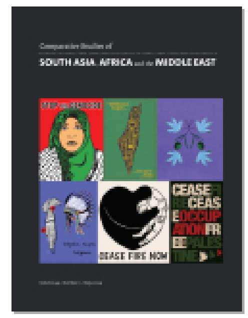
Precarious Petroleum: Volatile Reservoirs, Varied Natural Gas Compositions, and Development in 1960s Iran



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Volatile Reservoirs, Varied Natural Gas Compositions, and Development in 1960s Iran

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In the spring of 1964, an exploratory well in Iran's Masjid-e Sulayman oil field ruptured deep underground, destroying the wellhead apparatus and venting large volumes of natural gas across the arid landscape. More than a minor incident in the history of Iran's oil industry, the event was instead an inflection point for the country's state-directed programs of economic development, one rooted within the varied materiality of petroleum itself. Creating new configurations among buried petroleum deposits and inducing a series of compositional changes within them, the well break spurred the creation of a large petrochemical facility in the city of Bandar-e Shahpur that was aimed at meeting growing demand for synthetic fertilizers within Iran and abroad. In light of the aggressive new programs of industrialization and social reform being pursued across Iran at the time, this article studies the events at Masjid-e Sulayman as a window into the significance of nature's continued uncontrollability amid a modernizing drive predicated on harnessing natural resources for human ends. Such efforts relied on the exploitation of petroleum, but oil and natural gas deposits were not passive in the story. They instead migrated and mutated in ways unforeseen and uncontrolled by people, in the process enabling new opportunities for Iran's developmentalist state, a meeting of human ambition and natural phenomena that left both altered.

In looking at the operations of oil firms and their interactions with petroleum deposits, scholars have largely traced the translation of natural variability and unpredictability into systematized and transportable schema subject to management and control.[1] Such technical transformations were crucial not only for the physical and commercial aspects of oil production, but also for the political and contractual mechanisms that governed the ownership of oil resources—in both legal and practical terms—and the distribution of profits from their sale.[2] These perspectives, while giving important insight into the scientific and political regimes that have been built upon petroleum exploitation, largely reproduce the logics of mastery that Victor Seow has highlighted as giving rise to technocratic forms of governance in China and Japan.[3] Politics in such accounts are rooted foremost in the informational or physical management of fossil fuels and the consequences that flowed from chosen techniques of control.[4]

Focusing on the Shahpur petrochemical complex as a meeting point between the Masjid-e Sulayman blowout and Iran's own technocratic impulses, this article studies the character of Iran's developmentalist planning and its relationship to the natural world. Part of a larger program of top-down social change and industrialization, petrochemicals were crucial to efforts to boost productivity in an agricultural sector undergoing extensive redistributionist and commercializing interventions.[5] Scholars have long emphasized the role of expertise, the shah's ambitions, and the United States in the story of Iran's developmentalist planning.[6] Underappreciated is the influence of petroleum deposits themselves, not as sources of revenue or even energy but as unstable systems shaping available

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opportunities. Such opportunities were embedded in the relationship between the Iranian government and British Petroleum. Controlling much of Iran's oil sector even after the country's oil nationalization crisis of the early 1950s, British Petroleum maintained its position through what Katayoun Shafiee calls the technical and legal "organizational work" of oil production.[7] But that control was always to some extent precarious, and it was within spaces and moments of uncertainty—such as when a well ruptures and natural gas migrates—that Iranian planners were able to assert their developmentalist visions even in the face of opposition by British Petroleum officials more concerned with the potential costs of natural gas exploitation.

What follows is an examination of the 1964 well failure at Masjid-e Sulayman and its aftermath. After a discussion of this article's contributions and theoretical positioning, the narrative begins with a study of sulfur in Iran's early oil industry. It then examines the place of petrochemicals in the country's midcentury development plans, connecting efforts to utilize gas to widespread transformations within Iran's agricultural sector. The article then explores the role of hydrogen sulfide, a corrosive petroleum impurity, in causing the accident and the uncontrolled remaking of Masjid-e Sulayman's underground geography. The final section turns to the inherent uncertainty of controlling the field's gas, and the political outcomes that flowed from that unpredictability. Underlined in this article are the natural phenomena at work within the earth, a deliberate counterpoint to histories that have prioritized human actions and the effects of petroleum on the earth's surface. Highlighted is the role of uncertainty and the particular in shaping the political outcomes of twentieth-century Iran, showing how the natural limits of British Petroleum's managerial control enabled an assertion of Iranian developmentalist ambitions.

Oil and Precarity

The 1964 accident and its aftermath were the result of a complex causal web involving Iran's politics of development, British Petroleum's field operations, the corrosive effects of hydrogen sulfide, and the rocky underground strata of southwest Iran.[8] Far from being merely passive points of access to static and uniform underground deposits, oil and gas wells actively remade southwestern Iran's subterranean regions in unforeseen ways. When British Petroleum's well ruptured, Masjid-e Sulayman's previously distinct petroleum deposits were linked into a single reservoir, enabling new and uncontrolled movements of natural gas that would in turn help drive the construction of a new petrochemical complex. This causal sequence complicates our understandings of modernization in Pahlavi Iran, a state-centered phenomenon claiming legitimacy through a "politics of material promise" that was built in large part on the domination of nature.[9] Much of the scholarship on the period has reproduced such articulations, telling stories rooted in royal ambition, growing technocratic mastery over state and society, Cold War geopolitics, and, behind it all, soaring oil wealth.[10] More broadly, scholars have prioritized revenues in seeking to explain the political and economic developments of petroleum-producing states, giving rise to the idea of the "rentier state" and the "oil curse."[11] Such accounts treat petroleum as rents, forging a direct and isomorphic relationship upon which to build arguments that root political outcomes in disputes over the control of oil revenues.[12]

Timothy Mitchell has famously critiqued the focus on petroleum revenues as the primary driver of authoritarianism within the Middle East. He instead looks to the physical realities of fossil fuel exploitation, highlighting the influence that labor, private enterprise, and systems of production have had in opening and closing democratic possibilities around the world.[13] Such broader understandings of petroleum's social influence are part of a growing body of work recognizing oil and its industries as generative of a wide array of political and cultural arrangements.[14] Other scholars, writing with an eye toward climate change, have further examined the deep integration of fossil fuels into systems of capitalist accumulation and thus global ecology.[15] Such analyses, however, whether focused on revenues or carbon, have largely assumed the fungibility of oil, ignoring the considerable efforts put toward finding efficient ways of turning petroleum into standardized products.[16] More broadly, Laleh Khalili has pointed to the similarities between oil and other commodities like sand in their structuring of politics around the world.[17] As with oil, sand is not homogenous. Whether used for concrete or for fracking, different grades of sand are drawn from different sources and possess different political implications derived from both their specific material properties and the uses to which they are put.

