Chapter 4.
A Double Task, 1943–1945

While we move toward complete defeat of our enemies, we must lay the groundwork to return the Nation to peaceful pursuits. This double task is the essence of the Government's program.[1]

—Franklin D. Roosevelt

President Roosevelt, in his State of the Union Message to Congress on January 11, 1944, formally acknowledged what had been apparent to some Americans for several months: the need for postwar planning. The Commander in Chief marked the beginning of a new interval in what he called "the world's greatest war against human slavery."[2] Although ultimate victory seemed to be far in the future, planning for the postwar period, Roosevelt indicated, should not be delayed. The war, he vowed, "shall not be followed by another interim which leads to new disaster," caused by "the tragic errors of ostrich isolationism." The United States, he pledged, "shall not repeat the excesses of the wild twenties when this Nation went for a joy ride on a roller coaster which ended in a tragic crash."[3] Roosevelt sought "to concentrate all our energies and resources on winning the war, and to maintain a fair and stable economy at home."[4] As part of a renewed and enhanced New Deal, he asked Congress to pass a "realistic tax law," continue the statute that recognized war contracts to "prevent exorbitant profits and assure fair prices to the Government," enact bills for "cost of food" and "national service," and extend the price "stabilization statute of October 1942."[5] "[T]rue individual freedom," he continued, "cannot exist without economic security and independence." The new legislation, essentially a second Bill of Rights, would guarantee "security and prosperity * * * regardless of station, race, or creed," sufficient-salaried jobs, a decent living for farmers, businesses free from unfair competition, decent homes, adequate medical care, "adequate protection from the economic fears of old age, sickness, accident, and unemployment,"[6] and good education.

As Roosevelt spoke, British and American aircraft continued round the clock their combined offensives against the Luftwaffe, the German aircraft and related war industries, and their supporting civilian infrastructure. On August 1, 1943, nearly 180 Consolidated B–24 Liberator bombers of the 8th and 9th Air Forces had attacked the vital Romanian oil fields and refineries at Ploesti, doing some damage but also suffering heavy losses. The Royal Air Force's (RAF's) major strike on Peenemünde during mid-August destroyed most of the German test facilities for the two vengeance weapons being developed there—the Luftwaffe's pulse-jet cruise missile (V–1) and the Army Ordnance's rocket-powered ballistic missile (V–2). The Germans moved the equipment, specialists, and slave labor to underground sites at Nordhausen in the Harz Mountains and elsewhere in Germany, where work resumed on the V–2 within 6 months. In October 1943, the RAF began attacking the ramp sites along the English Channel coast built to launch the V–1s against Britain. U.S. Army Air Forces' (USAAF's) B–17s bombed the ball-bearing works at Schweinfurt and the Messerschmitt fighter factory at Regensburg, delaying for 5 months work on the new Me-262 Swallow, a swept-wing, turbojet fighter, but American losses on the two missions neared 20 percent. When the new P–51 Mustang and other long-range fighters began escort operations early in December,

Allied deep-penetration attacks continued with repeated 600- to 1,000-bomber raids, at night by the RAF and during the day by the 8th Air Force, now led by Lt. General Doolittle. Coevally, Soviet armies on the Eastern Front pressed their winter offensive to regain territory in the Ukraine.

As the Allies resumed their strategic-bombing campaign in December 1943, Roosevelt decided that General Marshall must remain in Washington as Army Chief of Staff. Roosevelt and Churchill agreed to appoint General Eisenhower as Supreme Commander of the Allied Expeditionary Forces. Eisenhower took command and oversaw continued planning for Operation Overlord, the cross-Channel invasion of northwest Europe, and the subsequent campaign to defeat the German armed forces. Also that month, Hitler entrusted Army Group B's defense of the French coast between the Brittany Peninsula and The Netherlands to Field Marshall Rommel, now restored to health. Rommel moved quickly to energize and improve the defenses of the new "West Wall." The Wehrmacht's best chance for victory depended on quickly driving the Allied forces back into the sea, but Hitler refused Rommel's request to shift armored divisions forward from a central reserve far inland to locations close to the potential invasion beaches.

In the Pacific, Allied forces advanced along New Guinea's northern coast, forged northwest up the Solomons, and began new attacks to the north, aided by new capital ships and smaller vessels of America's two-ocean navy. In the Central Pacific, Vice Admiral Spruance now led the U.S. 5th Fleet, whose aircraft struck Marcus (Minami-tori-shima), the Gilbert and Marshall Islands, Wake, and the Japanese major air-naval base at Truk in the Carolines (now Chuuk in the Federated States of Micronesia) during August and October 1943. In November, as U.S. land-based and naval aircraft attacked Rabaul, to cover the marines' landing on Bougainville, 7th Air Force B–24s, flying some 750 air miles from a base on Funafuti Atoll in the British Ellice Islands (now in Tuvalu), continued bombing targets in the Gilberts as a prelude to invasion. Charts from a triangulation survey of Tarawa in 1841, by Navy Lt. Charles Wilkes' U.S. Exploring Expedition, aided the invasion's planners.

On November 20, 1943, after days of air and naval bombardments, marines and soldiers of the V Amphibious Corps assaulted two coral and sand atolls in the Gilberts—Makin (Butaritari) Island, the seaplane base, and Tarawa Atoll's Betio Island, the headquarters and principal airstrip in the Gilberts, about 110 miles to the south. On 300-acre Betio, the 2d Marine Division (reinforced) encountered a very low tide[7] and skilled and tenacious Japanese forces. After 3 days of savage fighting, the marines secured Betio on November 23, but their 3,200 casualties (including nearly 1,000 dead) and dramatic photographs of the carnage showed Americans at home the cost of defeating a brave and fanatical enemy. More than 1,000 sailors also were killed or wounded on or off Makin and Tarawa. Seventh Air Force bombers, flying from the Gilberts, pounded Japanese airfields in the Marshall Islands, some 1,000 miles to the northwest.

In the Southwest Pacific, General MacArthur continued to plan the next steps in capturing New Guinea's entire northern coast as a prelude to returning to the Philippines. In July 1943, General Marshall ordered MacArthur to isolate the Japanese base at Rabaul. MacArthur's forces landed in December on the southwest and northwest coasts of New Britain. MacArthur also planned to invade New Ireland and Manus in the Admiralties to forge the remaining links in the Allied ring around Rabaul.

As the Allies advanced on all fronts, America's search for and production of mineral resources, a matter for concern in winning the war, now also became significant in planning for the peace. The value of mineral production in the United States, despite severe restraints on civilian, and in some instances military, consumption of most minerals, reached new highs during 1942–44. Domestic industry

could not meet all the war needs for some minerals, but after the Board of Economic Warfare arranged large-scale imports, the War Production Board reduced its stockpile objectives in February 1944. Deflation of the metal markets, forced curtailment of production, and widespread unemployment followed World War I. To avoid a repetition, Senator James Scrugham, acting for himself and the Special Committee to Study and Survey Problems of Small Business Enterprises, introduced a defense-stockpiling bill on June 3, 1943. Scrugham's bill, revised after public hearings and cosponsored by Carl Hayden and three other Senators, reemerged on December 8. Although substantial support existed for creating mineral stockpiles for national defense, freezing stocks at war's end to provide a nucleus for permanent stockpiles, and preventing undue dislocation of postwar markets, the 78th Congress took no action on Scrugham's bill or similar legislation during the first half of 1944. In March, the Army and Navy Munitions Board adopted a new definition of strategic and critical minerals, without differentiating between the two groups, and then divided them into three categories according to the practicability of stockpiling them. That fall, as the Allies' strategic situation improved and maritime shipping became less hazardous, Congress passed emergency legislation regulating the disposal of public property, including federally owned strategic minerals and metals, pending the enactment of permanent stockpiling measures.

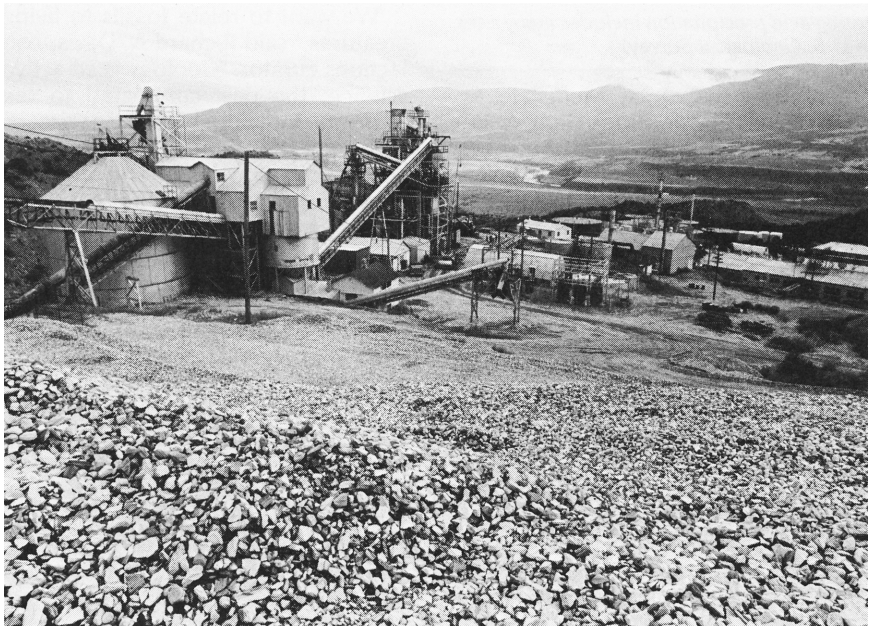
Petroleum and petroleum products posed different problems than those presented by metals. While domestic petroleum output made up an ever-increasing share of the value of total mineral and energy production in the United States, it provided a decreasing portion of America's total consumption. While Everette DeGolyer, "John" Morrell, Stribling Snodgrass, and William Wrather assessed Middle East production and reserves, Harold Ickes, still wearing his four hats as Secretary of the Interior, Petroleum Administrator for War, president of the Petroleum Reserves Corporation (PRCo), and Solid Fuels Administrator for War, publicly pleaded for increased American petroleum supplies. In the *American Magazine* for January 1944, Ickes warned of the dangers of and offered solutions to petroleum depletion. Supplies of and accessibility to oil, Ickes claimed, would be principal postwar problems. America now supplied 95 percent of Allied aviation gasoline, but U.S. proven oil reserves of 20 billion barrels in 1942 would last only 14 years, based on the rate of production in 1939, and the Nation could not service "a World War III." He urged oil stockpiling, new domestic discoveries, wiser use of domestic reserves, increased secondary recovery, developing fuels from coal, natural gas, oil shale, and tar sands, and securing greater peaceful and legal access to foreign oil resources. "The capital of the oil empire is on the move to the Middle East,"[8] and "we must be prepared to go where the gasoline is to be had." In 1942, Persian Gulf sources held an estimated 14.5 billion barrels of proven and probably recoverable reserves expected to last 161 years at 1939 rates, but reserves were predicted to increase significantly during the projected postwar development. The Soviet Union held 8.5 billion barrels of recoverable reserves; Europe, 743 million barrels; the Mediterranean (including Iraq), 6 billion barrels; and the Far East (including Burma), 1.6 billion barrels. The Eastern Hemisphere's reserves totaled 23 billion barrels, a number Ickes believed conservative, just 7 billion barrels less than the Western Hemisphere's reserves. Ickes awaited DeGolyer's revised estimates of Persian Gulf reserves as one source to meet the Nation's future petroleum requirements. Ickes recommended that the United States buy and store petroleum, "underground where possible and aboveground where necessary," to "build up and maintain reserves that will last 20 years, regardless of what the demands may be."[9]

On January 22, 1944, DeGolyer's Technical Oil Mission to the Middle East, where Caltex geologists Max Steineke and Richard Bramkamp guided its work, returned to the United States. DeGolyer's team reported by letter dated February 1 to the president (Ickes) and directors of the PRCo. The American Association of Petroleum Geologists received a copy of DeGolyer's letter on March 31 and

published it in its *Bulletin* for July. There, they repeated Ickes' claim. "The center of gravity of world oil production is shifting," they asserted, "from the Gulf-Caribbean area to the Middle East—to the Persian Gulf area—and is likely to continue to shift until it is firmly established in that area." Four companies or groups of companies, mostly British, owned all of the region's "important oil fields and practically all important prospective oil territories," and they controlled production. Anglo-Iranian's fields in Iran yielded 325,000 barrels daily, but each day the company returned another 50,000 barrels of residue to the ground. Iraq Petroleum's fields produced 90,000 barrels per day and were shared equally by Anglo-Iranian, Royal Dutch-Shell, Near East Development—Standard of New Jersey (later Chevron) and Socony-Vacuum (later Mobil and now Exxon-Mobil)—and a French consortium. Iraq Petroleum also controlled fields in Qatar, shut in since the Italian air raid in 1940, and "important concessions in Syria, Palestine, and the Trucial Coast" (Trucial States, now the United Arab Emirates). Caltex, renamed Arabian-American Oil Company (Aramco) in September 1944, and Bahrain Petroleum Company (both run by Socal and Texaco) continued to produce 35,000 barrels a day from the fields in Saudi Arabia and Bahrain. They also held "a substantial concession" in Saudi Arabia. Kuwait Oil, owned by Anglo-Iranian and Gulf, controlled the single field in Kuwait, also still shut in, and "a concession covering the entire Sheikdom."[10]

In assessing refineries and reserves, DeGolyer's team noted that the Bahrain refinery processed the short-haul Saudi crude but petroleum from Iraq's Kirkuk field went to the Mediterranean "by a pipeline system with terminals at Haifa, Palestine [now in Israel] and Tripoli [Trablous], Syria [now in Lebanon]." The foursome estimated that the daily capacity of the region's three refineries—at Abadan (in Iran), in Bahrain, and at Haifa—"when extended will become 500,000 barrels per day." The United States owned, through a Canadian firm, only 11.5 percent of the region's total refined output, which equaled 11 percent of U.S. capacity. DeGolyer and his colleagues estimated the Persian Gulf's proved reserves, those developed or "discovered but not yet fully explored,"[11] at 25 to 27 billion barrels. Of this total, 9 billion barrels were in Kuwait, 6 to 7 billion in Iran, 5 billion in Iraq, 4 to 5 billion in Saudi Arabia, and 1 billion in Qatar. The region's proved and indicated reserves compared well with those of the United States, but all Middle Eastern reserves had been discovered by fewer than 150 wildcat wells. By contrast, "more than twenty times this number" were drilled each year in the United States. "For the next ten to fifteen years at least, the Middle East area is likely to develop and maintain productive capacity of as much as four times its probable market outlet."[12]

