. In the standard rotary drilling procedure, drilling fluid was carefully composed of fluids, chemicals, and solids. The exact mixtures and proportions varied according to geological conditions. This drilling fluid had to be pumped down to the borehole to cool down and lubricate the drill bit and transport rock fragments back to the surface. The fluid could also counterbalance the formation pressure of the oil reservoir and hence prevent a blowout. Without proper ingredients, the drillers merely combined earth or even animal dung with water to produce makeshift drilling fluid, which had no effect on counterbalancing the formation pressure.

Even worse, Yumen technicians, who had only the experience of drilling in northern Shaanxi where the formation pressure was low, did not have the equipment or even the knowledge to measure the bottom-hole pressure. The problem was exacerbated by the shortage of steel casings, but, even if the workmen did lower casings into the well, they did not always cement them. Consequently, minor technical glitches were frequent and hence the drilling progress remained very slow. Furthermore, due to poor understanding of the geological conditions, drilling could only be done on level ground with the result that not enough space was allocated between wells. Such practices drastically decreased the pressure of the oil reservoir and ultimately affected the longevity of the oilfield.[60]

After one year's hard work, by 1941, seven wells, all of which were natural flowing wells, started to produce crude oil. These wells were not completed properly and some of them were open holes, unprotected by casings. Moreover, even if casings had been lowered into some of the wells, production tubing, which was necessary to protect casings from wear, had not been fitted and oil simply flowed out of the casings. Such bad practices would also affect the productivity of the wells.[61]

Furthermore, transport and storage out of the wells constituted other difficulties. Due to a lack of steel, the oilfield had limited piping and oil storage capability. Technicians dug gullies in the ground, to guide crude oil to flow from the wells into open-air earth

59 Ibid., p. 44.
60 Ibid., p. 46.
61 Ibid., pp. 73-74.

ponds.[62] By 1940, output had started to decline, and at some stage every well had suffered from partial collapse of its wellbores.

Then came the question of refining capacity. Different petroleum products could be separated by straight distillation with very simple equipment. Yumen technicians had no access to new thermal-cracking technology, which could turn lower grade petroleum products into gasoline and by the 1930s had become the standard. They could only use very simple and crude distillation apparatus to produce gasoline and diesel. In 1939, the oilfield purchased a simple retort with a 70-gallon capacity, which might have been initially designed for distilling spirits, from a chemical engineering firm in Jiuquan. Dried grass, wood, and coal were used as fuel and distillation was done in batches. A bucket of water was used to condense the vapour. Technicians manually filled the apparatus and collected the products in batches. The oilfield's own machine shop also built a few sets of horizontal cylindrical stills. Such simple refining devices could only supply a small amount of gasoline and diesel for the engines and automobiles of the oilfield.[63]

To increase output, in early 1940, the oilfield ordered two sets of refining equipment from machine shops in Chongqing, one of which was the Tung Li Oil Works, whose chemical engineers were probably the most competent in China. The new refining equipment was only slightly better than the original retort, but it included a fractionating column to a furnace, a still, and a condenser that allowed continuous distillation. This configuration saved time in loading and unloading crude oil and distillates. The oilfield's machine shop also constructed four simple horizontal stills. Unfortunately, the newly added refining equipment still required workmen to fill the apparatus manually.[64]

In short, technology at Yumen was very primitive by contemporary standards. Improper drilling and production procedures would later shorten the life of the oilfield. And the complete lack of safety measures in drilling and storage would later cause serious accidents.

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62 Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, pp. 865-866; Feng Zongdao 馮宗道, "Jin Kaiying yu Gansu Youkuangju 金開英與甘肅油礦局 (Jin Kaiying and Kansu Oil Mining Administration)," in Shiyouren Bianji Weiyuanhui 石油人編輯委員會 (ed.), *Shiyou Hepan* 石油河畔 (Publication location unknown: Shiyouren Chuban Weiyuanhui, 1965), pp. 105-106.

63 Lu Bao-qian and Huang Ming-ming, *Jin Kaiyin Xiansheng Fangwen Jilu*, p. 65; Zhang Shuyan, *Yumen Youkuangshi*, pp. 98-99.