By using petroleum and its impurities to study the significance of oil and gas compositions to Iranian history, this article examines the 1964 blowout and its aftermath to argue that petroleum has never been homogenous—an idea expressed through the use of terms like "oil" and "natural gas" in the singular—in either social or historical terms. In doing so it highlights petroleum not as a source of energy or revenue but as a feedstock for creating what Adam Hanieh has termed our "synthetic world" of plastics and engineered chemicals.[18] Proliferating in the decades after the Second World War, petrochemicals quickly found their way into daily life around the world, enabling new patterns of cheap consumption while choking the earth with long-lived poisonous waste.[19] In the 1960s, petrochemicals represented a potentially lucrative evolution of Iran's petroleum industry and a productive outlet for its natural gas resources. "Sour" gas—natural gas with high concentrations of corrosive hydrogen sulfide—was particularly useful for producing a variety of petrochemicals ranging from fertilizers to sulfuric acid and more. The 1964 accident at Masjid-e Sulayman suddenly and unexpectedly made large volumes of sour gas available for use, and it was exactly this new availability that spurred the construction of a large petrochemical complex at Bandar-e Shahpur that would quickly come to supply a major portion of Iran's growing demand for fertilizers and industrial chemicals.

However, the focus here is not on such products themselves or their scientific or commercial history. The focus is rather on the contingent encounters between human enterprise and uncontrolled natural phenomena that enabled the production of these products in places like Iran. This article thus follows the instability of Masjid-e Sulayman's petroleum deposits, in the process drawing upon and advancing methodologies of social analysis rooted in notions of precarity and environmental hybridity.[20] "Precarity is the condition of being vulnerable to others," Anna L. Tsing writes, and a "precarious world is a world without teleology."[21] At question here is a teleology of advancing human mastery within the petroleum industry, the logics of which find ultimate expression in the notion of the Anthropocene and its species-level vision of combusted hydrocarbons and an altered earth. Scholars like Jason W. Moore, Donna Haraway, and others have troubled that narrative, looking instead for the particular histories by which widespread environmental change has been made.[22] This article attends to one such history, exploring Iranian petrochemicals' roots in the vulnerability of oil operations to unforeseen natural forces. This is not a question of failure, which is the fate of many systematizing and modernizing projects.[23] Nor is it, as Andreas Malm argues, a question of diffusing agency—and thus responsibility—across ever more actors and undermining our ability to change the world for the better (or at least avert climate disaster).[24] Rather, putting indeterminacy at the center of our analyses highlights how human control is extended, where it slips, and what is made from such moments.

Oil and Brimstone

In 1967, three years after the original well rupture at Masjid-e Sulayman, consultant R. E. Old Jr., hired by the National Iranian Oil Company (NIOC) to evaluate the situation, blamed the explosion on operators' failure to account for the presence of hydrogen sulfide, one of petroleum's most common and challenging impurities.[25] Variously employed by Core Laboratories, a Texas-based oil field services company, Socony-Vacuum Oil Co., and NIOC, Old was a trained chemical engineer possessing considerable experience in petroleum reservoir analysis with a number of publications and conference presentations to his name.[26] His focus on hydrogen sulfide's role in the incident was not surprising. A toxic, corrosive, and flammable gas marked by the smell-deadening stench of rotten eggs, hydrogen sulfide is a naturally occurring petroleum impurity that appears in varying concentrations within oil and gas deposits. Petroleum's history thus shows recurrent and persistent concerns about sulfur quantities and the related "quality" of particular deposits. Reflecting such judgments, existing accounts have largely treated the element as an obstacle overcome or circumvented by companies intent on building an industry and competing for market share.[27] But sulfur, primarily in the form of sulfuric acid, has a long list of industrial applications, ranging from fertilizers to pigments to oil refining itself, and over the course of the twentieth century global sulfur demand was increasingly filled as a by-product of the oil and gas industry.[28] It was in this context that the sudden discovery of large quantities of sour natural gas would spur the creation of the Shahpur petrochemical complex.

Long before the incident in question, however, the relatively high concentration of sulfur in Iran's crude, a trait also observed in the crude oil of other Persian Gulf nations, presented unexpected challenges to oil explorers. With D'Arcy's original 1901 concession largely in the hands of the Burmah Oil Company by 1905, plans called for Masjid-e Sulayman's output to be refined mostly into kerosene for sale. Unlike the low-sulfur "sweet" Burmese crude with which they were familiar, the high levels of sulfur in Iran's oil surprised British petroleum experts and complicated the ambitions of the Anglo-Persian Oil Company (APOC). Tainting the Abadan refinery's output with a yellowish tinge, an unpleasant odor, and a tendency to film glass when burned, APOC products were of such low quality that they were virtually unmarketable and threatened the viability of the entire project.[29] APOC soon found its salvation in fuel oil, however, for which Iranian crude was more readily suited, and in the Royal Navy's fortuitous decision to convert its ships from coal to oil in the early 1910s. That turn was not without controversy, however, as a significant portion of the company's directors instead pushed to continue prioritizing kerosene production. But Abadan's inability to make it at sufficiently marketable qualities proved to be the tipping point.[30] APOC becoming the Royal Navy's primary supplier of fuel oil was not determined by Iranian crude's sulfur level, but it was an integral part of the story. Debates within APOC about fuel oil's commercial viability predated refinery problems, but it was sulfur-induced troubles with kerosene production that tipped the balance in favor of those advocating that the company shift focus to heavier fuels.[31]

Though the kerosene's filming effect was corrected by 1913, APOC's refinery issues continued in subsequent years, with even the Admiralty's fuel oil periodically failing to meet specifications. Despite significant investments of time and money, it was only with the arrival of petroleum cracking in the mid-1920s that the company managed to fully turn the corner on its sulfur problem.[32] Petroleum cracking, developed in the United States, enabled the production of higher-quality motor and aviation fuels.[33] APOC quickly adopted cracking practices, and the installation of Abadan's first cracking unit in 1927 marked a significant advancement in the company's refining capabilities. Cracking breaks apart hydrocarbons through heat and pressure, a process by which heavier oil fractions, which dominated the crude found in Iran's southwestern region, could be made into lighter, more lucrative ones. Cracked hydrocarbons are not finished products, however, and require further processing to remove unwanted residues. APOC turned to a sulfuric acid for that second stage, at first relying upon large amounts of sulfur shipped from Texas before quickly learning to extract the necessary quantities from the hydrogen sulfide contained in Abadan's own refinery gases.[34]

By the late 1930s, APOC—by this point renamed the Anglo-Iranian Oil Company (AIOC)—was using large quantities of sulfur not only to wash cracked hydrocarbons but also in new processes of alkylation used to meet rapidly rising demand for high-grade motor and aviation spirit.[35] In this way, over the course of the 1920s and 1930s, the sulfur in Iran's crude was transformed from an impediment to a "very important part of the company operations."[36] Iran's "oil" was thus never a pure substance simply lifted and shipped around the world; it was instead a series of manufactured products dependent on what had once been considered a noxious impurity. By conceptually cracking apart "oil" to focus on sulfur, it becomes possible to see the element's significance in shaping the early history of Iran's oil industry.