The Roosevelt administration proposed tapping the known oil resources and developing others in the Middle East by acquiring a complete, or at least a controlling, Federal interest in them and constructing a pipeline from Saudi Arabia and Kuwait to the Mediterranean. This offer and its views of international trade in petroleum caused grave concern in the U.S. Senate and in America's petroleum industry. To encourage production from hitherto little-used domestic sources, Congress passed and the President signed on April 5, 1944, the Synthetic Liquid Fuels Demonstration Plants Act to aid the war effort and conserve and increase the Nation's oil resources. The new law authorized "the construction and operation of demonstration plants to produce synthetic liquid fuels from coal, oil shales, agricultural and forestry products, and other substances." These plants would "be of the minimum size which will allow the Government to furnish industry the necessary cost and engineering data for the development of a synthetic liquid-fuel industry." To allay the petroleum industry's fears, the statute also required "that the combined product of all the plants constructed in accordance with this Act will not constitute a commercially significant amount of the total national commercial sale and distribution of petroleum and petroleum products."[13] The law enabled the Secretary of

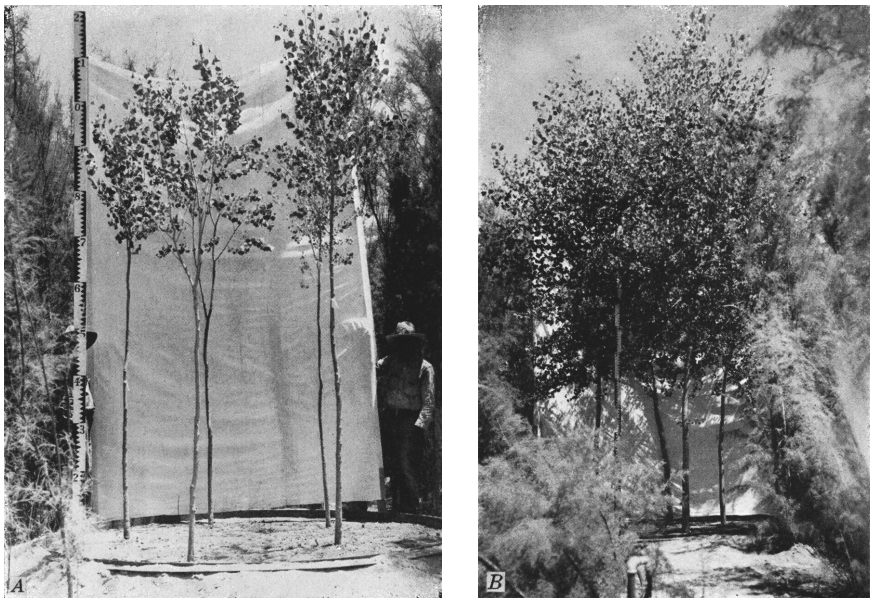


The U.S. Bureau of Mines (USBM) established in 1944 this retort-research facility on Naval Oil Shale Reserve No. 3 at Anvil Points, about a mile west of Rifle, Colorado. Under authority of the Synthetic Liquid Fuels Demonstration Plants Act, the USBM operated the facility until 1956. Development Engineering, Inc., leased the facility from the Interior Department in 1962. When the Department of Energy could not arrange for a subsequent lease in 1982, the company contracted with Mountain Region Construction Corporation at Grand Junction to remove all structures, dispose of dangerous materials, and reclaim the site. (Photograph by R.R. Peabody, U.S. Department of Energy; published in *Geotimes*, v. 30, 1985, p. 20.)

the Interior to acquire the patent rights and properties necessary to ensure the project's success and authorized up to $30 million to fund the work. On June 28, 1944, a second measure actually gave the U.S. Bureau of Mines $5 million during fiscal year 1944–45 for constructing, maintaining, and staffing the demonstration plants.[14] Later in 1944, the USBM established an experimental facility for oil-shale retorting at Anvil Points on Naval Oil Shale Reserve (NOSR) No. 3 near Rifle, Colorado.

Water supplies also received increasing interest during the first 6 months of 1944. On February 3, Mexico and the United States signed a treaty to divide the water of three international rivers—the Colorado, the Tijuana, and that portion of the Rio Grande (Río Bravo) along its length between Fort Quitman, Texas, and the Gulf of Mexico—"to obtain the most complete and satisfactory use thereof."[15] The United States proposed the agreement following increased use of Colorado River water for irrigation in Mexico just south of that country's border with California. The Mexican Government was no less concerned about the division of Rio Grande water due to the rapid expansion of irrigation on the U.S. side of the lower Rio Grande Valley. Although the U.S. Senate retained responsibility for consenting to ratification, the House of Representatives promptly passed a resolution directing its Judiciary Committee to examine the treaty.

Flood control again became a matter of some urgency after floods along the Missouri River during the spring of 1944 broke all previous records. After the spring floods in 1943, the House Committee on Flood Control requested a review to determine flood-control and irrigation needs on the Missouri. Colonel Lewis A. Pick, of the Army Engineers' division at Omaha, Nebraska, had prepared a response plan before leaving for India's Assam Province in 1942 to supervise (as a Brigadier General) construction of the Ledo Road begun that December to facilitate future Allied operations aimed at recapturing northern Burma. The Army Engineers approved Pick's scheme for the Missouri River Basin—528,000 square miles in 9 States—by the end of August 1943. The Bureau of the Budget (BoB) and an Inter-Agency River Basin Commission, established on December 29 and composed of representatives of the Army Engineers, the U.S. Bureau of Reclamation (USBR), the Department of Agriculture, and the Federal Power Commission, reviewed Pick's plan by February 1944. The USBR expressed reservations about the plan because W. Glenn Sloan, that agency's Assistant Regional Director at Billings,



These cottonwoods were grown during 1943–44 at the USGS Glenbar experimental station to assess the amount of groundwater lost in the American West to deep-rooted and rapidly developing phreatophytic trees and other plants. The cottonwoods, placed in tanks up to 10 feet in diameter, used 6 acre-feet of water in doubling their foliage height and width in less than 3 months. For comparison, the USGS also grew mesquite and salt cedars under the same controlled conditions at the Glenbar station, located near the Gila River and about 12 miles northwest of Safford, Arizona. (Photographs by the Phelps Dodge Corporation [at left] and Thomas W. Robinson [at right] from Gatewood and others, 1950, fig. 32*A*, *B*.)

Montana, was preparing a flood-control plan for the river. Sloan's proposal for controlling floods along the Missouri went to Congress early in May 1944, but, on May 9, the House passed a flood-control bill without considering Sloan's alternative plan.

A week earlier, Secretary Ickes established a Departmental Water Resources Committee[16] to coordinate the efforts of all of Interior's units to maintain liaison with other Federal organizations engaged in developing water resources. He expected the new Committee to consider all projects proposed by Interior's agencies and to forward those it approved for review by the Inter-Agency River Basin Commission. Ickes named forester Lee Muck, his assistant in charge of land utilization, to chair the new Committee; hydrologist Glenn Hoyt transferred from the USGS to serve as vice-chairman and executive officer. On July 20, Interior set procedures governing future cooperation in river-basin surveys and investigations between its units and the Army Engineers. The new requirements for approval by the Committee and the Secretary did "not extend to established procedures of the Geological Survey." Interior expected the USGS "to continue with regard to the installation, operation, and maintenance of gaging stations and the collection of ground-water data, or other information, provided that requests for the transfer of funds in connection with the rendering of such service shall be submitted to the Office of the Secretary for consideration and approval."[17]

The USGS, like many Federal agencies between fall 1943 and fall 1945, also pursued the double task of helping to win the war while planning for the future peace. The Federal budget for the fiscal year beginning on July 1, 1944, presented to Congress in January, called for a total expenditure of $100 billion, of which $90 billion would support the war effort. The estimate for Interior for fiscal 1944–45 totaled only $87.9 million, a reduction of $18.6 million, or more than 17 percent, below the sum for fiscal 1943–44. The budget for the USGS, still classified as a war agency, was just under $6,753,000 for salaries and expenses, representing an increase of more than $1.6 million, or nearly one-third more than the funds provided on July 12, 1943. For most items, the USGS requested only small increases to cover the costs of overtime and automatic in-grade raises in salaries. For topographic surveys, the agency asked for $1.25 million, or nearly twice the appropriation for the fiscal year then underway. Because fears of invasion had ended, the War Department decided not to transfer to the USGS any funds for mapping in the

United States; instead, the War Department would shift to the agency $1,060,000 for preparing maps for the actual theaters of war. The USGS, therefore, requested $342,500 to complete the strategic mapping begun under War Department auspices and an additional $102,000 to expedite mapping for the agency's strategic-minerals investigations.

The House subcommittee began hearings on the Interior Department's appropriations bill on February 28, 1944, more than 3 weeks after Secretary Ickes announced on February 6 the principles of the proposed agreement of January 24 among the Petroleum Reserves Corporation, Aramco, and Gulf. The new understanding provided for the construction, ownership, and maintenance by the PRCo of a trunk-pipeline system to transport crude petroleum from Saudi Arabia and Kuwait to the Mediterranean. The pipeline agreement clearly involved many problems—constitutional, economic, and military, as well as international—and both conservatives and liberals criticized it immediately, but Ickes' warning about insufficient petroleum for a future war had the most profound effect. Three days before Ickes spoke, Senators Ralph O. Brewster (R–ME, a member of the Truman committee) and Edward H. Moore (R–OK) noted that "adequate petroleum reserves are essential to our national security and economic welfare." Ickes, as Petroleum Administrator for War (PAW), "recently stated that the United States was not in a position 'to oil another war.'" The Senators proposed establishing a special committee, composed of members of the Foreign Relations, Interstate Commerce, and Public Lands Committees, "to make a full and complete study of petroleum resources and the production and consumption of petroleum and petroleum products, both within and outside the United States, in relation to our national welfare and security."[18]

When Director Wrather made his initial appearance, on March 6, 1944, before the House subcommittee responsible for reviewing the USGS budget, its members deluged him with questions about oil and oil reserves, Arabian oil, and the proposal for an Arabian pipeline, with which he disavowed any connection. Wrather's bout with amoebic dysentery,[19] beginning on Christmas day 1943, kept him in Aramco's headquarters at Dharhan after DeGolyer, Morrell, and Snodgrass left Saudi Arabia for London. Toward the end of January, Wrather accompanied two Aramco executives on a day's visit to Riyadh (Riyād) and an hour's audience with King Ibn Saud. They then traveled some 50 miles south to the Nejd's Kharj district, where Aramco aided agricultural development in the group of oases by installing pumps and building a canal to bring water 7 miles from limestone-pit sources. Wrather returned by air to Washington on February 5, a day before Ickes' announcement and 3 days after William Heroy (Sr.) became the Petroleum Administration for War's Director of Foreign Production. Wrather, still recovering from his illness, did not return to his USGS desk until well into February to end Thomas Nolan's 3-month tour as Acting Director and to reassume the responsibility for postwar planning. Wrather knew that

> **Survey operations had expanded greatly during the war. The organization had demonstrated its usefulness and its services were in demand in various fields of government activity. There was good reason to believe that it would expand further, if it fully occupied its authorized field.[20]**

Wrather decided that the USGS needed major organizational changes "to cope successfully with the greatly increased work load,"[21] but he postponed any modifications of the program branches until he knew more about USGS employees and their operations. He quickly discovered that "the Director's office was sadly understaffed."[22] With the approval of Secretary Ickes and the BoB, Wrather asked Representative Jed Johnson (Sr.), still the chairman of the subcommittee on Interior's appropriations, to authorize an Assistant Director for the USGS.

Johnson and his six-member subcommittee expressed their appreciation for Wrather's work as part of DeGolyer's mission and USGS efforts at home. Representative Michael Kirwan voiced his colleagues' apparent sentiment in observing

> **[w]hen I think of the amount of money being spent for the building of airplane factories and the billions upon billions spent for other purposes, I think that the few men which the Interior Department has sent to the mountains and the deserts, who have made all these discoveries and given to the country these additional resources—that money was certainly very well spent.[23]**

The subcommittee then made only minimal cuts of $7,500 for new appointments in the Office of the Director, $69,600 from topographic surveys ($42,500 from mapping strategic areas and about $27,100 from mapping strategic minerals), and $17,600 from publication expenses. The House accepted its subcommittee's recommendations. On April 7, the Representatives passed Interior's appropriations bill that provided for the USGS total funds of a little more than $6,258,000, or nearly 93 percent of the requested amount.

While the House evaluated the USGS appropriation for fiscal year 1944–45, the Senate Special Committee Investigating Petroleum Resources was duly authorized on March 13, 1944, and its members appointed on the next day by Vice President Wallace. The new committee, chaired by Senator Francis T. Maloney (D–CT), included 10 other Senators, 5 of them from the Foreign Relations, Interstate Commerce, and Public Lands Committees. The Maloney committee immediately began investigating Ickes' proposed Arabian pipeline. They seriously doubted that the framers of the act[24] of June 25, 1940, which authorized the Reconstruction Finance Corporation to create corporations to produce, acquire, and carry strategic and critical minerals, envisaged the establishment of a body such as the Petroleum Reserves Corporation with power to inaugurate a long-term program of oil procurement and pipeline construction and ownership either within or outside the United States. The law likely would be held as unconstitutional if it were interpreted as authorizing the establishment of a body empowered to make a contract calling for governmental action. Before the United States made any commitment along the lines of the pipeline proposal, the Maloney committee concluded, a long-range policy should be carefully developed and publicly considered. Early in April, the committee learned of a proposed agreement between the United States and Britain on international trade in petroleum; on May 24, it reminded Secretary of State Hull about the Senate's prerogative. On June 12, Roosevelt told Maloney that he asked Ickes not to enter into any contract relating to the Arabian pipeline without giving the Special Committee 30 days' advance notice.