64 Zhang Shuyan, *Yumen Youkuangshi*, pp. 99-100.

Although the output of crude oil and gasoline was too small for practical purposes, it still encouraged the NRC. In October 1940, after Qian Changzhao went to inspect the oilfield, the NRC drew up a two-year plan for expansion, setting the aim of producing 2.6 million gallons of gasoline in the first twelve months of production (September 1941 to August 1942) and reaching the level of 30 million in the following year. It also planned to purchase 20 drilling rigs, a refinery capable of processing 1,500 barrels of crude a day, and trucks from the United States. To achieve the goal, it budgeted 7.4 million Chinese *yuan* and 3 million US dollars for investment in the oilfield.[65] The investment would soon create China's largest wartime state-owned enterprise.

6. Effective Organization

As the operation expanded, the NRC laid the foundation of the oilfield's organization, whose central function was to ensure that the Yumen operation could be carried out effectively and at the same time to tackle the great technical challenges. In other words, it had to recruit an army of technicians and administrators and at the same time create a mechanism to enable transfer of new technology. As Morris Bian has shown, the whole operation was part of the NRC's efforts to build a governance structure for China's wartime state-owned enterprises.[66]

In March 1941, the NRC officially established the Kansu Oil Mining Administration (KOMA, *Gansu youkuang ju* 甘肅油礦局) with its headquarters in Chongqing. It gathered the most competent engineers in China. Sun Yueqi, the former director of the Northern Shaanxi Oil Prospecting Office, was appointed as General Manager. It had two major subdivisions. The administrative arm was based in wartime capital Chongqing, and included a secretariat and departments of operation, transportation, finance, accounting, and general services. The production arm in Yumen was separated into the oilfield and the refinery. Yan Shuang and other former drilling engineers from the northern Shaanxi oilfield led the oil drilling team, and Jin Kaiying and his colleagues at the Tung Li Oil

65 MEA/IMH, 18-31-03-019-01; NRC/AH, 003000024346.

66 Morris L. Bian, *The Making of the State Enterprise System in Modern China*, pp. 62-63.

Works were in charge of the oil refining works.[67] Because the KOMA did not have the authority to sell its products freely under the wartime liquid fuel distribution scheme, it provided the majority of its gasoline and diesel to government agencies in Chongqing and military forces in the northwest.[68]

The KOMA also employed young university graduates in chemical engineering or mining and mechanics from the railway industry. The bulk of the labour force was composed of young men enlisted from the nearby area as compulsory military service. By the end of the war in 1945, the oilfield had an 8,000-strong workforce. Along with their families, around 15,000 people resided in the oilfield complex, which included living quarters, a hospital, a school for the staff's children, a clinic, and a theatre.[69] The oilfield ran a welfare committee that was responsible for purchasing foodstuffs from the nearby area for the workforce. The committee also ran a vegetable farm. The KOMA was a work unit (*danwei* 單位) that both took care of production and worker livelihood.[70]

Besides, the KOMA had to transport imported equipment or parts produced in Chongqing to Yumen. Therefore, it included an extensive transport department. The long transport route stretched from the China-Burma border, where the KOMA's officials took over imported US equipment and transported it through Yunnan to Chongqing and then to Yumen. In 1940, there were no pipelines linking the oilfield and its major consumer outlets. The KOMA transported its products with a fleet of 66 trucks.[71] By 1945, the fleet had grown to 300. Service stations staffed with administrators and mechanics were established along the road, ensuring the smooth traffic, yet over-road transport of gasoline was not economical. Yumen staff recalled in reminiscences that in one return trip a truck would consume around 50 percent of the 15 barrels of motor fuels it loaded, or 39 percent

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67 Feng Zongdao, "Jin Kaiying yu Gansu Youkuangju," in Shiyouren Bianji Weiyuanhui (ed.), *Shiyou Hepan*, pp. 94-95; Sun Yueqi, "Ji Gansu Yumen Youkuang de Chuangjian he Jiefang," in *Sun Yueqi Wenxuan*, p. 37.

68 Morris L. Bian, *The Making of the State Enterprise System in Modern China*, p. 63.

69 Due to the long distance, the transportation department had four divisions (Chongqing-Guangyuan 廣元, Guangyuan-Lanzhou, Lanzhou-Jiuquan, Jiuquan-Yumen).

70 Descriptions of the lives in Yumen can be found in Sun Yueqi, "Ji Gansu Yumen Youkuang de Chuangjian he Jiefang," in *Sun Yueqi Wenxuan*, pp. 39-40; Lu Bao-qian and Huang Ming-ming, *Jin Kaiyin Xiansheng Fangwen Jilu*, pp. 76-88.