Petrochemical Fertility

Even with the transformation of sulfur into a valuable component of oil refining, in the following decades AIOC continued to face trouble with hydrogen sulfide's corrosive nature.[37] Indeed, it would be the root cause of the costly 1964 blowout at Masjid-e Sulayman. Losses associated with the incident were heavy, with R. E. Old estimating that some 396 billion cubic feet of natural gas valued at $193 million had been allowed to vent into the atmosphere in the three years since the initial rupture.[38] Nor were notional financial losses the sum total of the episode's potential harm. Writing in the spring of the same year, Manuchehr Eqbal, head of NIOC and a powerful figure in the shah's inner circle, described the continuing loss of gas as a "cause of great anxiety not only as an enormous wastage of valuable natural resource" but also as an impediment to the "the speedy implementation of one of the important industrial projects of the country," one "for which already considerable investment has been earmarked and committed."[39] That "important industrial project" was the Shahpur Petrochemical Complex in Bandar Shahpur, an enormous facility on the Persian Gulf coast then beginning construction that was intended to become a major supplier of petrochemicals both within Iran and abroad.

The Shahpur scheme was part of a 1960s- and 1970s-era wave of petrochemical projects built on Iran's enormous gas reserves, a new industry promising both lucrative revenues as well as a more diversified economy less dependent on crude oil exports. Petrochemicals were developed primarily in the United States prior to World War II before production expanded to Europe and Japan in the decades after. In the postwar years a host of new petrochemical products entered world markets, from PVC to polyester to Agent Orange and many more, and the sector became an important driver of the chemical industry's rapid growth during the period. Large multinationals, including those in the oil industry—enabled by falling trade barriers in the late 1950s and 1960s, and aiming to feed a seemingly insatiable appetite for plastics, pharmaceuticals, and synthetic fertilizers—began to establish production facilities around the world, at first largely in the Western Hemisphere before expanding into Europe and beyond. Though many ventures would prove unprofitable, AIOC—by this point renamed British Petroleum in the wake of Iran's oil nationalization crisis—quickly became one of the largest chemical companies in Europe by exploiting North Sea oil and gas.[40]

Driven by a desire for economic diversification and increased export revenues, petroleum-rich countries like Iran sought to enter the market during the 1960s and 1970s, often in cooperation with foreign firms. In 1961 the shah of Iran, seeing the industry's success, declared it "scandalous to burn" petroleum when it could be more profitably turned into petrochemicals.[41] Indeed, major American chemical companies like BF Goodrich, DuPont, and Allied Chemical were increasingly attracted to the country's cheap gas feedstocks and its geographic proximity to South and East Asia. Capitalizing on that interest, the Iranian government entered a series of joint ventures and thereby made petrochemicals an important part of its industrializing plans.[42] Other oil-rich states came to similar conclusions, with Saudi Arabia and Mexico investing heavily in the sector in the 1970s.[43] While such initiatives succeeded in establishing businesses trading in basic and intermediate commodity chemicals, most failed to break the American and European hold on the industry's upper tier.[44]

Beyond the anticolonial tenor of seeking to export more lucrative manufactured products instead of raw resources, petroleum-rich states in the global South moreover sought to lessen their dependence on imported petrochemical products.[45] In the postwar decades, Iranian demand for petrochemicals rose rapidly as the country industrialized and its agricultural sector was reconfigured by successive waves of reformist intervention. Originating in the work of the American engineering consulting firm Morrison-Knudsen in the late 1940s, Iran's programs of economic development and the five- and seven-year plans that structured them were dependent on petroleum and its rents. Natural gas was thus identified as a valuable but untapped source of energy for the country, one that Iranian officials had been agitating to utilize since the 1930s.[46] Standing in the way of those ambitions, however, were figures like John Cadman, chairman of AIOC in the 1930s, who saw gas exploitation as requiring too much investment and too much basic research to be compatible with the company's commercial priorities.[47] However, Morrison-Knudsen's recommendations were a turning point that gave the Iranian government a new tool with which to pressure British Petroleum.[48] Though years of negotiations, studies, and planning would intervene, by the 1960s a number of new gas projects were either operating or under construction. Prominent among them was a new petrochemical sector intended make Iran "self-sufficient in almost all major petrochemicals and plastic ingredients."[49]

Iran's foray into petrochemicals came amid the so-called Green Revolution, a decades-long period in which technoscientific techniques of agricultural production—hybridized crop varietals, mechanization, new irrigation systems, and the use of chemical fertilizers and pesticides—were spread around the world. Promoted by organizations like the US Agency for International Development, such programs sat squarely within the paradigms of modernization theory and the American government's harnessing of it as a Cold War weapon.[50] Drawing from a similar playbook, Morrison-Knudsen had recommended sweeping reforms to Iranian agriculture that were couched in technical terms but that carried significant political implications.[51] Around the turn of the century, Iranian agriculture had largely moved toward export-oriented sharecropping as the country was integrated into European trade networks, a change that accentuated the power of landlords. By the middle of the century, Iranian agriculture was thus marked by highly stratified social arrangements where a small group of wealthy owners held some 80 percent of all arable land and pursued greater profits through ever-increasing exploitation of labor rather than, as Morrison-Knudsen thought they should, capital investment.[52]

The economic power of landlords was moreover translated into political power through their paternalistic social control of rural villages and the vote harvesting it enabled. Any changes to Iran's agricultural system were thus highly politicized and became more so when the communist Tudeh party made land redistribution a central pillar of its demands. Though Tudeh was violently suppressed in the wake of Iran's 1953 coup, the idea of redistribution lived on and was championed in the early 1960s by the left-aligned Prime Minister ʿAli Amini and Minister of Agriculture Hassan Arsanjani. For the shah, however, land reform was primarily of interest as a way to break the power of landed elites and bind Iran's rural classes to his increasingly autocratic state, a signal example of what Ali M. Ansari argues was the shah's efforts to root his rule in new forms of modernist legitimacy.[53] Land reform was thus implemented as part of a broader set of social reforms known as the White Revolution, undertaken first and foremost with an eye toward its political implications for the shah. When unrest grew following the program's commencement in 1963—rural inhabitants defied landlords and demanded immediate ownership—it was quickly watered down into a system of long-term tenancy. Though the program was again revised in favor of direct redistribution in the late 1960s, results were disappointing, with most grantees receiving only small amounts of land and the rest, nearly a third of rural inhabitants, pushed into crowded urban slums.[54]

As a result of small plots and the continued viability of inexpensive familial labor, the reforms Morrison-Knudsen sought made little impact among most Iranian farmers. Chemical fertilizers, however, were the exception. With their use promoted by expansive new irrigation projects and government subsidies, chemical fertilizers were a reliable way to increase productivity on plots of land of any size. Iranian smallholders were thus among the country's heaviest users, and consumption of ammonia-based compounds grew from negligible amounts in the 1950s to some one million tons per annum in 1977.[55] Domestic production was very limited in those early years, however, with only a single facility near Karaj producing some two tons per year.[56] It would not be until the early 1960s that the situation changed, when a new plant for producing nitrogen-based fertilizers from natural gas opened near Shiraz.[57]