On May 12, 1944, while the President considered the pipeline issue, the Senate appropriations subcommittee began hearings on the USGS budget for fiscal year 1944–45. By that time, the petroleum situation was so critical that the USGS submitted a supplemental item for $1,075,000 to explore for oil in Alaska. When Hayden's Senate subcommittee reviewed this request, Michael Straus spoke for Interior, William Heroy represented the PAW, and Wrather and Philip Smith testified for the USGS. Straus reported on the Navy-Army-Interior agreement reached earlier in 1944 to share exploration in Alaska. The Navy would continue work in Naval Petroleum Reserve No. 4 (NPR–4) in northwestern Alaska, the Army would look in the Wide Bay area of the Aleutian Range, and the USGS would examine, by naval-military request, other areas in the Territory. The USGS proposed to investigate five prospects: Yakataga and Katalla (southeast of Cordova), Iniskin (near Oil Point in the Aleutian Range), the Alaska Peninsula, and northern Alaska. Earlier work by the agency indicated that these regions seemed the best possibilities for significant petroleum reserves. The USGS planned to map the geology, appraise

sources of petroleum, determine locations for drilling test wells, determine future work, and correlate and integrate the data gathered to guide the development of any discoveries that might be made.

Wrather told Hayden's subcommittee that finding sufficient oil to service the war in the Pacific was becoming increasingly difficult and that he anticipated still more demands. While every known source of oil was being tapped to meet Navy and Army needs, Alaska remained practically untested. In past years, the USGS had made some progress in investigating petroleum resources in the Territory, but appropriations only allowed it to scratch the surface. It was "increasingly urgent that the Geological Survey should perform its obvious function and proceed with the geological exploration which must precede any actual drilling for oil,"[25] and the USGS could begin such work almost immediately after funds became available. Most of the study areas were in southern Alaska near the coast, and no more than 20 to 25 miles of pipeline would be required to send any new-found petroleum to shorelines, where it would be immediately accessible for refining and war use. The subcommittee recommended the full amount of the USGS supplemental request and it also restored the cuts made by the House in the budget items for topographic surveys and publication costs. The Senate followed its subcommittee's recommendations, but the House figures held when its members of the conference committee refused to accept any of the Senate's amendments.

The discussion in the House of Representatives on June 20, 1944, following the reading of the conference committee's report on the USGS budget, provided an illuminating view of conflicts of interest in attaining certain goals. Anthony J. Dimond, Alaska's Democratic delegate since 1933, asked why the funds for oil exploration in the Territory had been dropped from the USGS appropriation. Iowa's Benton ("Ben") Jensen replied by stating that the conference committee decided not to permit the monies because the House turned down an amendment to raise the price of crude oil by about 35 cents a barrel. "Just as long as the Congress insists on not giving [fair prices to] the oil producers of this Nation, the small producers in this Nation, where we know the oil is and where it is already flowing in the lower producing fields," Jensen continued, "I for one, as a member of the Interior Appropriation Committee, will insist that we do not go outside of the confines of the United States and spend a lot of money to get oil and to make investigations, because we can get all the oil we want right now in this war period, and we would be getting it if we will pay a fair market price."[26]

Representative Michael J. Mansfield (D–MT) reminded Jensen that Alaska was part of the United States and Mansfield believed that it was up to Congress to facilitate the exploration and development of the Territory's natural resources. America could spend $100 million to develop Canadian properties, Mansfield added, but it would not expend $1 million to develop its own resources. Perhaps, he suggested, the House should give serious thought to statehood for Alaska. Arkansas' William Norrell hastily assured Mansfield that the conference committee was not discriminating against Alaska but it wanted no Federal appropriation for oil exploration until the oil companies had an opportunity to spend their own funds. Dimond pointed out the impasse; Alaska lands were Federal lands, and all potential oil lands were reserved from entry, and so no private individual or company could explore them. Despite the logic of Dimond's position, the House adopted the report of the conference committee. Roosevelt signed Interior's appropriations bill into law[27] on June 28, which gave the USGS a little more than $6,738,000 in direct appropriations for fiscal year 1944–45, only $15,000 less than requested. Subsequent deficiency and supplemental appropriations and funds from outside sources raised the total to almost $12,599,000 for the agency's some 2,800 regular and seasonal personnel and their operations during the year, an increase of slightly more than $1 million from the sum received in fiscal 1943–44.

In the 6 months after Roosevelt's address to Congress in January 1944, the Allies continued their successful offensives in both hemispheres. In the Italian campaign, Anglo-American forces landed at Anzio on January 22, during which operation William Rasmussen earned a Bronze Star while leading a water-supply company. Churchill hoped the Anzio invaders would outflank the Germans' Gustav Line. Instead, the Prime Minister got a partial replay of Salerno; Allied forces dug in rather than advancing rapidly toward the Alban Hills. The Allied forces repelled all German attacks and finally broke out of the beachhead on May 23. Linking up on the 25th with other Allied troops moving north from Cassino, they captured Rome on June 4.

Just 2 days after the Allies liberated the Eternal City, General Eisenhower's Anglo-American forces landed on the coast of Normandy to begin the long-awaited second front in Europe. In the weeks before the invasion, Allied aircraft flew mostly tactical missions, but they also struck German synthetic-fuels installations and transportation targets. Allied ships and aircraft conveyed General Montgomery's 21st Army Group, including the nine divisions of Lt. General Omar Bradley's U.S. 1st Army and General Miles C. Dempsey's Anglo-Canadian 2d Army. Paul Thompson, now a full Colonel, was badly wounded while leading the 6th Engineer Special Brigade on D-day (June 6, 1944).[28] By June 11, more than 300,000 Allied troops were safely ashore in France. They defeated German piecemeal counterattacks and consolidated their landing areas into a solid front, helped by Hitler's decision to hold back panzer and other reserves to defend against the long-suspected, but bogus, invasion at the Pas-de-Calais. The Allies took Cherbourg on June 27, began clearing the port, and started constructing the Pipe Line Under The Ocean (PLUTO) beneath the English Channel to send oil from Britain to France. Although 1 million men, including Raymond Nace's company of the 487th Water Supply Battalion, were in Normandy by July 1, units of Field Marshal Rommel's Army Group B, their defenses enhanced by the difficult bocage country, resisted all Allied attempts to break out of the Cotentin Peninsula.

On the Eastern Front, the Soviet Union's winter offensive relieved Leningrad's defenders, broke German lines along the Dnieper River, cut off German forces in the Crimea, and moved westward toward the Dniester River. By April 1944, although delayed by a skillful and tenacious German defense, the Soviets reoccupied the entire Ukraine. On June 22, Soviet forces led by Marshal Zhukov, now Stalin's second in command, launched an offensive to recapture White Russia and timed to support the Allies in Normandy. Soviet armies mauled units of the Wehrmacht's Army Group Center, took Minsk on July 3, and began pushing into easternmost Poland. Other Soviet troops punched through the Mannerheim Line and forced Finnish forces to seek a truce on September 4 that took their country out of the war. Other Soviet armies cleared the Crimea in May, but not before the Germans evacuated most of their forces from Sevastopol to Odessa.

In the Central Pacific, the American V Amphibious Corps invaded Kwajalein Atoll in the Marshall Islands on January 29, 1944. Benefiting from lessons learned at Tarawa, the marines and soldiers captured Kwajalein's principal islands by February 7. Admiral Nimitz moved up to February 17 the scheduled assault on Eniwetok (Enewetak) Atoll to the northwest, and marine and army units completed taking the atoll 6 days later. After MacArthur's troops captured Hollandia, they landed during February and March on Green Island, and on Los Negros and Manus in the Admiralties, closing the ring around Rabaul. Admiral Spruance's 5th Fleet raided Truk on April 30 and went on to strike Wake and Marcus in May as additional preludes to the invasion of the volcanic Mariana Islands, which included Guam to the south and the Northern Mariana Islands (now the Commonwealth of the Northern Mariana Islands, CNMI).

The American assault on June 15 on Saipan (in the Marianas),[29] about 1,200 miles northwest of Enewetak and an equal distance south-southeast of Tokyo,

brought an immediate and major Japanese response. The Combined Fleet, under Admiral Toyoda Soemu since Admiral Koga's accidental death on March 31, sortied from bases in the western Carolines to stop the invasion and destroy the 5th Fleet. Japanese planners in the 1st Mobile Fleet proposed adding attacks from Marianas-based aircraft to those from the carrier-based aircraft (launched beyond the range of U.S. planes and refueled ashore before returning to their ships). Between June 19 and 21, Japanese and U.S. naval aircrews fought over the Philippine Sea. Japan's rebuilt forces lost three carriers (to U.S. aircraft and submarines) and lost more than 400 aircraft and most of their crews. Some 130 American planes and 75 crewmen were lost, but no U.S. ship was sunk or even significantly damaged.

As the global war continued to turn in the Allies' favor and the new fiscal year began on July 1, 1944, the USGS employed 2,800 people, not counting those assigned abroad or the gage and well readers at home, of whom about 87 percent worked full time. Some 90 percent of the staff served in the program branches, and the others, in the general administration or in the engraving and printing units. While the USGS remained focused on efforts to advance the Allied war effort, Director Wrather also prepared the agency for "a normal peacetime program"[30] during the postwar years. As Wrather's many organizational changes could not be done "all at once," he reformed the program divisions "one at a time," as Director Walcott did during the 1890s. Wrather knew that

> **[s]ome of the men occupying key posts were approaching retirement. Some of them were my personal friends of long standing. I believed that the division chiefs, at least, should be younger men with the prospect of long service ahead. I had no intention of running the divisions. That responsibility would rest on the division chiefs and I believed they should have a hand in shaping the organization for which they would be responsible.[31]**

Wrather began his changes in July by relieving Wilmot ("Bill") Bradley of his duties as Chief of the Military Geology Unit (MGU) and appointing him as the new Chief Geologist.[32] Bradley succeeded Gerald Loughlin, who, like David White before him, asked to return to research. The Director made Loughlin a Special Scientist and consultant on his staff to undertake work on problems in economic geology, fulfilling Loughlin's wished-for role in the postwar USGS. A revolt within the Geologic Branch, designed principally to break the logjam of Branch manuscripts, all of which Loughlin had to read before they received Director's approval for publication, also fueled Wrather's decision. Wrather asked Loughlin, as part of his new duties, to review and classify for elimination or completion, as publications or open-file versions, the many existing unfinished manuscripts in the files left there by deceased, resigned, or retired authors.[33]

Bradley succeeded Loughlin as Chief Geologist on July 17, 1944. Charles Hunt replaced Bradley as head of the MGU, which continued operations under the second agreement signed with the Army Engineers nearly 6 months earlier on January 22. Fritiof M. Fryxell, a geologist and mountaineer on leave since 1942 from teaching at Augustana College, later took Hunt's place as Assistant Chief. Wrather asked Bradley to concentrate on planning for postwar geological activities in the prewar regional centers and to rebalance basic and applied research. Bradley, like his predecessors David White and Walter Mendenhall, strongly supported fundamental studies and quickly remade the Geologic Branch. He restored "Division" as an administrative level between the Branch and its Sections, repeating the arrangement in place during 1902–26. The two new Divisions—Economic Geology and Basic Sciences—more philosophically resembled Director King's original organization of the USGS into Mining Geology and General Geology than Walcott's Divisions of Geology and Paleontology, Chemistry and Physics, and Mineral Resources.

Bradley assigned the Sections of the Geology of Fuels, Geology of Metalliferous Deposits, and Geology of Areal and Nonmetalliferous Deposits to the Division of Economic Geology. He placed the Sections of Chemistry and Physics, Paleontology and Stratigraphy, Petrology, Military Geology, and a reactivated unit for editing geologic maps in the Division of Basic Sciences. Whenever possible, Bradley, encouraged by Wrather, chose younger geologists as Section managers to combine innovative ideas with technological advances.

In another break with tradition, the Geologic Branch's new Division chiefs did not also serve concurrently as Section chiefs. Both Harold Bannerman, who led the Division of Economic Geology, and Basic Sciences' William Rubey were new (or almost new) to the Geologic Branch's administrative hierarchy. In November 1943, when George Mansfield retired, Bannerman replaced him as head of the Geology of Areal and Nonmetalliferous Deposits Section. Rubey also chaired the National Research Council's (NRC's) Division of Geology and Geography, to which he had been elected for a 3-year term in 1943, after service with Bradley, Gilluly, Heald, Longwell (chair), and Paige on the Committee on War Projects in 1942–43. On July 19, 1944, Bradley began additional managerial changes within the Branch. He designated Foster Hewett a Staff Geologist, and Thomas Nolan became Acting Chief of the Geology of Metalliferous Deposits Section. Josiah Bridge, primarily a biostratigrapher who led the agency's ongoing bauxite program, succeeded Bannerman as the head of the Geology of Areal and Nonmetalliferous Deposits Section. On October 31, Bradley and Rubey appointed geochemist Waldemar T. Schaller to lead the Section of Chemistry and Physics, replacing Roger Wells, in whose place Schaller had acted since Wells' death in April.

Bradley continued to modify the Geologic Branch's administration. On November 24, he and Bannerman relieved Nolan, freeing him for reassignment, and appointed Charles Park, Jr., who had concentrated on manganese and other strategic-mineral investigations, to lead the Geology of Metalliferous Deposits Section. Effective the same day, Bradley and Rubey established, within the Basic Sciences Division, a new Engineering Geology Section, under Edwin B. Eckel, who managed the Division's studies of domestic mercury deposits and then replaced Hunt as Assistant Chief of the MGU before being succeeded by Fryxell. Bradley also relieved Stephen Capps as Assistant Chief Geologist in November and reassigned him to the MGU. Joe W. Peoples, who studied chromite deposits in Montana's Stillwater Complex and remained interested in geophysical prospecting, succeeded Capps.