71 NRC/AH, 0030103010789.

if it carried 18 barrels.[72]

Because of KOMA's importance in China's war efforts and its potential to become a provider of liquid fuel to the country's future industrial development, Nationalist government officials visited the oilfield frequently. Just after the fire, Chiang Kai-shek inspected the oilfield on his way to Xinjiang in August 1941.[73] Therefore, the strategic importance translated into financial support. The NRC invested extensively in the KOMA, making it the largest enterprise in terms of budget and organization under the NRC. Between 1936 and 1944, the NRC invested 1,797,341,000 *yuan* into the KOMA. That was around 40 percent of the NRC's overall budget for this period.[74] The extensive investment enabled the oilfield to obtain necessary equipment and technical assistance from the United States and improved the drilling and refining works.

7. Gushers, Fire, and Improvement in Technology

The early 1940s saw the tide of war start to turn. Although Soviet aid to China ended in 1941, in May of the same year the US government extended the Lend-Lease Act to China. Soon, American weaponry, machinery, medicines, as well as technical and military personnel would go into China through Burma, and, after 1942, also by air over the Himalayas.

However, before KOMA could obtain any new equipment through the Lend-Lease scheme, several serious accidents on the oilfield manifested the importance of imported equipment. First, in April 1941, while technicians struggled with technical difficulties of deepening the fourth well with a coalmine rotary rig ill-suited for oil drilling, the drilling bit breached an unknown high-pressure reservoir. Lacking knowledge of the bottom-hole pressure or the equipment to control it, crude oil gushed out of the well, ignited, and

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72 Zhang Yu-yan, "Kangzhan Qijian Shiyou Qicai Yunshu Zayi," in Shiyouren Bianji Weiyuanhui (ed.), *Bilu Ji*, p. 54.

73 Sun Yueqi, "Ji Gansu Yumen Youkuang de Chuangjian he Jiefang," in *Sun Yueqi Wenxuan*, pp. 42-43; Lu Bao-qian and Huang Ming-ming, *Jin Kaiying Xiansheng Fangwen Jilu*, p. 67.

74 Xue Yue-shun 薛月順 (ed.), *Ziyuan Weiyuanhui Dang'an Shiliao Huibian: Guangfu Chuqi Taiwan Jingji Jianshe* 資源委員會檔案史料彙編：光復初期臺灣經濟建設, vol. 1 (Taipei: Academia Historica, 1993-1995), p. 458.

resulted in a severe fire. To make matters worse, Yumen technicians lacked the necessary firefighting equipment. Sand, gravel, and blankets were thrown into the wellbore, but with little effect. The fire raged for a couple of hours until the wellbore completely collapsed. Workers were injured and both the rig and the well were completely destroyed.[75]

Despite the disaster, the gusher indicated that the Yumen oil reserves were much richer than had been expected, and the Nationalist government was excited. It also reminded the KOMA of the importance of proper drilling procedures. In September 1941, when technicians were drilling the eighth well, they carefully measured the bottom-hole pressure and cemented the casing when they found the pressure was rising. However, before they could lower the production tubing, the well blew out. Without a blowout preventer, helpless technicians could only watch the oil gushing out uncontrolled. The blowout was so violent that the oilfield stopped all drilling and implemented strict control over the use of fire across the whole area. The gusher lasted for 31 hours and was subdued only by the partial collapse of the wellbore. The well ceased producing oil in 1943. The tenth well also blew out and was soon completely destroyed in January 1942.[76]

The open-air oil ponds were also hazardous. In August, a fire broke out and was only brought under control when holes were drilled into the walls of the storage ponds to release the stored oil.[77] The damage and waste caused by such accidents convinced the workforce of the importance of new equipment. Storage was improved between 1942 and 1943, as the KOMA purchased oil storage facilities from foreign oil firms in Chongqing, Hunan, and Henan and transported and reassembled them in Yumen.[78]

Drilling also slightly improved after 1942, thanks to US equipment. The US-made blowout preventers and production trees controlled the gushers of the eighth and tenth wells. In 1943, two US-made rotary rigs arrived.[79] Proper materials were obtained to

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75 Zhang Shuyan, *Yumen Youkuangshi*, pp. 46-47.

76 Ibid., pp. 48-49.

77 Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, pp. 865-866; Feng Zong-dao, "Jin Kaiying yu Gansu Youkuangju," in Shiyouren Bianji Weiyuanhui (ed.), *Shiyou Hepan*, pp. 105-106.