It was against this backdrop that the 1964 blowout at Masjid-e Sulayman became meaningful. The sour gas suddenly discovered was significant not just for corroding the well apparatus but also for the economic and developmental benefit for which it might be harnessed.[58] While plans like Shiraz Chemical were aimed at meeting domestic needs, Iranian development planners had greater ambitions, attracted to the fact that the ECAFE region—a UN-designated area comprising South and East Asia along with Oceania and portions of the Middle East—possessed some 60 percent of the world's arable land but consumed only one-fifth of its fertilizer supplies.[59] As early as 1962, Iranian delegations to international symposia began to argue that their country's gas reserves and geographic proximity made it a potentially important supplier for the region.[60] The Shahpur complex, designed and built in the late 1960s and early 1970s, embodied those ambitions. Conceived as one of the largest fertilizer plants in the world, Shahpur was intended to take natural gas from oil fields like Masjid-e Sulayman and turn it into a suite of products destined for export.[61] The Shahpur project—a joint venture between the American firm Allied Chemical and the National Petrochemical Company, formed in 1964 to oversee Iran's petrochemical sector—was more reflective of Iranian developmental ambitions than any plans for aggressive international expansion by Allied.[62] Planning and design commenced in December 1965, with the site at Bandar-e Shahpur chosen to take advantage of the region's petroleum fields and for its easy access to road, rail, and oceangoing transport. Construction would take from 1966 to 1970 and was contracted to the American Kellogg company for a total cost of $250 million, a price that included the costs of supporting systems like electricity generation, water purification, housing, and a two-hundred-kilometer natural gas pipeline.[63]

Sour Gas

From its inception the Shahpur petrochemical complex was intertwined with Masjid-e Sulayman's natural gas compositions and their sulfur content. It was not the simple presence of sulfur that spurred the project—and AIOC had been producing thousands of tons per year from the field since the mid-1940s—but the unusually high concentrations of it.[64] Indeed, it had only been "following the discovery of high H_2S content gas [from the blown well that] . . . NIOC/NPC . . . developed a scheme to utilise such in a petrochemical complex."[65] Middle Eastern crudes were known to contain relatively high concentrations of H_2S, but that was not necessarily true for all fields within reach of the new plant.[66] Spurred by a 1944 proposal from the Cabot Company to use Iranian gas to produce carbon black—a crucial component in rubber tires—AIOC undertook an evaluation of southwest Iran's gas resources.[67] Carbon black production depended on the use of "sweet" gas, or natural gas with low hydrogen sulfide content, which in turn necessitated a better understanding of sulfur distributions within Iran's petroleum-producing areas. But sulfur's own value also prompted AIOC geologists to prepare a report aimed at forecasting the province's "total sulphur that, given [a] suitable extraction plant, might be obtained from the various fields."[68] The report's predictions were only tentative, which reflected not only uncertainty regarding the technical and commercial aspects of sulfur recovery, but also the complex and not fully understood underground geography of southwest Iran.[69] Tenuous as its findings were, the report's anonymous authors nonetheless concluded that Masjid-e Sulayman was likely to be among the region's more productive fields over the short and medium term. What was not found, however, was any discernable pattern of sulfur concentrations across Khuzestan's various petroleum fields.[70] Some, like Lali and Haft Kel, also exhibited significant potential; while others, like White Oil Springs, Gach Saran, and Agha Jari were thought to contain "negligible" amounts of recoverable sulfur.[71]

AIOC had long dismissed natural gas as commercially unviable, in the process leaving the subsurface conditions of natural gas opaque through indifference. It was only the sudden possibility of using gas as an industrial feedstock that made gas compositions a matter of pressing concern. The production of technoscientific knowledge about Iran's gas reserves was thus intertwined with the business priorities of companies like AIOC and Cabot, a continuation of the process by which Khuzestan and its oil fields served as a laboratory for fixing petroleum within an organizational framework linking commerce, science, and the natural world.[72] Indeed, in the following months and years, company engineers and field managers reported volumes of data on Khuzestan's natural gas, attempting to capture and record gas availabilities and compositions in different fields, at different pressures, and at different points in the production chain.[73] But no matter how much information they gathered and analyzed, there nonetheless remained irreducible uncertainty that was rooted in the mutability of the region's petroleum deposits. As Katayoun Shafiee argues, AIOC's concessionary control over Iran's petroleum was solidified through the accumulation and management of information; but such political possession never represented true physical mastery.[74] AIOC's control was always partially precarious, vulnerable to irruptions of the region's long natural history.

As was true for most of southwestern Iran's oil fields at the time, Masjid-e Sulayman's primary producing horizon lay within the petroleum-rich Asmari formation, a 1050- to 1600-foot-thick layer of Oligocene-Miocene limestone that had been deposited between thirty-five and fifteen million years ago. The Asmari was noted for its extensive fracturing, deep "whale-back" folds, and a thick seal of impermeable stone that lay above it, features that made the layer an ideal zone for trapping and accumulating petroleum. Those features were the product of a particular history, one marked by the advance and retreat of shallow seas, the long accumulation of organic remains, the heat and pressure of the deep earth, and the inexorable deformations of tectonic movement. The histories of the Asmari's rock and its oil were not identical, however, as the pooled petroleum originated within inky carbonate marls thousands of feet deeper and hundreds of millions of years older. That oil, high in hydrogen sulfide because of the extensive activity of sulfate-reducing bacteria, had migrated upward through the earth, getting trapped in the fractured matrix of the Asmari limestone and thus becoming available for exploitation.[75]

By late 1966, British Petroleum had extracted 85 percent of the total crude oil available at Masjid-e Sulayman, some 1.3 billion barrels, turning what had once primarily been an oil reservoir into one with extensive secondary gas caps. But the field, sitting atop a kilometers-deep column of rock reflecting hundreds of millions of years of earth's history, was the potential outlet of not one petroleum reservoir but several, each with its own composition, pressure, and history. In addition to the Asmari, oil had also been discovered deeper underground in a layer of limestone dating to the Eocene period, some fifty-six to thirty-four million years ago. Indeed, the original purpose of the ruptured well, named MIS-306, had been "exploring the prospects of [oil] production in deeper formations," particularly very ancient sediments dating to the Lower Cretaceous, Jurassic, Triassic, and Paleozoic eras. After penetrating through Masjid-e Sulayman's new gas cap, the Eocene reservoir, and the Cretaceous layers, in the spring of 1964 drilling was terminated 15,003 feet below the surface. Despite little evidence of oil, three rounds of testing were ordered. The first two produced little of note, while the third, conducted in the Middle Jurassic layers, proved to be a seminal moment for Iran's petrochemical industry. It was during this test, on April 4, 1964, that the wellhead equipment began to leak, permitting natural gas to "blow across [the] wellsite." Two days later, on April 6, the wellbore's casing failed deep underground, stymieing efforts to bring the situation under control and prompting the drill team to cement off MIS-306 and abandon it.[76]

Although the venting gas on the surface was the accident's most visible result, far more significant was the subterranean movement that the well's failure had enabled. MIS-306's wellbore had for the first time connected heretofore distinct hydrocarbon pools, a link that allowed gas to migrate from deep Jurassic layers into the shallower Asmari and Eocene reservoirs.[77] British Petroleum technicians followed that movement