Bradley also changed assignments in the Geologic Branch to reflect modified emphases on the importance of its work. On July 28, Bradley received a copy of an informal committee's study, dated May 3, that Wrather requested to gage "the relative importance of projects now being carried out by the geologic staff * * * and the revision of the distribution of personnel to those projects." Foster Hewett (chairman), Harold Bannerman, Carle Dane, John Reed (Sr.), and Charles Park, Jr., evaluated the existing or potential importance of 36 ongoing projects and project groups. They used six criteria: (1) "immediate contributions to the war effort," (2) staff knowledge of commodities on the War Production Board's (WPB's) mineral-classification lists, (3) extent of requests "for information from the War Agencies," (4) the USGS value of commodities based on "consumption, imports, production, reserves, and substitutes," (5) "requests for information, cooperation, or assistance from State or other Federal agencies," and (6) the "availability, fields of experience, and special qualifications" of USGS geologists. Each project received a rating of "A" (utmost importance), "B" (intermediate importance), or "C" (minor importance), a second and similar rating letter for personnel now assigned, and the number of possible changes in their personnel. These ratings reflected "an attempt to retain a practical view as to the size of the [geologic] staff

and the scope of the duties the Survey might be expected to perform" but "arbitrarily ignored the Selective Service situation as well as expected projects."[34]

The informal committee's members gave A rankings to 11 projects and recommended adding 35 geologists to 5 of them. Those funded by the War or Navy Departments would gain 25 geologists; the uranium project, 4; Alaskan oil, 3; fluorspar, 2; and minor metals, 1. The staff sizes would stay the same for the remaining 6 projects: Alaskan coal, asbestos, conterminous U.S. oil, foreign work, optical calcite, and pegmatite. Twelve projects received B ranks: natural gas, iron, copper, lead and zinc, manganese, magnesite, strontium and barium, potash and phosphate, talc, work with Massachusetts, cooperation with other States, and Alaskan minerals. Hewett's committee suggested that seven geologists should be reassigned from the iron (–5) and copper (–2) projects and four geologists should be added to the studies of lead and zinc (+1), strontium and barium (+2), and talc (+1) for a net loss of three geologists in the B category. For the 12 C-level projects, they suggested a net reduction of 40 geologists: conterminous U.S. coal (no change), tar sand (–2 geologists), bauxite (–20), chromium (–2), mercury (–10), tungsten (–1) vanadium (no change), dolomite (–2), alunite (–2), clay (no change), magnesium (no change), and areal geology (–1). The report also listed glacial geology studies by François E. Matthes as the 36th and only unranked project. The committee called for "a continuing reappraisal of personnel requirements," including the unstudied support staff, a group they thought "badly needed" increased help.[35]

During fiscal year 1944–45, Bradley's Geologic Branch received for geologic surveys and strategic- and critical-minerals investigations by its some 620 full- and part-time employees (as of June 30, 1944) a total of about $2,967,000. That sum represented an increase of more than $343,000 over the total available for fiscal 1943–44. Direct appropriations provided a little more than $2 million, but the War Department transferred $410,000 and the USBM shifted $317,000 to make up the new total. On May 27, 1944, with approval from Secretary Ickes, the USGS and the USBM signed an administrative order that defined their respective functions. Geologic Branch specialists continued their scientific work in field and laboratory entirely devoted to war-related projects. By the end of fiscal 1944–45, their wartime work aided the discovery of new mercury and tungsten ores worth $25 million, but war consumption depleted 97 percent of the Nation's mercury, 78 percent of its chromium, 70 percent of its vanadium, and considerable (if lesser) reserves of copper, fluorspar, manganese, tungsten, and zinc. For copper, the long-continued basic studies by the USGS of principal mineral districts as a basis for future exploration, now in cooperation with the USBM and its drilling program, identified copper reserves at San Manuel in Arizona estimated to be as large as 64 million tons for mostly sulfide ore averaging just 0.1 to 0.2 percent below the content of the deposits being worked extensively elsewhere in Arizona and in Utah. Similar wartime work added about 10 million tons of domestic bauxite ore[36] to the known reserves of 75 million tons.

The results of the Branch's studies on bauxite, uranium, and other important commodities provided a positive response to Interior's report, with USBM input, to the WPB early in 1944. USGS investigations through August 1943, the report claimed, discovered only a small number of higher grade deposits from which minerals could be produced under peacetime conditions. The report acknowledged that the many lower grade deposits of strategic and critical commodities recently disclosed by USGS studies might become useful if acute shortages arose before war's end or in future emergencies, provided technical developments continued to reduce production costs. Finding new and better grade mineral deposits to restore reserves still required accurate and detailed geologic mapping, but only some 7 percent of U.S. lands were mapped at scales adequate to serve a discovery program sufficient to sustain the Nation's industries.

To help meet these mineral needs, Geologic Branch personnel also investigated new techniques in geochemical and geophysical analyses. Victor Vacquier and other engineers at Gulf Research and Development's Geophysical Division developed "a gyro-stabilized magnetic detector which saw limited antisubmarine use early in the war." The Germans introduced the saturable core in 1936, by which "accurate magnetic measurements could be made by employing the principle of the fluxgate or flux valve."[37] The Naval Ordnance Laboratory (NOL), the Bell Telephone Laboratories (BTL), and the Airborne Instrument Laboratory of Columbia University's Division of War Research (under contract to the National Defense Research Committee, NDRC) then combined their talents to develop a self-orienting fluxgate Magnetic Airborne Detector (MAD), including one wingtip-mounted version. The new detector was designed to measure the submarine-caused transient anomalies but also registered total magnetic intensity. In 1942, the United States and Canada equipped more than 100 B–18 medium bombers with the MAD and search radar to help the Allied hunt for U-boats in the Atlantic and the Caribbean.

Late in 1942, USGS geophysicist Herbert E. Hawkes, Jr., heard about the new device when asked about interpreting the effects of rock masses on the MAD because "spurious signals from geological conditions" were only "partially removed by a series of filters."[38] Hawkes, who earned his Ph.D. at the Massachusetts Institute of Technology (MIT) in 1940 before joining the USGS for work on chromite deposits, recognized the detector's potential use as an exploration tool in the agency's searches for strategic minerals. In 1943, as the NOL tested its magnetometer, the USGS published the results of James Balsley's and John A. Reinemund's plane-table and alidade mapping and their compass and dip-needle survey in September 1942 of four vanadium-bearing magnetite and ilmenite deposits in the Sanford Hill district, about 30 miles west-southwest of Westport, in northeastern New York. Balsley, while working with the Office of Scientific Research and Development (OSRD) and the Manhattan Engineer District (MED), also recognized the detector's geophysical potential. He began discussions in December 1943 with physicist L. Hamilton Rumbaugh, the NOL's Chief of Research and Torpedo Engineering, about the "modifications necessary to adapt the magnetometer for mapping extensive areas." Subsequent modifications of the magnetometer involved "some improvements in the electronic equipment," but most of them related to "aerial navigation and determination of the plane's position for geophysical mapping."[39]

Cooperation by Philadelphia's Aero Service Corporation, Bell Labs, the Navy's Bureau of Aeronautics, and the USGS enabled the USGS to field test the USGS-modified Navy magnetometer early in 1944. Aero Service sent its best pilot and a Beech Model 17 biplane—a single-engine, staggered-wing light transport—to carry the officially still-secret AN/ASQ–3A Magnetic Airborne Detector and its bomb-shaped cover, together known wryly to its operators as the "bird." In the low-level flights, the "bird" trailed out on a cable behind and below the aircraft to a point beyond the immediate effect of its own magnetic field. The initial test of the modified detector came in April 1944 on the magnetite deposits in Triassic diabase near Boyertown, Pennsylvania, some 40 miles northwest of Philadelphia, as part of a multiagency program requested by the WPB. The area's mines were among Pennsylvania's principal producers of iron ore between 1850 and 1900 but had been shut down since then. The USBM completed a ground-magnetic survey in 1943 that the USGS resurveyed and extended in 1944. The Defense Plant Corporation used these surveys as the basis for a two-hole diamond-drilling program, logged by the USGS, to supplement the data from commercial drilling in 1916–17. The results of the new deep drilling demonstrated the magnetite deposits' downdip continuity.

The USGS and the USBM then combined their efforts in geologic and magnetic surveys of areas in and near Boyertown. Arthur F. Buddington directed the USGS portion of the project and provided geologic interpretations. Herbert

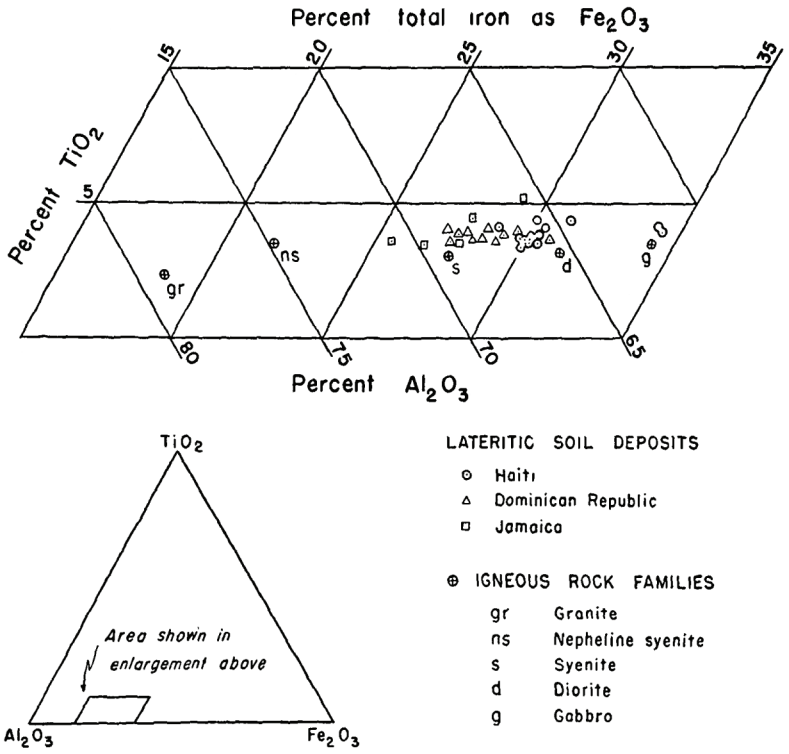
Geophysicist James Robinson Balsley, Jr. (1916–94), educated at the California Institute of Technology (Caltech) and Harvard, joined the USGS full time in 1941. He adapted the Navy's airborne magnetometer, used to hunt Axis submarines, for aerial geophysical prospecting and surveys. In August 1944, Navy Captain William G. Greenman arranged for Balsley's team to survey magnetic anomalies associated with known oil-producing structures in Oklahoma and Wyoming and compare them with the results of ground surveys. In 1945 and 1946, Balsley's team, flying in a PBY–5A Catalina, surveyed nearly all of the 37,000 square miles of Naval Petroleum Reserve No. 4 in northern Alaska. Continuous photography from the PBY–5A linked to existing trimetrogon records ensured ground control. Results disclosed a regional magnetic gradient to the northeast, confirmed the structure at Umiat that had been identified from the surface geology, and suggested other anticlinal closures elsewhere. Balsley flew magnetometer surveys over Antarctica during the Navy's Operation Highjump (1946–47), led the USGS Geophysics Branch (1953–59), and served as Assistant Chief for Geologic Processes (1959–62) and as Assistant Director for Research and for Land Resources (1970–79). His support of basic research led to the development of key evidence for plate tectonics and the paleomagnetic time scale. (Photograph from the USGS Denver Library Photographic Collection in the "Magnetic Detectors" subject album as magnet08, https://www.sciencebase.gov/catalog/item/51dd7f42e4b0f72b4471b403; published in Yochelson and Nelson, C.M., 1979, p. 35.)

Commodore William Garrett Greenman (1888–1956) was "the officer most responsible for the exploration for oil in [Alaska's] Naval Petroleum Reserve No. 4." Captain Greenman's *Astoria* was one of four Allied heavy cruisers that the Japanese sank at the Battle of Savo Island in August 1942. Although wounded, he then led Naval Base Guadalcanal before commanding the Advanced Base Planning Section in the Central Pacific Area and earning a second Legion of Merit. In June 1944, Greenman was appointed Director of Naval Petroleum and Oil Shale Reserves (DNPR); he had spent 1936–39 inspecting operations on NPRs 1 and 2 in California. The Navy promoted Greenman to Commodore (now Rear Admiral, lower half) in November 1945. He completed his tour as DNPR in December 1950 and retired in April 1951. (Photograph and quotation from Reed, J.C. [Sr.], 1958a, facing p. V.)

Hawkes, Jr., and Helmut Wedow, Jr., handled most of the ground-based geological and vertical-intensity magnetometer surveys. Balsley led the aeromagnetic-survey flight team, including geologists Cleaves L. Rogers and Darwin L. Rossman, in measuring total intensity. Balsley's crew also completed five experimental airborne-magnetometer traverses—two northeast of the town, approximately parallel with the ground-level magnetic surveys, and three, without such control, across the old mine workings at Boyertown. The traverses, flown at altitudes of 600 and 900 feet, recorded relatively large anomalies that reflected the ore bodies of two of the former mines, but industrial anomalies, which masked the ground survey, also adversely affected the results from the overflight at 300 feet. These aerial surveys "came within a few miles of finding a major magnetite deposit (the Grace Mine) later discovered by Aero Service."[40] The flights did demonstrate "the speed, accuracy, and broad applicability of the equipment." In May and June, the same plane and magnetometer overflew "1,500 square miles of wood and swamp land"[41] near Iron River, in the western, iron-rich part of Michigan's Upper Peninsula and recorded significant positive and negative linear trends.

For greater safety in transporting the 350-pound magnetometer payload, the USGS sought a twin-engine aircraft to support additional tests. Discussions with Captain William G. Greenman, the newly appointed Director of Naval Petroleum and Oil Shale Reserves (DNPR), convinced him to use the new geophysical technique in a rapid and extensive reconnaissance survey of Alaska's NPR–4. The Navy Department also was under new management; Secretary Frank Knox died in April 1944 and Under Secretary James V. Forrestal replaced Knox on May 9. Captain Greenman relieved Rear Admiral H.A. Stuart as the DNPR on June 10. Greenman had served afloat in everything from destroyers to battleships and carriers but also ashore as Inspector of Naval Petroleum Reserves in California during March 1936–July 1939. On August 9, 1942, the Japanese wounded Greenman and sank his *Astoria*, one of the four Allied heavy cruisers lost in the Battle of Savo Island. Greenman, after recovering, served in support capacities in the Pacific before becoming DNPR. In August 1944, Greenman, "who recognized the applicability of the equipment for making surveys in Naval Petroleum Reserve No. 4," arranged to use a Navy twin-engine Beech SNB–1 for further experiments in a new project with the NOL and the BTL. The Navy's SNB–1, like the Army Air Forces' AT–11 Kansan bombing trainer, was a modified Beech Model 18 with a glazed nose, dorsal dome, and twin-boom tail. During December 1944, Balsley and his team used the SNB–1 to survey "typical low-gradient anomalies associated with oil structures"[42] around Mangum, Oklahoma, and compared them with ground surveys. The USGS then employed the ever-improving equipment in May and June 1945 to survey nearly 3,200 square miles and the high-intensity, near-surface, and extensive magnetic anomalies in the iron-bearing area of the northern Adirondacks, including the Benson and other iron mines of New York's St. Lawrence County.