78 MEA/IMH, 18-31-03-019-02; 18-31-03-019-03.

79 These two rigs were actually among the 12 rigs ordered from the US under the 1940 two-year plan of the oil mining administration. The breakout of the Pacific War as well as the occupation of Vietnam and bombing of Rangoon by the Japanese forces made transporting those rigs difficult. Only two rigs could be

produce drilling fluid.[80]

However, better equipment did not mean better production practices. The most obvious problem was that technicians completely ignored the need for maintaining the pressure of oil reservoirs. The problem manifested itself in the case of the most productive eighth well. Although a string of production tubing was lowered into the well, the KOMA ordered technicians to allow crude oil to gush out of the production nozzle unrestrained for 16 months to achieve the production target of 1.8 million gallons of gasoline. That practice had a serious negative impact on the reservoir pressure. Because it was not completed properly, the well stopped producing any oil due to the collapse of the wellbore wall in the following year.[81] Unfortunately, this lesson did not stop technicians from using the same method for the remaining productive wells. Finally, in 1944, the KOMA suddenly realized the seriousness of the drastic reduction of reservoir pressure and its consequences in reduced long-term output. Technicians were then ordered to use smaller production nozzles.[82] Unfortunately, the damage had been done and the Yumen oilfield's output suffered from reduced pressure at least before 1949.

Furthermore, the refining capacity was expanded but only with available technology. Earlier in 1940, the NRC had instructed the Tung Li Oil Works to form the Yumen Engineering Department especially for building a new refinery, and the site chosen was in the ancient town of Jiayuguan, 76 kilometers away from the oilfield. The new refinery, which consisted of a set of more efficient tubular stills, was completed and entered production in 1942. It had the capacity of producing 1,200 gallons of gasoline, 4,000 gallons of kerosene, and 2,000 gallons of diesel per day.[83] Unfortunately, due to the difficulty involved in the transporting crude oil with trucks and carts, the equipment was moved back to Yumen in 1943 and merged with the recently-completed five sets of

assembled from the parts that arrived at Yumen in 1943.

80 Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, p. 845; Zhang Shuyan, *Yumen Youkuangshi*, pp. 51-65.

81 Zhang Shuyan, *Yumen Youkuangshi*, pp. 48-49, 75-76

82 Ibid., pp. 77-78.

83 Yan Chang-jin, "Jindai Zhongguo Shiyou Gongye Fazhan zhi Yanjiu (1932-1949)," p. 91. The equipment had the capacity to process 1,900 barrels of crude oil a day. Ding Xiangshao 丁祥紹, "Canjia Laojunmiao Lianyou Zhuiyi 參加老君廟煉油追憶 (Reminiscence of Participating in the Oil Refining Works in the Laojun Temple)," in Ling Hong-xun et al., *Shiyouren Shihua*, p. 309.

horizontal stills built using material recovered from scrapped ships.[84] Sadly, the locally built equipment was crude and no match for contemporary standards. Technicians had to organize several stills into one structure with a small fractional tower attached to each of them. Lacking enough pumps, gravity was used to cause the crude to flow from the higher to the lower stills, which was inefficient because of poor heat conduction caused by the poor quality of manufacture.[85] Although the Oil Creek flooded in 1943 and seriously damaged the refinery, technicians quickly rebuilt it and resumed production because the equipment itself was so simple.[86] Combined with the tubular stills moved from Jiayuguan, the refinery could process 1,900 barrels of crude oil per day, which was a much larger capacity than the original refinery.[87] Fortunately, the oil reservoirs contained no water and the crude only contained low levels of sulphur, hence complex dehydration and desulfurization equipment was not needed. Still, the Yumen refinery could only produce a low percentage of gasoline, which had low octane and high amounts of paraffin wax. Such fuel easily caused automobile engines to malfunction, and hence was not popular with consumers.[88]

Advanced refining equipment had to be imported in order to improve gasoline quality and to increase yields. The KOMA had, in 1941, ordered a set of thermal cracking equipment from the US. Yet, due to the breakout of the Pacific War in December 1941 and the disruption of the Burma Road by the Japanese forces, the delivery of the equipment became difficult and part of the equipment was lost on the way. Technicians had no choice but to assemble the surviving US equipment with locally produced parts, building a refinery that could process 1,500 barrels of crude oil a day. The new refinery, which was four kilometers from the oilfield, started to produce gasoline in 1946, although the technicians had difficulty starting the thermal cracking process.[89]

Furthermore, an essential part of the break with the past was improved training. The

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[84] NRC/IMH, 24-12-57-002-01; Zhang Shuyan, *Yumen Youkuangshi*, pp. 97-98, 100, 103; Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, pp. 858-860.