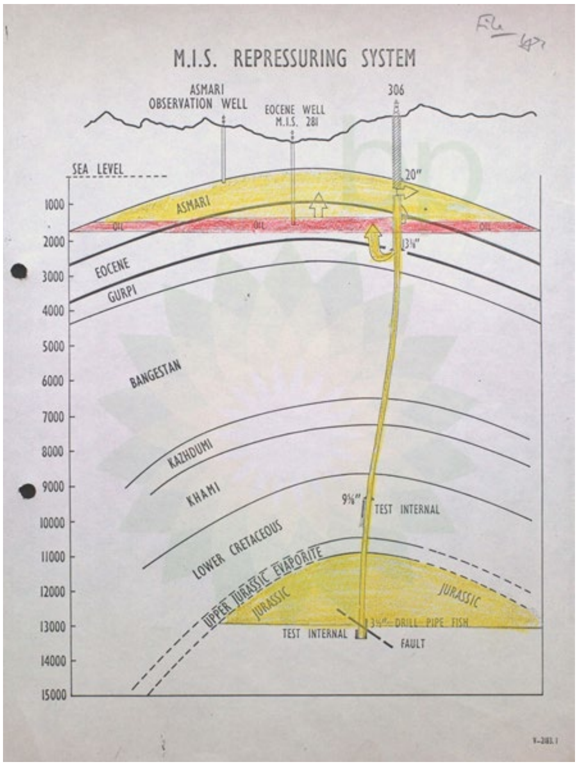

Figure 1. Illustration of Masjid-e Sulayman Field Reservoir System, “Fourth Joint Meeting,” *MIS Jurassic Gas Well, Iran (1964–1969)* (51493), BP Archive, University of Warwick, © BP plc.

through changing pressures in Masjid-e Sulayman’s production wells. On April 12, 1964, it was observed through rapidly rising pressures that “gas from MIS-306 was entering the Eocene reservoir,” and by early June pressure readings had nearly tripled. A sudden reversal in the middle of the month, coinciding with newly observed increases in Asmari pressures, “indicated that communication had been established between the two reservoirs.”[78] MIS-306 and its failed casing thus created a new underground system, one where the hydrocarbon pools of the Asmari, Eocene, and Jurassic were bound into a single unit (fig. 1). The sudden availability of high-H_2S gas at Masjid-e Sulayman was thus the combined result of human action and geologic history. The particular material characteristics of the gas, including its high hydrogen sulfide content, were outcomes of long-lived natural processes, but its availability within the existing parameters of Iran’s petroleum industry was the unintended result of human actions. It was the unforeseen movement of high-pressure sour gas into shallower reservoirs already in production that drove the Shahpur petrochemical project, not its long presence thousands of feet deeper amid the rocks of the Jurassic.

Productive Uncertainty

Shortly after MIS-306’s failure, drilling of the first relief well, MIS-308, was begun, marking the start of more than three years of effort to seal the rupture. But with Jurassic gas flooding into the Asmari reservoir, pressures were rising rapidly and putting oil operations at risk. With numerous natural gas seeps, abandoned wells, old wellhead equipment, and active producers dotting the field, and no way of knowing what pressures could cause failures, it was decided that gas from the Asmari and Eocene reservoirs would be flared to give more time to relief operations. Between October 1964 and the spring of 1968, periodic flaring thus resulted in the loss of some 227 billion cubic feet, or 52.5 percent of the “432 MMMSCF [billion cubic feet] of sour gas transferred from the Jurassic to the Asmari gas dome.”[79]

The enormous loss of gas sparked a dispute between British Petroleum and NIOC, with the latter maintaining that not only had the British company caused the initial accident but that it had also declined to aggressively rectify the situation. These tensions came to a head in a series of four meetings held in the summer of 1967. Convened in order to discuss the killing of MIS-306 and the feasibility of using Jurassic gas for the Shahpur plant, discussions hinged on notions of uncertainty and its management. R. E. Old Jr., working on behalf of NIOC, argued for a multicausal understanding of the accident, but one where primary fault lay with the failure of well operators because “the presence of H_2S should have been suspected and a more suitable grade of casing used [for the well shaft].”[80] The operating companies largely agreed, writing in 1966 that there was “no doubt as to the cause of [the] pipe failure—hydrogen embrittlement,” a well-understood form of corrosion and cracking in steel that occurs in the presence of hydrogen sulfide.[81] Even more damning in Old’s assessment, however, were British Petroleum’s actions subsequent to the accident, and he wrote that “in his opinion good oilfield practice had not been fulfilled” by accepting the risks of continued well testing in the face of early warning signs. He moreover accused company officials of lacking urgency in the matter, arguing that they would have been less sanguine about the matter had MIS-306 been an oil producer.[82]

Though British Petroleum officials feared that this assessment reflected broader opinion within NIOC and the Iranian government—and indeed it did, though NIOC was careful to highlight Old’s status as a hired consultant—they rejected accusations of mismanagement even as they in practice confirmed his appraisal of their priorities.[83] Despite pressures emanating from Manuchehr Eqbal, chairman of NIOC, and through him from the shah of Iran, British Petroleum officials declined a NIOC request for an urgent loan of drilling equipment to kill MIS-306, instead offering to facilitate a contract between the Iranian company and a third party. British Petroleum's refusal to prioritize the Iranian government's stated interests underlined its continuing control over petroleum production in southwest Iran. It moreover reflected the company's desire to avoid responsibility for supplying gas to the Shahpur project.[84] Plans for the complex called for a daily volume of one hundred million cubic feet of gas to be made available by January 1969, a figure that rose to 250 million by 1970.[85] Stakeholders like Eqbal and the shah were thus keen to see MIS-306 brought under control and its gas preserved for later utilization, a position that in the spring of 1967 sparked a renewed effort to finally seal the blown well.[86] Doing so would be a complicated process involving a number of multistage cementations placed via new secondary wells. Here again uncertainty reared its head. British Petroleum officials, fearing that any drilling near the blown well would compromise the integrity of the cement stops, advised that "the kill wells [in the Jurassic layers] should not be included in the future plans to provide gas."[87] They advised instead "the utilisation of Asmari gas," a plan to reduce risk by abrogating the need to fully kill MIS-306 and stop the movement of gas that it enabled.[88]

But while the discovery of sour Jurassic gas entering the Asmari reservoir had been the original spur for the Shahpur project, its feasibility as a source of sulfur was far from certain. Samples taken from a secondary well, one "probably producing almost pure Jurassic gas," indicated a hydrogen sulfide content of some 23 percent, a concentration some 2.5 times what could be obtained from the Asmari reservoir even after the introduction of Jurassic gas to it.[89] Moreover, the use of Asmari gas was not straightforward, as it would need expensive compression that the high-pressure Jurassic gas would not. As R. E. Old wrote, "The suggestion had been made . . . to use gas produced via the Asmari. The cost, however, to make gas completions and to install compressors would be some $11,300,000 plus a yearly operating cost of about $1,400,000. Furthermore, much sulphur may be lost by the reaction of the H_2S with the limestone matrix to form CO_2, and loss by this would total about $500,000,000."[90] Old further suggested that despite British Petroleum's claims that "each [Jurassic] well should be considered as a wildcat with no assurance of gas, and that Asmari gas would, therefore, be more feasible," the extensive fissuring of the deeper layers would likely enable sufficient access to the gas.[91] In both cases neither Old and NIOC nor British Petroleum were able to predict with surety what would happen if wells like MIS-308 were used as gas producers. Uncertainty thus structured the entire debate surrounding MIS-306 and its Jurassic gas, reflecting the complexity and precarity of the environment the well had tapped and subsequently altered.[92]