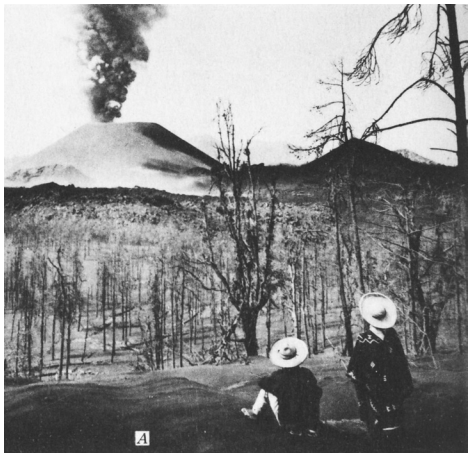
To the Geologic Branch's funds for geologic surveys and studies of strategic and critical minerals during fiscal year 1944–45, the State Department transferred $90,500, a $16,000 gain, for work in other American Republics. The Foreign Economic Administration (FEA) contributed $64,000. Under these auspices, and those of the Institute of Inter-American Affairs, which replaced the Office of the Coordinator for Inter-American Affairs (the former Interdepartmental Committee for Cultural and Scientific Cooperation), Branch geologists, in cooperation with their Latin American colleagues, continued or began investigations of 13 mineral commodities in Brazil, Chile, Cuba, the Dominican Republic, Haiti, Mexico, and Puerto Rico. The Smithsonian's William Foshag continued his cooperative work in Mexico on its mercury, tin, tungsten, and other strategic minerals, and at the still-growing Parícutin Volcano. At intervals during the fiscal year, scientists joining Foshag in studying the minerals and (or) the volcano included USGS geologists John Dorr 2d, Edwin B. Eckel, Carl Fries, Jr., David M. Larrabee, Ward Smith, and Francis Wells



This graph shows the proportions of the oxides of aluminum, iron, and titanium in the laterites of the Dominican Republic, the Republic of Haiti, and Jamaica. After high-grade aluminous lateritic soils were discovered in Jamaica in 1942, Reynolds Mining Corporation confirmed in July 1943 similar occurrences in Haiti, as suggested by USGS geologists in 1921. For the State Department, USGS geologists Samuel S. Goldich and Harlan R. Bergquist studied the geology and estimated reserves of laterites in Haiti during October 1943–April 1944. Using differential thermal analysis to identify principal minerals and assess grades, they located several deposits with as much as 50 percent alumina that totaled 15 million long tons, of which 10 million seemed recoverable. (From Goldich and Bergquist, 1948, fig. 7.)

and volcanologists Richard E. Fuller (University of Washington), Howel Williams (Berkeley), E. George Zies (Carnegie Institution of Washington's [CIW's] Geophysical Laboratory), and their Mexican colleagues Jenaro González-Reyna, Ezequiel Ordóñez, and Eduardo Schmitter.

Fuller arrived in Mexico on August 14 as Chairman of the U.S. Committee for the Study of Parícutin Volcano, formed by the NRC's Division of Geology and Geography at the request of Fuller's Section of Volcanology of the American Geophysical Union (AGU). The Committee, formed "to integrate the study of the eruption and its effect before the record was lost,"[43] worked in cooperation with a corresponding committee of seven Mexican scientists led by Ordóñez. Fuller's 15-person Committee included Fred M. Bullard, University of Texas; William Foshag; Louis C. Graton, a former USGS geologist on Harvard's faculty; Foster Hewett; Ezequiel Ordóñez; William Rubey (ex officio); Francis Wells; Howel Williams; and George Zies. Some of the State Department's funds went to support an initial 8-month's mapping and study of the volcano and the surrounding area by Williams and Kenneth Segerstrom. Other money from the State Department funded magnetic and seismological observations at the volcano directed by Austin E. Jones, of the U.S. Coast and Geodetic Survey, who conducted a seismic study of Kilauea's eruption in 1931–32. The Geological Society of America, as urged by Graton, gave Fuller's committee $15,000 for aerial and gravity surveys of Parícutin, and the American Philosophical Society provided additional financial support. Fuller's Committee established its field headquarters, staffed by onsite observer-caretakers for 8-month tours each, near the volcano. Segerstrom's topographic control and aerial photographs taken for the Committee by the Compañia Mexicana Aerofóta in April passed to the Secretaria de Agricultura's Departmento de Geografía y Meteorología, directed by Manuel Medina, a member of the Mexican Committee, to produce Multiplex-map coverage on mosaics at scales of 1:10,000, 1:20:000, and 1:40,000. During 10 days in July, the USAAF's Air Service Command supplied a helicopter to ferry parties to Parícutin and photograph in color eruptive activity from above and on the volcano's rim. During that interval, the participants



This view of Mexico's Parícutin Volcano, taken in March 1944, looks southwest from the Cerro de Equijuata along the line of the 1943–44 vents toward the main cone more than 2 miles distant. Satellite cone Sapichu stands at the foot of Parícutin, and the lava flows of June 1943 occupy the middle distance. The volcano's cone grew rapidly after the eruption began in February 1943 and ash and lava flows quickly covered large parts of the surrounding area. (Photograph by Arno Brehme; published in Foshag and González-Reyna, 1956, pl. 39*A*.)

Lava of the Parangaricutiro tongue of Parícutin's Taquí flows spared the bell tower and most of the church of San Juan Parangaricutiro (shown here), but beyond the church, the tongue buried completely the town of San Juan Parangaricutiro, northwest of Uruapan, Mexico. (Photograph, January 25, 1945, from Foshag and González-Reyna, 1956, pl. 43*A*.)

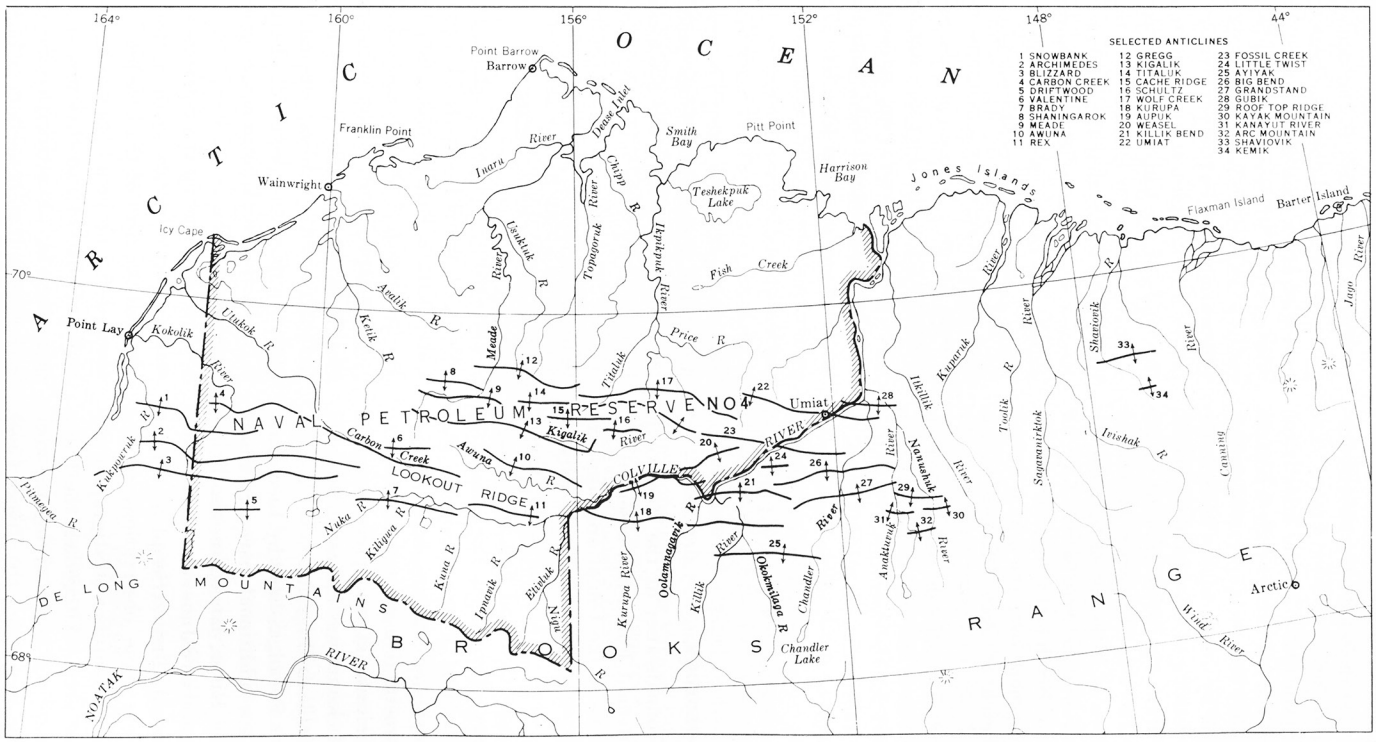
included Bullard, Foshag, Graton, Medina, Ordóñez, Frederick Pough, Segerstrom, and Igor T. Sikorsky, whose R–4B helicopter they used had been in production since 1942.

Domestic investigations of metallic minerals by the Geologic Branch emphasized basic geologic studies of the principal ore-producing districts in the United States to provide a better foundation for further exploration. Some of these investigations paid off immediately. In addition to the copper discoveries at San Manuel, Arizona, Branch scientists also sought new deposits of several rare elements needed for war projects, including uranium for the nuclear-weapons program. The Branch's vanadium project on the Colorado Plateau, begun in 1939 as part of its strategic-minerals investigations, produced geologic studies by Richard Fischer and his colleagues of the uranium-vanadium deposits in carnotitic sandstones and other rocks, a diamond-drilling exploration in cooperation with the USBM in 1943, and a classified report about the region's uranium deposits later that year for the MED that expanded on the previous year's estimate for the OSRD. "This study helped to crystallize an optimistic assessment of a large uranium potential on the Colorado Plateau."[44] In June 1944, the USGS sent four field parties, advised by the results of laboratory analyses and equipped with Geiger-Müller counters, to search for radioactive-mineral deposits in the conterminous United States and in Alaska Territory.

In October, after representatives of the MED and the USGS conferred, the two organizations established a joint program to explore for domestic sources of radioactive commodities, especially uranium and thorium. The program's field investigations, managed by William Rubey (within the Geology of Metalliferous Deposits Section), were initially directed toward occurrences indicated

by gamma-ray measurements of the mill- and smelter-product samples and later expanded along different lines based on additional data. Chemical, radioactive, and spectrographic determinations of these elements continued to supplement field studies. Geochemist Michael Fleischer left his studies of the mineralogy of manganese-oxide minerals as aids to prospecting and joined chemist Frank S. Grimaldi, the MGU's Esper S. Larsen 3d (the son of E.S. Larsen, Jr.), William Pecora, John Rabbitt, and other USGS geologists in related contributions to the MED's search for new sources of uranium and thorium, and for beryllium, boron, columbium, germanium, the lanthanides, selenium, tellurium, and other rare elements. As USGS work progressed, expanding estimates of ore tonnage at 0.001 percent of uranium led to raising the lower limit of potential reserves to 0.01 percent of uranium in black shales, phosphatic sediments, late-phase differentiates of igneous rock, placers, and deposits of fluorite, manganese, and tungsten. In November 1944, James O. Harder replaced Rubey as head of the trace-elements program. To improve administration and security, Bradley took the trace-elements work out of the Geology of Metalliferous Deposits Section on April 26, 1945, and made Harder the Chief of a Trace Elements Unit (TEU) that reported directly to Rubey.

During fiscal year 1944–45, Geologic Branch personnel also continued oil and gas investigations and published 28 preliminary maps and charts. They also expanded their fuels-related work in Alaska. The studies completed during 1945 included preliminary geologic and topographic maps and sections of the Katalla area by Don Miller, Darwin Rossman, and Charles A. Hickcox. Although Congress denied the USGS a supplemental appropriation to explore for oil in the Territory, Branch geologists Robert Coats and George Gryc accompanied the Navy party in Naval Petroleum Reserve No. 4. Captain Greenman enthusiastically supported the increased effort, aided by Lt. Commander William H. Rex's Seabee detachment from the construction battalion led by Commander Bart W. Gillespie, then assistant for oil matters to Rear Admiral Ben Moreell, Chief of the Navy's Bureau of Yards and Docks and its Civil Engineer Corps. Between early June and early August 1944, Lt. William Foran's group, including geologist and Lt. James J. Brazil, concentrated



This index map of northern Alaska (originally at about 1:3,750,000) shows the boundaries of Naval Petroleum Reserve No. 4 and the general locations of 34 selected anticlinal structures, including one of the more promising ones at Umiat on the Colville River. Prudhoe Bay, not identified on the map, is east of the northeast end of NPR–4, beyond the Sagavanirktok River's delta and east of the Jones Islands. (From Reed, J.C. [Sr.], 1958a, fig. 12.)