[85] Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, pp. 858-860.

[86] Ibid., p. 869.

[87] Ding Xiangzhao, "Canjia Laojunmiao Lianyou Zhuiyi," in Ling Hong-xun et al., *Shiyouren Shihua*, p. 310.

[88] Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, p. 860; Zhang Yuyan, "Kangzhan Qijian Shiyou Qicai Yunshu Zayi," in Shiyouren Bianji Weiyuanhui (ed.), *Bilu Ji*, p. 56.

[89] NRC/AH, 003000023003A.

KOMA joined the NRC's overseas training program and in 1942, sent a group of technicians, including two geologists, a drilling engineer, and a refining engineer, to be trained in the US for two years.[90] In 1944, 16 Yumen technicians joined the NRC for training in the US under Lend-Lease arrangements.[91] In the same year, the NRC also sent two Yumen engineers for training in the oilfields of the Anglo-Iranian Oil Company (later to become British Petroleum in 1954) in Iran.[92]

The KOMA also hired American technicians. In 1942, it contracted one drilling engineer and two assistant engineers from Texaco Petroleum Co. to work in Yumen for a year. After that, another American engineer was hired for a year. Those engineers instructed the Yumen technicians in drilling and completion procedures.[93] In 1942, the KOMA contracted a refining engineer for two years to instruct the Yumen technicians on how to assemble the refining equipment purchased from the US.[94]

The overseas training program and the recruitment of a handful of American technicians could not drastically improve the technology in Yumen, where drilling and refining equipment remained obsolete and inefficient. By 1945, the oilfield had drilled 26 wells. Twenty-two more were completed between 1945 and 1949. Table 3 shows the amount of gasoline and diesel produced by the Yumen oilfield. It can be seen that after 1942 the production of both crude and oil products increased dramatically. Crude oil increased from 3,635,109 gallons in 1941 to 14,262,330 gallons in 1942. In 1945, production reached 20,253,960 gallons. Gasoline increased from 209,321 gallons to 1,865,724 gallons. It further increased to 3,036,594 in 1943 and 4,047,940 in 1944 but slightly decreased to 3,766,347 in 1945.

90 Cheng Yu-feng 程玉鳳 and Cheng Yu-huang 程玉凰 (eds.), *Ziyuan Weiyuanhui Jishu Renyuan Fumei Shixi Shiliao: Minguo Sanshiyi Nian Huipai* 資源委員會技術人員赴美實習史料——民國三十一年會派, vol. 1 (Taipei: Academia Historica, 1988); Zhang Shuyan, *Yumen Youkuangshi*, p. 50.

91 NRC/AH, 003000000153A.

92 MEA/AH, 020000002071A.

93 Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, p. 845; Zhang Shuyan, *Yumen Youkuangshi*, p. 50.

94 Zhongguo Shiyou Zhi Bianji Xiaozu (ed.), *Zhongguo Shiyou Zhi*, vol. 2, p. 845.

Table 3: Output of the Kansu Oil Mining Administration (unit: gallon)[95]

	Crude Oil	Gasoline	Kerosene	Diesel
1939	128,784	4,160	4,101	7,393
1940	414,702	73,463	32,335	61,535
1941	3,635,109	209,321	112,590	141,125
1942	14,262,330	1,865,724	596,935	53,090
1943	18,769,785	3,036,594	558,458	28,468
1944	21,202,450	4,047,940	2,157,657	155,374
1945	20,253,960	3,766,347	1,654,197	270,292

Unfortunately, the amount of gasoline and diesel Yumen could produce was so small that the Nationalist government controlled area continued to rely heavily on biofuels. By 1944, 306 factories were producing alcohol and 67 produced vegetable oil fuel to supply eighty-five percent of liquid fuels in the Nationalist government controlled area.[96]

The end of the war also gave China's budding petroleum industry an opportunity to develop. The NRC dispatched Yumen engineers to Shanghai, Manchuria and Taiwan to take over Japanese petroleum facilities. In the following year, the commission merged all those facilities and formed the China Petroleum Corporation, incorporating the KOMA into itself as the Gansu and Qinghai Branch of the new company. No private funds were involved in financing the company: the NRC was the largest shareholder with other government agencies as the minority partners. Its directors and managers were appointed by the government. Fuel rationing was abolished and the new company strove to compete in the Chinese petroleum market against foreign firms. The Yumen oilfield continued its production while the NRC was drawing up grand plans for China's industrialization.