MIS-306 was finally killed in January 1968, nearly four years after the initial incident.[93] During that time the Shahpur project had continued, and despite British Petroleum's objections, NIOC officials were able to push ahead with repurposing MIS-306 and MIS-308 as producers.[94] Uncertainty surrounding the effects of hydrogen sulfide nonetheless remained. Operators had "insufficient knowledge of the producing formation both in character and depth," had difficulty choosing the right steel because of a lack of data on the precise composition of the gas, and faced reservoir pressures unstable enough to cause "mechanical problems."[95] Compounding such risk was the fact that neither NIOC nor British Petroleum possessed the necessary expertise for handling highly sour gas and were forced to seek the "specialist assistance" of other firms.[96] Despite such challenges, British Petroleum committed itself to supporting the Shahpur project with its operational expertise and "far superior" understanding of the region's geology.[97] British Petroleum officials nonetheless feared "bearing all the criticisms and sharing none of the benefits" of the Shahpur project, and the risk of such an outcome lay at the forefront of their discussions.[98] As Joseph Addison, chairman of the consortium, wrote:

> The question arises whether it is advisable to continue such an arrangement [British Petroleum operating the wells] indefinitely. . . . From an operational point of view it is preferable to combine the two operator functions into one, once the gas system is regularized. A division of responsibility in control functions should, if possible, be avoided, in particular since the Producing Company could, we feel, be held responsible for possible malfunctioning of and/or damage to the dehydration plant in case of an ineffective control of gas flow from the producers.[99]

Debate on the subject continued throughout 1968 and 1969 with numerous divisions of responsibility proposed, though eventually British Petroleum concluded that NIOC was capable of handling the wells through contracted operators.[100] It was thus uncertainty itself that gave NIOC and its representatives room to maneuver, allowing them to push back against the significant informational advantage that British Petroleum commanded.

In the end six new Jurassic wells were drilled to meet Shahpur's gas demand, of which one was lost to blowout and fire.[101] Despite such setbacks, operations commenced at the Shahpur Petrochemical Complex in the summer of 1970. By 1974 it had come under full Iranian control after Allied Chemical, beset by problems in its home markets, sold its stake to Iran's National Petrochemical Company.[102] In those four years the plant had become a success, taking some 177 million cubic feet of sour gas per day to make nearly 500,000 tons of fertilizer, 251,000 tons of sulfur, 10,000 tons of sulfuric acid, and 41,000 tons of phosphoric acid each year.[103] On the other hand, Iranian hopes that Shahpur would serve as the centerpiece of a regional fertilizer network were never realized, and it was instead fully turned toward domestic markets.[104] Today the complex—expanded in the late 1970s, rebuilt and modernized following the 1980–88 Iran-Iraq War, and privatized as the Razi Petrochemical Company in 2008—remains the largest source of chemical fertilizers, sulfur, sulfuric acid, and related products in Iran.[105] More broadly, Shahpur paved the way for a thriving petrochemical export sector. By 2011, supported by special economic zones and steady government investments, Iran was selling 18.193 billion tons of petrochemicals worth $14.662 billion per year in South and East Asia, second only to Saudi Arabia in the Middle East, and leading a steady rise in Iran's non-oil exports.[106]

Conclusion

As Iran's use of natural gas accelerated in the 1970s, the composition of its reserves continued to be a critical factor for industry operations.[107] In this sense, "natural gas" as a singular substance did not exist in either Masjid-e Sulayman or anywhere else in southwest Iran. Petroleum was thus never simply lifted to the earth's surface from underground bathtubs full of fuel. Instead it consisted of varied mixtures of combustible hydrocarbons and corrosive impurities, held under immense pressures in geologically complex circumstances, and subject to change. More than a quirk of the earth, that fickleness ensured that the control exercised by people—British or Iranian—over petroleum resources would remain forever precarious. The rupture of MIS-306 and the subsequent migration of gas brought that precarity to the fore, in the process refiguring the place of natural gas projects in both Iranian development schemes and in the political calculus of British Petroleum.

The movement of high-H_2S natural gas within the Masjid-e Sulayman reservoir was concerning for officials within British Petroleum because of uncertainties surrounding the field's underground geography. While they wished to assume as little responsibility as possible for the Shahpur complex, the events of the previous four years had shown that the Jurassic wells could not be considered in isolation.[108] Jurassic gas potentially threatened oil operations across the whole field, and as early as 1966 changes were already being detected. As was reported in 1967,

> repressuring has definitely been detrimental in that it has increased the H_2S content of reservoir crude which, in turn, has created additional corrosion problems. Apparently, contaminated oil is draining down the flanks from the high H_2S invaded area of the dome because abnormal H_2S content has been observed only in crude produced from wells adjoining that area. . . . [Further,] this crude is handled by all major producing facilities at M.I.S. so the corrosion problem is becoming quite severe.[109]

The rupture in MIS-306 thus not only uncovered a new source of feedstock for the Shahpur plant, it also put British Petroleum's existing oil operations in a precarious position. It is striking that such uncertainty persisted in a place like Masjid-e Sulayman, a field that had been in continual production since 1908 and had been subject to considerable exploration and mapping by geologists.[110] Uncertainty and precarity were thus not conditions that could be eliminated via the accumulation and management of information. In the 1960s, British Petroleum still had the upper hand vis-à-vis the Iranian government, a situation resting not only on the terms of their concession but also on the company's carefully constructed frameworks for managing petroleum information. But that power was constrained by the natural world's unpredictability, and it was within precarious spaces propped open by uncertainty that Iranian officials were able to push British Petroleum to support their ambitions.

Under the pressures of our present climate crisis, scholars have increasingly turned toward concepts like the Anthropocene and its cousins the Capitalocene and the Plantationocene to explain, for lack of a better phrase, "how we got here." Anna L. Tsing has rightly pointed to the continued human-centeredness of such perspectives, championing instead a sense of interconnectedness and playful exploration to understand the sprawling webs and networks that make our world.[111]

Pahlavi Iran was no exception, where shifting subterranean geographies and petroleum's heterogeneity were crucial factors in making developmental initiatives like the Shahpur petrochemical complex possible. Following the trajectory of gas and its impurities uncovers how uncertainty, precarity, and perceptions thereof drove such outcomes, in the process showing how new social arrangement are sometimes made with uncontrollability, not despite it.

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Notes

1. Bowker, *Science on the Run*.

2. Shafiee, *Machineries of Oil*.

3. Seow, *Carbon Technocracy*.

4. See also Barak, *Powering Empire*.

5. Nassehi, "Domesticating Cold War Economic Ideas"; Najmabadi, *Land Reform and Social Change in Iran*.

6. Abrahamian, *Iran*; Ansari, "The Myth of the White Revolution"; Bostock and Jones, *Planning and Power in Iran*; Mofid, *Development Planning in Iran*; Razavi and Vakil, *Political Environment*; Summitt, "For a White Revolution."