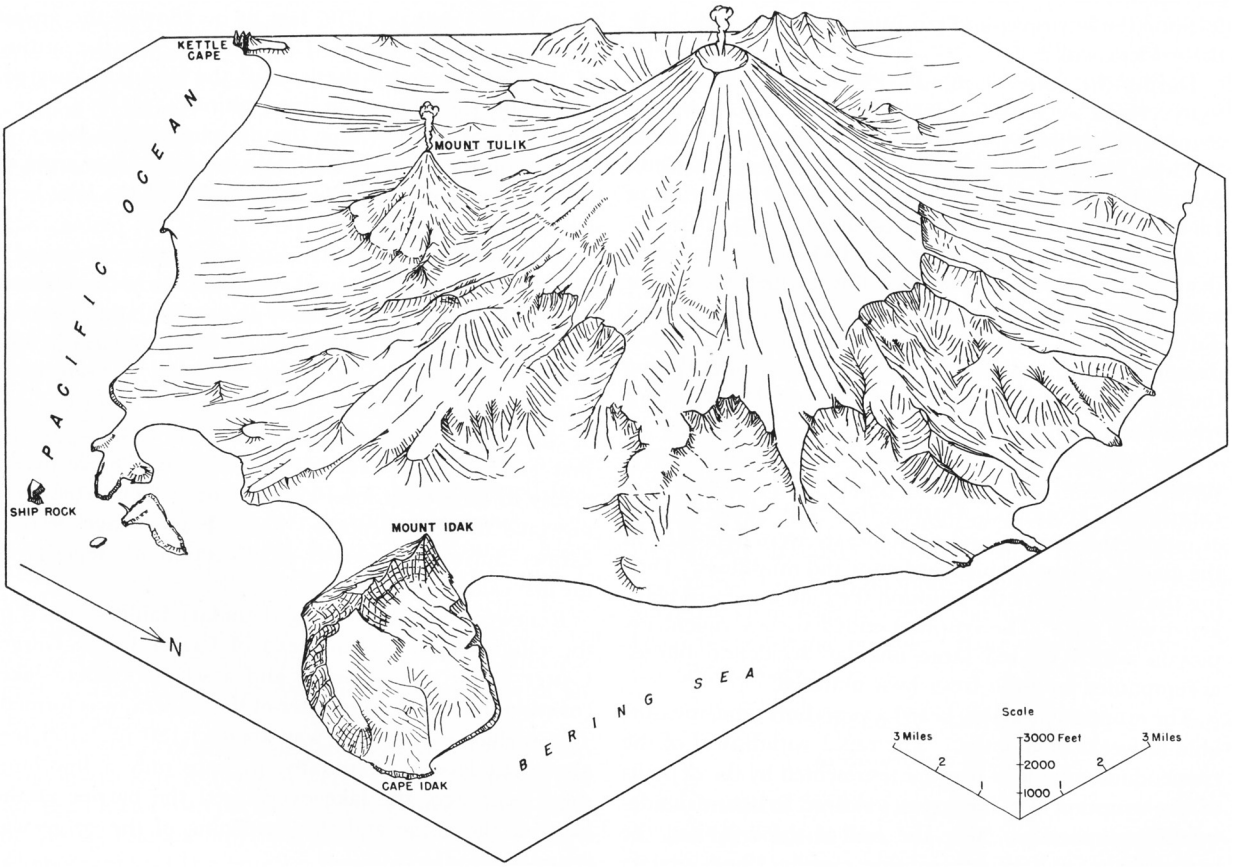
on preparing structure maps of a major anticline in the Umiat area in the far east-central part of NPR–4. The USGS geologists focused their studies on the stratigraphy of the Colville River bluffs, from above Umiat to about 40 miles downstream from that point. In October, near the Navy's new base at Barrow, Rex's party failed to recover cores from shallow test wells and lost one rig to fire but successfully drilled a third well to a depth of 685 feet.

The Navy received $1,620,000 to conduct operations in NPR–4 during the 1945 field season. On December 13, 1944, Admiral King asked Greenman to advise Secretary Forrestal about establishing general principles for work in NPR–4. Greenman, Gillespie, Lewis W. MacNaughton, Brazil, and one of Admiral Moreell's officers met to evaluate Rex's plan to drill an initial test well at Umiat and shallow cores at Cape Simpson. Greenman also advocated "an agreement whereby the Geological Survey would carry out a large part of the geological studies,"[45] rather than authorizing additional work by Navy geologists or turning to civilian contractors for geologic expertise. In January 1945, Secretaries Forrestal and Ickes authorized Greenman to deal directly with Wrather in planning the cooperative work for the coming field season. Greenman used two companies—(1) Hoover, Curtice, and Ruby, and (2) DeGolyer and MacNaughton—as consultants. Hoover's United Geophysical signed on for geophysical surveys, and the newly organized Arctic Contractors took on the drilling work.

The Alaskan Branch, now with more than 280 employees, received for its efforts during fiscal year 1944–45 a total of slightly more than $830,000, including a $20,000 increase in direct appropriations. Transferred monies included $600,000 from the War Department, but that amount actually represented a loss of nearly $112,000; although the Navy provided $50,000, the Branch received for the year some $60,000 less than in fiscal 1943–44. Branch specialists continued to use aerial photographs to compile aeronautical charts and maps for the USAAF. They made maps of some parts of Alaska but mostly made maps of other areas worldwide. To staff that work adequately, the Branch postponed regular detailed mapping in the Territory, although the need for such maps grew ever greater. The USGS estimated that more than 99 percent of Alaska lacked planimetric or topographic maps at suitably large scales. Two-thirds of the Branch's geologists worked on the military and naval projects. In addition to the studies in NPR–4, they continued to assess coal, copper, mercury, tin, and zinc deposits within the Territory. In conjunction with the Military Geology Unit, they also paid increasing attention to the nature of and problems associated with building and maintaining facilities on permafrost. Siemon Muller left the MGU in 1943 to begin consulting work for the USAAF in Alaska. He prepared an expanded edition of the MGU's Strategic Engineering Study (SES) 62 about permafrost, and the new version appeared during calendar 1945.

Requests to Alaskan Branch geologists to assess volcanic hazards on the Alaska Peninsula and in the Aleutians reemerged when another explosive-extrusive eruption began "on or a few days before the evening of June 4, 1945,"[46] in the 7-mile-wide Okmok Caldera on the northern part of Umnak, one of the Fox Islands. The volcano had been active in 1931 and 1938. Mild tremors that began late in May 1945 preceded June 1's "sharp earthquake" felt at Fort Glenn (later Cape Air Force Base), less than 10 miles south of the caldera, but clouds hid the caldera's rim. "On June 4, pilots [of the 11th Air Force] reported a column of black ash rising from the southern part of the caldera to a height of 9,000 feet, and that evening the clouds lifted above the rim to reveal red reflections."[47]

Lt. General Delos C. Emmons, who had commanded the Alaska Defense Command since 1944, requested advice from the USGS about the real and potential dangers to the personnel, main and active-satellite airfields, and other facilities at Fort Glenn and those some 60 miles to the northeast at Fort Mears and other


KETTLE CAPE
PACIFIC OCEAN
MOUNT TULIK
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CAPE IDAK
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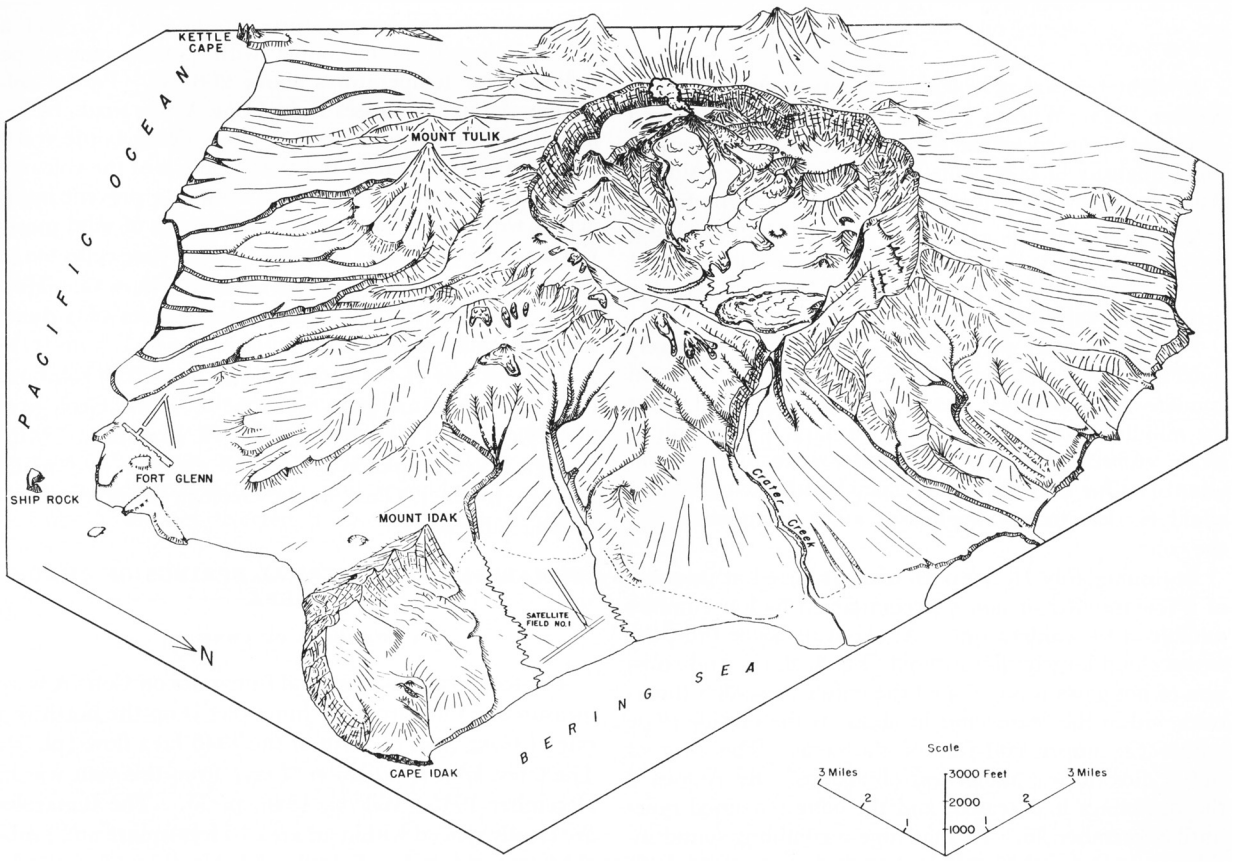
KETTLE CAPE
PACIFIC OCEAN
MOUNT TULIK
FORT GLENN
SHIP ROCK
MOUNT IDAK
Crater Creek
SATELLITE FIELD NO.1
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CAPE IDAK
Scale
3 Miles
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On June 10, 1945, a four-man military-civilian team prepared to descend into Okmok Volcano's 7-mile-wide caldera to assess the ongoing eruption and its hazards. The team included geologist Ray Everett Wilcox (born 1912, at left), then a 2d Lieutenant in the U.S. Army Signal Corps, and USGS geologist Gershon Duvall ("Robby") Robinson (1918–2005, at right). The ash-steam cloud to Robinson's right issued from an erupting cone about a half-mile from the rim. Studies of volcanoes and volcanic processes by USGS geologists began with Clarence E. Dutton's investigations in the Hawaiian Islands in 1882. The USGS operated an Aleutian Volcano Investigations Unit at Adak, supported primarily by Army and Navy funds, during 1949–54. (Photograph by Army Colonel G.A. Polk; published in Robinson, G.D., 1948, p. 516.)

installations around Dutch Harbor on Unalaska. Emmons had seen Alaska's and Hawaii's volcanoes and their dangers firsthand. On June 6, 1912, ash from the Novarupta-Katmai eruption[48] threatened then Lt. Emmons and his fellow passengers on their ship in Shelikof Strait. In December 1935, Colonel Emmons, now a air-wing commander, and Thomas A. Jaggar, Jr., Director of the Hawaiian Volcano Observatory (HVO) since 1912, overflew the tunnel through which lava from Mauna Loa advanced at a mile per day toward Hilo's water supply. Emmons approved Jaggar's plan for B–18 bombers to target the tunnel, slowing and then stopping the flow in the headwaters of the Wailuku River. As a Lt. General, Emmons ended his tour as leader of the USAAF's Combat Command to take over the Hawaiian Department on December 17, 1941. He authorized Jaggar's scheme for bombing another flow from Mauna Loa in 1942.

Emmons now feared that a major eruption of Okmok might destroy Fort Glenn; if the base needed to be evacuated rapidly, the garrison would encounter transportation difficulties for lack of a natural harbor. Emmons knew that the major explosive eruption on June 12, 1944, of Mount Cleveland, on Chuginadak Island and only 95 miles southwest of Fort Glenn, killed a soldier and closed the small outpost there. Although Stephen Capps accompanied the Navy's reconnaissance of the Aleutians in 1932, Jaggar, now in his mid-70s, remained the geologist most familiar with the Aleutians' volcanoes. USGS funds aided Jaggar's studies after the HVO came into the agency in 1924, still operating under its motto *Ne plus haustae aut obrutae urbes* (No more burned or buried cities), and he began leading the Geologic Branch's Section of Volcanology 2 years later. In 1932, Jaggar reported on Okmok's eruption during the previous year. The Interior Department shifted the HVO in 1935 to the National Park Service, whose Hawaii Volcanoes National Park, established in 1911, enclosed about 198,500 acres. In 1940, Jaggar retired and turned the HVO over to Ruy H. Finch, who joined Jaggar's staff in 1919 and led studies of Lassen Peak, California, between 1926 and 1935.

On June 6, 1945, a colonel on General Emmons' staff appealed to the USGS office in Anchorage to send a specialist to assess the danger to Fort Glenn. USGS geologist Gershon D. ("Robby") Robinson took the call. With no volcanologist

◀ These two isometric views (originally at about 1 inch = 3.5 miles) of Okmok Volcano, on Umnak Island in the eastern Aleutians, look southwest before the caldera formed (above) and after (below) the eruption early in June 1945. As part of the USGS' assessment of the caldera-forming eruption, geologist Frank M. Byers, Jr. (1959, p. 341), estimated that the blast removed between 7 and 16 cubic miles of material from the volcano's summit. Ash falls from the volcano posed a hazard for the U.S. Army Air Forces' base at nearby Fort Glenn, but lava flows remained confined to the volcano's caldera. (From Byers and others, 1947, fig. 9*A*, *B*; fig. 9*B* also appeared [at about 1 inch = 5.5 miles] as Byers, 1959, pl. 50.)

immediately available, Robinson left within the hour for Umnak by air and while en route saw steam and ash rising from the Pavlof (near the tip of the Alaska Peninsula) and Shishaldin (on Unimak) Volcanoes. Once at Fort Glenn, Robinson assured the base commander that the lack of strong earthquakes accompanying the ongoing eruption indicated that it was not a major volcanic event. When the weather cleared on June 10, Robinson, Army Colonel G.A. Polk, 2d Lt. Ray E. Wilcox of the Signal Corps (who earned a Ph.D. at Wisconsin in 1941 with a study of the optical mineralogy and petrology of basalts and rhyolites on the Gardiner River in Yellowstone National Park), and a sergeant reached the caldera and descended into it.