Yet, China was soon plunged into civil war. In 1949, as the Nationalists retreated to Taiwan, some of the China Petroleum Company's managers and engineers also moved to Taiwan and the company continued to operate with the oil refining facility on the island. It has been operating as the largest state-owned enterprise and has monopolized the production and distribution of petroleum products in Taiwan ever since. On the mainland,

95 Zhang Li-men 張麗門 and He Bao-shan 何葆善, "Shinian lai zhi Shiyou Shiye 十年來之石油事業," in Tan Xi-hong 譚熙鴻 (ed.), *Shinian lai zhi Zhongguo Jingji: 1936-1945* 十年來之中國經濟：1936-1945, vol. 1 (Taipei: Wenhai Press, 1974, reprint of 1948 edition), pp. 329-330.

96 Yan Chang-jing, "Jindai Zhongguo Shiyou Gongye Fazhan zhi Yanjiu (1932-1949)," pp. 108, 140.

all the petroleum facilities were reorganized under the Ministry of Fuel Industries and later in 1955 under the Ministry of Petroleum Industry as part of the new socialist government's bureaucracy until the ministry was abolished in 1988 and reorganized into two state-owned petroleum enterprises, which not only dominate Chinese petroleum market but also compete in the world market.

8. Conclusion

The geological assessment on petroleum made oil exploration unattractive to private entrepreneurs in China in the 1910s and 1920s. Start-up costs in technological investment were so high that the petroleum industry could only have been attractive within the context of strong political will of the newly founded Nationalist government. Petroleum enterprises were to be built under central direction in line with the Nationalist vision of an industrialized China. The fact that little technical knowledge was available within China in the early 1930s also fit readily with that line of thinking. The crisis of the Sino-Japanese conflict extended the issue of motor fuels beyond consideration of profit and cost. To meet military needs, the Nationalist government formed the National Resource Commission, mobilizing all available technical, personnel, and financial resources for exploring oil reserves in Shaanxi, Sichuan, and Gansu. Yet, technology remained the toughest challenge. The discovery of oil in Yumen had more to do with luck than with careful geological study. Besides, assorted technical difficulties exposed China's lack of petroleum technology. Despite the technicians' efforts, the oilfield's output simply could not meet China's wartime needs.

As an extension of a government bureaucracy, the KOMA was designed to ensure that production could be carried out on the edge of the Gobi Desert. The central government provided capital and set production goals for the enterprise, which was organized in a way that equipment, administrators, and technicians could be gathered and managed to fulfil its purpose of providing liquid fuel to military forces, government units, and to a small extent the general public. More importantly, it laid the foundation for technical knowledge that could be shared and stored because it provided on-the-job training to newly recruited technicians, and hence the hard-learned technical knowledge could be passed on. Besides, the organization had to take care of the daily life of the staff and their families.

Thus, the history of the creation of China's state-own petroleum enterprises from oil seepages to oilfields shows that the role of the Nationalist government in China's industrialization cannot be described in over-simplified theoretical terms. For a country with little technical impetus to develop oil drilling and refining, technology necessitated the state's extensive intervention. The Nationalist government did so in the form of government bureaucracy especially for war needs, and the bureaucratic formation of Chinese petroleum enterprise in a planned economy remained largely unchanged for the next three decades. That history requires more research, which would greatly enhance our understanding of the historical foundation of China's current industrial achievement.

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從石油露頭到油田：技術、機構創建與中國早期石油企業，1914-1945

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摘　要

近來學者多運用「發展型國家理論」來研究 1927-1949 年間的國民政府對於經濟發展的貢獻。本文希望以國營石油企業開創的例子，來與此一研究取向進行對話。1930 年代之前，一方面缺乏石油地質研究，加上私人企業的石油探勘結果不佳，使得實業家在中國進行石油開發的意願不高。1927 年南京國民政府成立之後，有意要開發石油資源，卻受到缺乏石油技術與人才的限制而無法發展。最後在中日戰爭的壓力下，國民政府才動員所有的資源，在甘肅玉門進行石油開發。本文認為，即使在意識型態或經濟國族主義的影響下，中國政府有意開發石油，但是複雜且資本密集的石油技術，使得國家必須要創立新機構，取得新技術，才能在偏遠的地區進行大規模石油開採與煉油事業。

關鍵詞：玉門油礦，資源委員會，翁文灝，錢昌照

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