7. Shafiee, *Machineries of Oil*, 6–7.

8. Bennett, "The Agency of Assemblages"; Latour, *We Have Never Been Modern*.

9. Schayegh, "Iran's Karaj Dam Affair," 626.

10. Schayegh, "'Seeing Like a State'"; Brew, *Petroleum and Progress in Iran*.

11. Mahdavy, "Patterns and Problems of Economic Development"; Ross, *The Oil Curse*. See Ross for a detailed synthesis of the enormous volume of literature produced on these topics.

12. Abrahamian, *Oil Crisis in Iran*; Dietrich, *Oil Revolution*; Garavini, *Rise and Fall of OPEC*; Mahdavi, *Power Grab*.

13. Mitchell, *Carbon Democracy*. Also, for the case of Iran, see Jafari, "Linkages of Oil and Politics."

14. Jones, *Desert Kingdom*; Vitalis, *America's Kingdom*; Limbert, *In the Time of Oil*; Ehsani, "Social Engineering"; Bet-Shlimon, *City of Black Gold*; Huber, *Lifeblood*. See also Wilson, Carlson, and Szeman, *Petrocultures*.

15. Malm, *Fossil Capital*; Moore, *Capitalism in the Web of Life*; Ortiz, "Oil-Fueled Accumulation in Late Capitalism"; Wainwright and Mann, *Climate Leviathan*.

16. A full accounting of these efforts is beyond the scope of this article. For more, see Forbes and O'Beirne, *Technical Development*.

17. Khalili, "A World Built on Sand and Oil."

18. Hanieh, "Petrochemical Empire," 27.

19. Geiser, *Materials Matter*.

20. For more on hybrid environments, see Walker, *Toxic Archipelago*.

21. Tsing, *The Mushroom at the End of the World*, 20.

22. Moore, *Capitalism in the Web of Life*; Haraway et al., "Anthropologists Are Talking."

23. Scott, *Seeing Like a State*.

24. Malm, *The Progress of This Storm*.

25. Aide memoire, "Third Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MIS Jurassic Gas Well, Iran (1964–1969)* (51493), BP Archive, University of Warwick (hereafter *MJGW*).

26. Old, "Analysis of Reservoir Performance"; Old, Saidi, and Zarghamee, "Analysis of Statistical Methods"; Graham et al., "Effect of Production Restriction."

27. Mitchell, *Carbon Democracy*, 59; Shafiee, *Machineries of Oil*, 57–62; Yergin, *The Prize*, 36–37, 282, 510–11. Barak has briefly noted the quality of coal in his analysis; see Barak, *Powering Empire*, 106–7, 126–27, 153. Hydrogen sulfide has been noted as an oil field hazard; see Santiago, *The Ecology of Oil*, 183–99.

28. Nehb and Vydra, "Sulfur."

29. Ferrier, *The History of the British Petroleum Company*, 117, 133, 152–53.

30. Ferrier, *The History of the British Petroleum Company*, 150–58, 162–63.

31. Yergin, *The Prize*, 134–48; Ferrier, *The History of the British Petroleum Company*, 160–65.

32. Ferrier, *The History of the British Petroleum Company*, 149, 152, 162, 199, 285–94, 452–54.

33. Aftalion, *A History of the International Chemical Industry*, 210–11.

34. Bamberg, *The History of the British Petroleum Company*, 192–94.

35. Bamberg, *The History of the British Petroleum Company*, 202–5, 292–95.

36. Mostashari, "Masjid-i-Sulaiman Sulphur Plant," May 6, 1951, reverse, *Masjid-i-Sulaiman Sulphur Plant* (185193), BP Archive, University of Warwick.

37. See, e.g., H. W. Lane to C. J. Wright, "Sulphur Production M-i-S," 11127, March 13, 1943; J. M. Pattinson, "Sulphur Production at M.I.S.," 11153, March 31, 1947; C. E. Spears to B. J. Ellis, "Catalytic Cracker—Abadan," April 2, 1947; C. J. Wright, "Sulphur Production at M.I.S.," 7224, March 25, 1947; W. H. Bowling (?), "Supplies of H_2S from the Sulphur Recovery Plants, M.I.S.," 14049, January 13, 1950; and P. Dockery to H. W. Lane, "Automatic Gas Dehydration Units," September 9, 1948, *Production 15th January 1946 to 15 September 1948* (58787), BP Archive, University of Warwick.

38. Aide memoire, "Third Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MJGW*.

39. M. Eghbal to J. A. Warder, 29/5–54879, March 6, 1967, 1, *MJGW*.

40. Aftalion, *A History of the International Chemical Industry*, 214–42, 262–63, 275–76. That history has been largely told from American and European perspectives. See Blaszczyk, "Synthetics for the Shah," 670–723; Spitz, *Petrochemicals*; Aftalion, *A History of the International Chemical Industry*; Galambos, Hikino, and Zamagni, *The Global Chemical Industry*; and Arora, Landau, and Rosenberg, *Chemicals and Long-Term Economic Growth*.

41. Pahlavi, *Mission for My Country*, 288.

42. Blaszczyk, "Synthetics for the Shah," 671–72.

43. For more, see chapter 12 of Spitz, *Petrochemicals*.

44. Galambos, Hikino, and Zamagni, *The Global Chemical Industry*, 3–8.

45. Spitz, *Petrochemicals*, 486–88.

46. Morrison-Knudsen, *Report on the Program for the Development of Iran*, 247–52; R. P. Liddard, "A Review of Iran's Expanding Gas Industry," August 1975, 8–19, *A Review of Iran's Expanding Gas Industry* (31971), BP Archive, University of Warwick (hereafter *RIEGI*).

47. See, for example, "Research Advisory Committee, Minutes of Meeting Held on Friday, December 2nd, 1938 at Britannic House," December 6, 1938, 2, *Utilisation of Natural Gas* (44113), BP Archive, University of Warwick.

48. "Notes on Messrs. Morrison Knudsen's Report to the Persian Government on 'Provision of Fuel—Natural Gas,'' attached J. M. Pattinson to L. C. Rice, September 23, 1947 (44105), *Iran: Pipelines: b) Khuzistan/Teheran*, BP Archive, University of Warwick.

49. International Bank of Reconstruction and Development, "The Economic Development of Iran," vol. II (part I), Sectoral Analyses (parts I and II), October 1974, 130.

50. Cullather, *The Hungry World*.

51. Morrison-Knudsen, *Report on the Program for the Development of Iran*, 22–31.

52. Hooglund, *Land and Revolution in Iran*, 10–35; Najmabadi, *Land Reform and Social Change in Iran*, 45–47.

53. Ansari, "The Myth of the White Revolution."

54. Hooglund, *Land and Revolution in Iran*, 49–68.

55. Abrahamian, *Iran*, 428–29; Najmabadi, *Land Reform and Social Change in Iran*, 140–41.

56. Morrison-Knudsen, *Report on the Program for the Development of Iran*, 140.

57. National Iranian Oil Company, "Karkhaneh-ye Kudshimiai-ye Shiraz," 12.

58. OSCI, "Estimated Wet Gas Availability and Utilization, 1974–1978," March 1974, 31–32, *Estimated Wet Gas Availability and Utilization, 1974–1978* (60103), BP Archive, University of Warwick.