On Okmok's plain, the four men saw ash "being erupted copiously from a small cinder cone near the southwest edge of the caldera floor and lava was flowing from the base of the [150-foot-high] cone" in a 40-foot-wide stream at "about 30 feet per minute."[49] Northwest winds carried ash to form deposits several feet thick on the caldera's southeast floor and several inches thick on its rim. Only a fraction of an inch of ash fell at points within a mile of Fort Glenn, which was built on Okmok's earlier pyroclastic deposits. Robinson returned to Anchorage and "reported to General Emmons that there was little risk of a disastrous eruption"[50] that might heavily damage or destroy the Umnak airbase. Emmons authorized placing Wilcox "in charge of the volcano. I was to show visitors around—in addition to my other duties," Wilcox later recalled. "Howel Williams came up from Mexico to check it out; I had known him before and we had a good time."[51] Okmok's "explosive activity declined somewhat in the last half of June, but increased again early in July." Wilcox reported that after "about a month of intermittent, but declining, activity," the lava extended 4 miles from the cone but was still well within the caldera. "By late July [on the 22d], lava effusion practically ceased and the amount of ash in the eruptive column generally decreased until only steam was emitted, and that only in weak surges."[52]

While USGS investigations continued in Alaska, Bradley's Military Geology Unit, as requested by the Office of the Chief of Engineers, expanded its terrain and materials studies. The MGU also supplied some 50 geologists to the overseas theaters of operation for strategic and tactical intelligence or scientific and engineering consulting in combat operations. The MGU reduced its work in the Mediterranean and played only a minor role in the planning for the invasion of France. Geologist-historian Edward P.F. Rose, a retired Colonel of Royal Engineers, described how British specialists took over most of the assessments of the loess, sand, and other materials of Quaternary age overlying the relatively flat Jurassic bedrock on Normandy's beaches and adjacent areas on the Calvados Plain chosen for their trafficability (off-road movement) and construction materials over the older and harder rocks to the west at Cherbourg and elsewhere on the northern and western Cotentin Peninsula.[53] Studies of airfields and airfield sites, beaches, construction materials, German defenses, and water supplies passed principally to the geographers, geologists, and photo-interpreters of the Inter-Services Topographical Department (ISTD) at Oxford since 1941, aided by members of the Imperial General Staff's Geographical Section and the staff of General Montgomery's 21st Army Group. To support staff planning, the MGU contributed a series of small-scale terrain maps of all the coastal countries of western and northern Europe and a terrain-appreciation folio of France (SES 87, at 1:3,000,000).[54] Members of the MGU, with those from the Tennessee Valley Authority (TVA), also participated in the Anglo-Canadian-American Benson Program, which extended earlier and ongoing mapping, at scales of 1:250,000, 1:100,000, and 1:50,000, by using RAF aerial photographs to provide (1) Multiplex-generated base maps at 1:25,000 for the French coast and areas inland and (2) maps at 1:12,500 for the specific invasion locales in Normandy.[55]

A few American geologists and related specialists in uniform, among them Private (later Sergeant) Clifford A. Kaye, formed the Information Section of the Chief Engineer's Intelligence Division at General Eisenhower's Supreme Headquarters Allied Expeditionary Forces (SHAEF). Kaye and his colleagues began their contributions "following the assumption of full-scale staff work in the theater by U.S. forces in the spring of 1944."[56] The SHAEF Information Section's initial products included maps of the "main terrain units and the major beach exits"[57] in Normandy, air-photo interpretation of sediments and bedrock in Quiberon Bay to aid the construction of an artificial port, if the existing ones in Brittany could not be captured and restored for use, and air-photo analyses of bomb-crater shapes as a guide to the nature of unconsolidated sediments. The Section's staff then concentrated on preparing terrain-appreciation maps and reports.

The MGU also exchanged information and personnel with one of the ISTD's units. On July 7, 1944, a month after the Allies invaded Normandy, Charles Hunt sent to the ISTD's Daniel C. Ion, a Squadron Leader (later Wing Commander) in the RAF, the MGU's constructive criticism, in its Miscellaneous Paper 11, of the ISTD's 1:500,000 geologic map and terrain analysis of Formosa. Ion, an Oxford-educated geologist who worked for Anglo-Persian (Iranian) Oil Company in the Middle East, joined the ISTD as a geographer in April 1943. Later that year, the ISTD established specialist Sections for engineering, resources, and geology. Ion's letter of thanks on August 6, 1944, led to a visit to the ISTD's Geological Section during September 5–28 by the MGU's Fritiof Fryxell and Robert L. Pendleton to exchange information and methods with Ion, his four geologists, including Lt. (later Major) John L. Farrington, and four soils scientists serving as Captains of Royal Engineers. After Fryxell's interval with the ISTD's Geological Section at Oxford, and his time spent in Cambridge at the Naval Intelligence Division's subcenter and in London at the Imperial General Staff's Geographical Section, Hunt visited the Geological Section early in October. Hunt and Ion agreed to additional exchanges between their staffs to improve cooperative efforts, and they also tried but failed to arrange for a postconflict collaboration to prepare a mutual history of wartime geology. Farrington came to Washington between October 19 and November 9, spending much of that time with the MGU. The MGU continued to report to Major Arthur H. Spillers, Jr., a forester in civilian life, who replaced Colonel Paul Thompson as head of the Army Engineers' Strategic Intelligence Branch in Washington after Thompson's transfer to Britain early in 1943. Fryxell recommended to Major Spillers that German mineral resources be surveyed as the country was occupied, especially to determine how Germany achieved some self-sufficiency in raw materials. In December 1944, Fryxell also suggested that Hunt consider sending a MGU representative to the Mediterranean Theater and also establish a reserve corps of military geologists. The Anglo-American collaboration also generated supportive visits to the ISTD's understaffed Geological Section in 1945–46 by the MGU's geologists Maxim M. Elias (Army Engineers) and Louis L. Ray (USGS) and geochemist Lyman C. Huff (USGS).[58]

By the end of 1944, at the Army Engineers' request, the MGU completed shifting most of its efforts to the Pacific, initially in General MacArthur's Southwest Pacific Area, and then expanding to the Pacific Ocean Areas of Admiral Nimitz. Colonel (later Brigadier General) Hugh J. Casey, as MacArthur's Chief Engineer, began his Intelligence Division's operations in Australia on August 25, 1942, by gathering information about northern Australia and New Guinea from local residents and Australian publications. During 1943 and early 1944, Australian civilians and some U.S. officers joined Casey's Intelligence Division to map and study areas in New Guinea, making ever-increasing use of aerial photographs as aids to the continuing offensive on the island by MacArthur's troops. Casey's Division added additional Australian geologists and expanded its assessments to New Britain and the East Indies, while the OSRD sent Harvard and USGS geologist

This photograph shows Army officers and USGS Military Geology Unit (MGU) members, Research and Reports Branch, Engineer Intelligence Division, Office of the Chief Engineer (Major General Hugh Casey), Southwest Pacific Area (and Army Forces Pacific), outside the bullet- and shell-pocked Manila City Hall (Luzon, Philippine Islands) in September 1945. Personnel shown include (from left to right): (front row) Wallace de Laguna (4th) and Robert Bryson (7th); (middle row) Major Arthur Spillers (2d), Lt. Colonel Hubert Schenck (4th), Fritiof Fryxell (5th), Captain Roger Baker (6th), and Philip Stephenson (8th); (rear row) James Thorp, Morris Austin, John Collins, Walter White, Frank Whitmore, Jr., Vincent McKelvey, Leopold Stach, and Edward Sampson. Casey began his Intelligence Division's operations in Australia in 1942. The initial MGU team, led by James Gilluly, joined the Intelligence Division in May 1944. His team aided plans for the invasions of Leyte and Luzon and three of its members landed with U.S. troops on Leyte in October. In March 1945, Fryxell led a second team to relieve Gilluly's group and directed the MGU's and the Army officers' terrain research of Honshu and Kyushu, respectively, as part of preparations for the planned (but later canceled) invasions. Members of the MGU's third team, assigned to the Pacific Ocean Areas and originally based on Oahu, contributed to planning for the invasions of Iwo Jima and Okinawa. (Photograph from the USGS Denver Library Photographic Collection, Portraits, in the "Group–1900's identified" folder; published in Nelson, C.M., and Rose, E.P.F., 2012, fig. 8.)

Marland P. Billings to New Caledonia to assess that island's nickel deposits. Casey, before taking over (as a Major General) the Army Service Command, requested a team of terrain specialists from the MGU to aid the U.S. officers in the Intelligence Division.

The MGU's initial field-research team, all civilian consultants with simulated-officer status and led by James Gilluly, arrived in Brisbane in May 1944. The Engineer Terrain and Intelligence Team moved to Hollandia (now Jayapura) on New Guinea and later to Morotai. Gilluly's team included Geoffrey B. Bodman, a soils scientist from Berkeley; geologists A. Lincoln Dryden, Jr., a heavy-minerals specialist from Bryn Mawr, and William C. Putnam, an expert on coastal geology from the University of California at Los Angeles (UCLA); and groundwater hydrologist Nelson Sayre. Gilluly's group concentrated on preparing reports, based principally on more detailed data from improved aerial photographs and increased coverage, to aid planning for operations in northwestern New Guinea, on Morotai, and in the Philippines. Dryden analyzed landing beaches, and his colleagues focused on inland-engineering problems, water supplies, and other concerns. Gilluly's team produced increasingly briefer and less technical reports and maps at 1:10,000 or 1:20,000, the same scales as most of the aerial photographs. Unfortunately, Gilluly's team did not form a separate section in the Intelligence Division. After Casey's departure, the team was not delegated the same operational initiative and responsibility for assignments given to the MGU. Officers unfamiliar with the team's expertise tried to dictate how the specialists should do their work. The quality of the team's subsequent reports varied, and the team missed some deadlines. When attempts to remedy the situation failed, some team members sought field-force assignments.[59]

As the MGU aided military operations in the Pacific, under the third overall agreement signed with the Army Engineers on May 25, 1944, the Topographic Branch continued to divide its work between war-related projects, principally the production for the War Department of maps from aerial photographs, and

domestic mapping. For salaries and operations by the nearly 680 full- and part-time employees (as of June 30), the Branch received slightly more than $3 million during fiscal year 1944–45, but that sum represented an increase of just $64,000 over the previous year. Direct appropriations for topographic surveys rose sharply from $672,500 to just above $1.8 million, and miscellaneous repay funds more than doubled, offsetting the loss of about $589,000 in War Department transfers. Of the direct appropriations to the USGS for its topographic surveys, Congress limited $240,000 to State-municipal cooperation, a sum more than met by the $330,000 contributed by those governments. Branch personnel in the Arlington, Virginia, and Chattanooga, Tennessee, offices, devoting about 80 percent of their time and services to producing maps of areas in countries abroad, compiled stereophotogrammetric coverage of some 64,000 square miles.

To make the new mapping techniques available to a wider audience, the American Society of Photogrammetry sponsored a preliminary edition of the "Manual of Photogrammetry," published in New York late in 1944 and distributed in January 1945.[60] Ronald Wilson, still Chief of the Topographic Branch's Computing Section, Alaskan Branch topographic engineer John I. Davidson, and three of their colleagues outside the USGS coedited the new volume. Wilson also wrote the book's sections on regular coordinates and standard horizontal data and on oblique photographs for the surveyor. Davidson and Branch engineer James L. Buckmaster combined to produce a section on the USGS radical-intersection method, while Branch engineer Channing P. Van Camp discussed practical tilt corrections for single-lens aerial photographs. Branch Chief Thomas Pendleton wrote one section on the Multiplex instrument and its use and a second section about field inspection and completion. Lt. Colonel Gerald FitzGerald led the preparation of the volume's section about reconnaissance mapping via trimetrogon photogrammetry[61] by members of his USAAF Aeronautical Chart Service (then including Buckmaster and Davidson and other USGS topographic engineers in the Alaskan Branch). FitzGerald then accompanied Interior Department delegate Thomas Pendleton to the Second Pan American Consultation on Geography and Cartography in Rio de Janeiro during August 14–September 2, 1944. Colonel Minton Kaye, still FitzGerald's commander, supplied the new book's preface, and William Putnam, before serving with the MGU in the Pacific, contributed the section on photo interpretation.

Other parts of the Topographic Branch's domestic work also supported the war effort.[62] More than 180 of the maps published during fiscal year 1944–45 included areas termed strategic by the War Department. Branch engineers also completed another 6,300 square miles of map coverage for areas within the United States and 9 special projects to support investigations of bauxite and other sources of aluminum, copper, iron, manganese, zinc, and other strategic minerals. The domestic program also included field surveys in 35 States. USGS topographers worked cooperatively with colleagues in 19 of these States, with the TVA, on flood-control projects of the Army Engineers, and on 5 large-scale maps for the Bureau of Reclamation's irrigation and reclamation projects. Field mapping within the United States totaled some 14,000 square miles, including resurveys of 5,400 square miles.

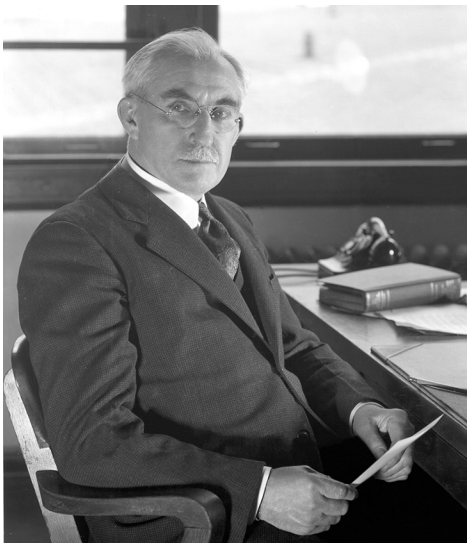
During fiscal year 1944–45, the Water Resources Branch received nearly $4.1 million in total funds, $500,000 more than in fiscal 1943–44; the total included cooperative monies and those transferred from other Federal agencies for work with a greater domestic emphasis. Congress supplied $1,590,000 in direct and supplemental appropriations; State, county, and municipal governments added another $1,269,000, $169,000 above the congressional limit; and other Federal departments and agencies furnished the remainder. The War Department transferred about $919,000, an increase of $207,000 over the previous year; the USBR

raised its contribution by nearly $7,000 to more than $76,000; and slight increases in contributions by the State Department and the TVA, and new funds from the FEA, helped to offset an $18,000 reduction by the Defense Plant Corporation. As the fiscal year began, the Branch employed 765 full- and part-time persons. The number of requests for special reports in connection with war activities continued to decline, although Branch members completed about 4,220 reports during the year, part of a total of some 15,000 since July 1941.