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60. Iranian Delegation, "Discussion Paper," 430–31.

61. Mofid, *Development Planning in Iran*, 58.

62. Aftalion, *A History of the International Chemical Industry*, 254.

63. National Iranian Oil Company, "Behrebardari as Gaz-e Masjid-e Sulayman dar Mojtama'-ye Shimiai-ye Shahpur," 6. For more on the Shahpur complex, see Ardekani, *Tarikh-e moassesat-e tamaddoni-ye jadid dar Iran*, 307–13.

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65. G. W. Spencer to W. J. George, "Member Company Technical Assistance High Pressure, High Hydrogen Sulphide Gas Wells," August 14, 1967, 1, *MJGW.*

66. Alsharhan and Nairn, *Sedimentary Basins*, 508.

67. D. G. Smith, "Carbon Black," no document number, February 16, 1944, 1, *UNG*.

68. "Sulphur Available from Fields Gas," March 28, 1944, *UNG*.

69. "Analysis of 16 Samples of Rock of Permian and Triassic Age from Bakhtiariland," AP.S/53, May 19, 1938; Report from Fields Chemical Laboratory, "Multistage Stabilization of Pazanun Condensate," 5563, October 31, 1944, 1–3, *UNG*.

70. This has been confirmed by later findings. See Alsharhan and Nairn, *Sedimentary Basins*, 730.

71. "Sulphur Available from Fields Gas," March 28, 1944, *UNG*.

72. Shafiee, *Machineries of Oil*, 67–74.

73. See, e.g., Memorandum Comins to Pattinson, "Iran Gas Utilisation—Hydrocol Pressure Investigation," 485, January 21, 1948, *UNG*.

74. Shafiee, *Machineries of Oil*, 7–10.

75. Though not conclusively shown, "[all] the available geochemical data point to the Kazhdumi Formation as the source rock for the accumulations found in the main fields"; Alsharhan and Nairn, *Sedimentary Basins*, 718–26.

76. Baniriah, Beckman, and Birks, "Repressuring of the Masjid-i-Sulaiman Oilfield," 717–23, 765–66.

77. Baniriah, Beckman, and Birks, 765. For the Jurassic fault as the source of gas, see aide memoire, "Second Joint Meeting on the Repressuring Program and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 3, *MJGW*.

78. Baniriah, Beckman, and Birks, "Repressuring of the Masjid-i-Sulaiman Oilfield," 766.

79. Baniriah, Beckman, and Birks, "Repressuring of the Masjid-i-Sulaiman Oilfield," 769–70; W. P. Sibley, "Repressuring of M. I. S. Reservoirs Progress Report No. 9," attached 4176, May 7, 1986, 5, *MJGW*.

80. Aide memoire, "Third Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MJGW*.

81. Baniriah, Beckman, and Birks, "Repressuring of the Masjid-i-Sulaiman Oilfield," 766.

82. Aide memoire, "Third Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MJGW*.

83. J. Addison, "M. I. S. Repressuring," 4046, December 19, 1967; J. Addison, "M-I-S Repressuring," 3954, 1, August 15, 1967, *MJGW*.

84. C. A. R. O'Brien for J. A. Warder to Dr. M. Eghbal, 1–2, *MJGW*.

85. G. W. Spencer to W. J. George, "Member Company Technical Assistance High Pressure, High Hydrogen Sulphide Gas Wells," August 14, 1967, 1, *MJGW*.

86. M. Eghbal to J. A. Warder, 29/5–54879, March 6, 1967, 1, *MJGW*.

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88. See C. A. R. O'Brien for J. A. Warder to Dr. M. Eghbal, 1, *MJGW*, for British Petroleum's rejection of equipment loans; for the company's defense of their actions, see aide memoire, "Third Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 3, *MJGW*.

89. Baniriah, Beckman, and Birks, "Repressuring of the Masjid-i-Sulaiman Oilfield," 770.

90. Aide memoire, "Third Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MJGW*.

91. Aide memoire, "Third Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MJGW*.

92. D. S. Pitkeathly to W. J. George, "Notes on Discussion Held with Senior Representatives of IROS & IROP on Mr. D. S. Pitkeathly's Visit to M. I. S.," September 26, 1967, *MJGW*.

93. Aide memoire, "Fourth Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 12, 1967, 1; and W. P. Sibley, "Repressuring of M. I. S. Reservoirs Progress Report No. 9," attached 4176, May 7, 1968, 5, *MJGW*.

94. See M. Eghbal to J. A. Warder, 29/5–54879, March 6, 1967, 1; aide memoire, "Second Joint Meeting on the Repressuring Program and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 3, *MJGW*; Aide memoire, "Fourth Joint Meeting on the Repressuring Problem and Gas Utilisation in the Masjid-i-Sulaiman Field," August 12, 1967, 2; and G. W. Spencer to W. J. George, "Member Company Technical Assistance High Pressure, High Hydrogen Sulphide Gas Wells," August 14, 1967, 2, *MJGW*.

95. D. S. Pitkeathly to W. J. George, "Notes on Discussion Held with Senior Representatives of IROS & IROP on Mr. D. S. Pitkeathly's Visit to M. I. S.," September 26, 1967, *MJGW*.

96. Aide memoire, "Second Joint Meeting on the Repressuring Program and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MJGW*; "Control of Hydrogen Sulphide Gas Wells in M. I. S.," attached G. W. Spencer, September 6, 1967, 1; and W. J. George, "Iran M-i-s Jurassic Gas Wells," October 12, 1967, *MJGW*.

97. C. A. R. O'Brien for J. A. Warder to Dr. M. Eghbal, 1–2; aide memoire, "Second Joint Meeting on the Repressuring Program and Gas Utilisation in the Masjid-i-Sulaiman Field," August 5, 1967, 2, *MJGW*.

98. J. Addison, "M. I. S. Jurassic Gas Wells for NIOC," 4291, September 9, 1968, 1, *MJGW*.

99. J. Addison, "M. I. S. Jurassic Gas Wells," 463, July 16, 1968, 1, *MJGW*.

100. J. Addison, "M. I. S. Jurassic Gas for N. I. O. C.," 925, December 19, 1969, 1, *MJGW*.

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102. Ardekani, *Tarikh-e moassesat-e tamaddoni-ye jadid dar Iran*, 309; Carey, "Iran and Control of Its Oil Resources," 171.

103. See R. P. Liddiard, "A Review of Iran's Expanding Gas Industry," August 1975, 15–16, *RIEGI*.

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108. J. Addison, "M. I. S. Jurassic Gas Wells for NIOC," 4291, 1, *MJGW*.

109. Baniriah, Beckman, and Birks, "Repressuring of the Masjid-i-Sulaiman Oilfield," 771.

110. Shafiee, *Machineries of Oil*, 57–85.

111. See Tsing, *The Mushroom at the End of the World*.

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