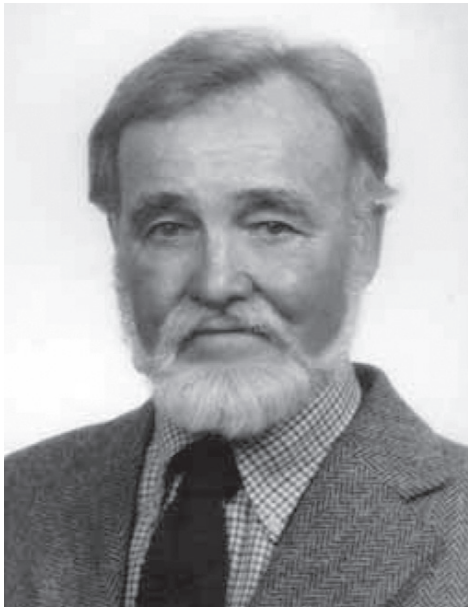
In fiscal year 1944–45, the USGS expanded its activities outside the national domain. During July 1944, the Geologic Branch established a Committee for Cooperative Investigations Abroad, chaired by John Dorr, who reported to Bannerman's Division of Economic Geology. Later that year, Glen F. Brown left his domestic studies for the Water Resources Branch to work in Saudi Arabia as part of one of the missions of Federal experts striving to improve economic conditions in strategic countries by surveying and planning for utilizing, improving, and developing local resources. Brown's assignment developed from appeals by King Ibn Saud to President Roosevelt and to the U.S. Minister Plenipotentiary in Jiddah for help in searching for and developing water supplies, especially in the central part of the Kingdom, to foster agriculture as an aid to oasis farmers and to Bedouin resettlement. During May–December 1942, Karl Twitchell's team, after traveling some 11,000 miles in the Kingdom, contributed to plans that included establishing model farms in the Kharj district. Twitchell returned to Saudi Arabia to lead a preliminary-evaluation team, including two specialists from the Agriculture and Interior Departments. Wrather, during his hour's audience with the King in January 1944 before visiting Kharj, agreed to send a USGS geologist to serve as the requested longer term adviser on water supplies and other natural resources.

Although USGS personnel still lacked specific statutory authority to serve officially outside the national domain, they had worked unofficially and intermittently since 1882 in Hawaii, Nicaragua, the Philippines, and the Caribbean. The Interior Department now employed a long-used Federal method to send Glen Brown to Saudi Arabia. On August 10, 1944, Under Secretary Michael Straus, as Acting Secretary,[63] approved Director Wrather's preliminary agreement with Leonard Parker, of the State Department's Saudi desk, to have a USGS groundwater geologist accompany for 1 year a second U.S. agricultural mission being recruited by the FEA's Food Programs Division. David A. Rogers, a graduate agronomist who farmed in Arizona's Skull Valley and participated in a War Relocation Project on Arizona's Gila River, led the second mission that included two of Rogers' farmer neighbors. Under an 18-month contract that extended to December 1945, Rogers' demonstration team established their headquarters at and thereafter worked principally in and from the 3,500-acre experimental farm in the Kharj district owned by Sheik and Minister Abdullah al-Hamdan. Two days after Under Secretary Straus approved the Wrather-Parker understanding, Oscar Meinzer, still Chief of the USGS Ground Water Division, agreed to detail a USGS scientist to the FEA's mission. For this work, Meinzer selected Glen Brown, who examined the geology of mineral deposits in China and the Philippines during 1936–38 and then investigated groundwater resources in Mississippi, including water supplies for Army camps, and in California as part of units managed by Victor T. Stringfield and Arthur Piper.

On November 11, 1944, Secretary Ickes approved Wrather's arrangement for Brown's reimbursable detail to the FEA.[64] Wrather, in writing to FEA Administrator Leo Crowley on November 28, expected that Brown "will be given wide latitude for independent judgment in the conduct of his technical work, such as will be involved in the reconnaissance of recharge areas and outcrop belts of the aquifers being developed by the [second agricultural] mission."[65] On January 2, 1945, Ickes formally approved the transfer of Brown's official-duty station from Washington



Geohydrologist Oscar Edward Meinzer (1876–1948) joined the USGS as a geologic aid in 1906. He succeeded Walter Mendenhall as Chief of the Ground Water Division (later Branch) in 1912 and led the unit until he retired in 1946. During those years, Meinzer made major contributions to advancing basic and applied quantitative studies of groundwater, including artesian aquifers and large springs, and he encouraged similar work by his younger colleagues. Improvements in field and laboratory techniques accompanied his melding of chemistry, engineering, geology, and physics with hydrology in broadening qualitative and quantitative studies of groundwater. His 1942 book on hydrology became a standard reference. He also cofounded and chaired the American Geophysical Union's Section of Hydrology. (Photograph from the USGS Denver Library Photographic Collection, Portraits, as port0242, https://www.sciencebase.gov/catalog/item/51dda25be4b0f72b4471df43.)



Geologist and hydrologist Glen Francis Brown (1911–2001), after joining the USGS in 1938, investigated groundwater supplies for military installations and other consumers in Mississippi and California. He began USGS operations in Saudi Arabia in October 1944, while on detail to the Foreign Economic Administration (FEA) and David Rogers' U.S. agricultural mission to the Kingdom. Brown's association with the FEA's mission, during which he mapped geology and located water supplies, extended into May 1946. He then served on a 2-year reconnaissance of Thailand's geology and mineral resources. Brown returned to Saudi Arabia as chief of the USGS field team during 1950–54 and 1963–69, while continuing to advise the U.S. and Saudi Governments. With Aramco's aid, members of the USGS-Saudi program completed mapping Saudi Arabia at 1:500,000 in 1958. (Photograph from Reinemund, 2002; see also the 1945 photograph of Brown and Rogers with King Ibn Saud in Hart, 1998, p. 101.)

to Dhahran. On February 14, Roosevelt and Ibn Saud chatted aboard an American heavy cruiser anchored in the Suez Canal's Great Bitter Lake (Buheirat Murrat el Kubra). The President approved additional aid for the Kingdom, which by then received more than $33 million in oil revenues. In discussing the Palestine question, the President assured the King that his administration would take no action hostile to the Arabs and that America would not change its policies regarding Palestine without first consulting with both Arab and Jewish leaders.

Glen Brown's association with the FEA mission to Saudi Arabia extended into May 1946. He flew to Dhahran, the site of a planned major airbase on the military transport route between Cairo and Karachi. Aramco provided Brown's radio links and ground transportation; his mail and supplies came through Parker T. Hart, who opened the U.S. consulate in Dhahran in September 1944.[66] Brown, based near the U.S. Embassy in Jiddah, paid particular attention to water supplies and mineral deposits in his preliminary reconnaissance of surficial geology. David Rogers and his FEA colleagues continued to examine sinkholes, repair pits and wells, and supervise the construction of new irrigation channels to facilitate better production of wheat, other grains, and vegetables in the Kharj district. Working 60-hour weeks, Brown completed his studies at Kharj,[67] located several aquifer sources in the Nejd region, supervised wells dug in Riyadh, discovered additional water supplies in Jiddah and elsewhere along the Red Sea littoral region, and mapped in detail the Mesozoic–Tertiary geology and surface features of some 800 square miles, aided by information from Aramco's Steineke and Bramkamp. None of these finds, however, yielded water in amounts sufficient for major irrigation. Between December 1944 and June 1946, the FEA transferred to the USGS nearly $9,400 to support Brown's work in the Kingdom, which produced a realistic, if preliminary, appraisal of the groundwater resources in the region he examined. Ibn Saud asked Brown to stay on in Saudi Arabia with the agriculture mission, but Brown returned to America later in 1946. There Brown took charge of groundwater studies in Mississippi during 1946–47 and used his work in the Kharj district as his doctoral dissertation at Northwestern completed in 1949.[68]

While Glen Brown worked in Saudi Arabia, the Water Resources Branch continued to operate its principally domestic program. The Branch's Surface Water Division collected records of the stage, quantity, and availability of surface water at some 5,600 gaging stations in every State and in the Territory of Hawaii. Division hydrographers also advanced the ongoing special studies of the utilization and control of streams, investigations in connection with the Federal Power Commission, and those along the international boundaries. During fiscal year 1944–45, the Ground Water Division made periodic measurements of water levels or artesian pressure in about 7,000 observation wells, and continued investigations underway in nearly every State and in Hawaii. Studies of specific areas completed and published included Charles Jacob's analysis of precipitation and groundwater levels on Long Island that explained the potentiometric surface's retreat after recharge ended and demonstrated that aquifers' geohydrologic characteristics determined their responses to varying conditions during recharge and discharge. Division hydrologists pursued investigations designed to determine the depletion of groundwater caused by war industries and other war establishments, believed to total as much as several hundred billion gallons, and to provide against possible shortages. The Division's staff also looked at natural and artificial replenishment of groundwater supplies and at their maximum utilization for many prospective postwar demands. Members of the Quality of Water Division began cooperative studies of the chemical character of surface waters in Pennsylvania and Virginia and continued similar investigations in Florida, Georgia, Louisiana, New Mexico, North Carolina, and Texas. They analyzed chemically more than 6,900 water samples, many of them collected in connection with studies of water supplies for Army and Navy

establishments,[69] munitions plants, and housing developments. Albert Horton's illness ended the existence of his Division of Power Resources as a distinct unit. On March 31, 1945, the Division's functions passed to Royal Davenport's Division of Water Utilization; Horton died on April 22.

The Conservation Branch's work during fiscal year 1944–45 remained entirely domestic in its orientation but very much a part of the war effort as its members continued to supervise the production of mineral and energy resources, worth nearly twice 1939's sum, from public and Indian lands. The Branch, now with 210 full- and part-time persons (as of June 30, 1944), received $240,000 in direct appropriations, and almost $2,500, mostly from States, counties, and municipalities, for classifying the public lands. To the $557,000 Congress provided in direct funds for mineral-leasing activities, other Federal units, principally the Office of Indian Affairs (OIA) and the Navy, added some $108,000. The Branch used a total of nearly $907,500, about $51,500 more than in fiscal 1943–44, for work directed by its new Chief Harold Duncan. Secretary Knox agreed with Secretary Ickes' request to postpone from April 1943 to January 1944 the beginning of active duty for Hale Soyster, Herman Stabler's successor as Chief of the Conservation Branch since February 8, 1943, and a Lt. Commander in the Naval Reserve. The delay gave Soyster time to complete a reorganization of the Branch, to inspect its field operations, and to attend to some allegedly irregular personal concerns. Soyster left the USGS on January 27, 1944, for duty with the Bureau of Ships; the USGS officially furloughed Soyster for military service on April 20, and the Navy reassigned him to Captain Greenman's Office of Naval Petroleum and Oil Shale Reserves. Duncan, who succeeded Soyster as Chief of the Oil and Gas Leasing Division in April 1943, became the Conservation Branch's Chief a year later on April 11, 1944, replacing John Northrop, who acted in that capacity after Soyster's departure. Soyster died at Bethesda Naval Hospital on January 24, 1945.

All four of the Conservation Branch's divisions continued their work during fiscal year 1944–45. Members of the Water and Power Division supervised some 530 power projects, surveyed the topography of nearly 150 linear miles of streams and 8 dam sites, and acted on more than 2,200 case of hydraulic and waterpower classification. Power-site and reservoir-site reserves now totaled, respectively, nearly 6.8 million acres and about 137,000 acres. The Mining Division supervised operations on 572 public-land properties, 235 Indian properties, and 3 Secretarial authorizations. In addition, Division engineers served as consultants to the U.S. Department of Agriculture (USDA) on its mining leases and also supervised production of public-land minerals by the Metals Reserve and Defense Plant Corporations. The total output of minerals from the lands supervised by the division had a value exceeding $66 million. Oil and Gas Leasing Division personnel supervised operations on more than 7,000 properties on public lands, nearly 4,800 leaseholds on Indian lands, and, for the Navy Department, 31 properties under lease in NPR–1 and NPR–2. Income from all supervised petroleum operations on the public domain rose by some $127,000 from the previous year's total to about $3,674,000. Production of oil, natural gas, and natural gasoline and butane increased from the now 312 active NPR wells in California; their royalty value reached $600,000. In addition, investigations by the Division's four special-study groups aided secondary recovery operations and other engineering practices required for the conservation and maximum ultimate recovery of petroleum from public-land leases. The Mineral Classification Division's staff acted on more than 13,000 cases, an increase of 20 percent over the preceding year. The Division opened an additional regional office at Tulsa, Oklahoma. On June 28, 1944, Secretary Ickes began arranging for leasing, under the Mineral Leasing Act of 1920 and through advertisement, competitive bidding, or other regulated methods, of up to 640 acres each of the Nation's asphalt lands, but no person, association, or corporation could hold more

Petroleum engineer Harold Judson Duncan (born 1895), an Army veteran, spent 6 years in the oil industry before joining the USGS Conservation Branch and its Mineral Leasing Division shortly after the Branch's establishment in 1925. He supervised the Rocky Mountain (later Northwestern) District from Casper, Wyoming, during 1932–43. Duncan then served a year as Chief of the Oil and Gas Leasing Division in Washington before becoming the Chief of the Conservation Branch (later Division) in April 1944. He retired in August 1965, one month before Thomas Nolan resigned as USGS Director. (USGS photograph, Public Inquiries Office 63–12 [1b].)

than 2,560 acres.[70] Leases could be offered for up to 20 years in return for advance payments, increasing from the first (25 cents per acre) to the fifth ($1 per acre) years, and royalties of not less than 25 cents per ton. By the end of fiscal 1944–45, production from all public-land mineral and energy resources under Branch supervision rose to $150 million, royalties reached nearly $12 million, and the estimated value of the resources under lease climbed to more than $2 billion.

Congress remained in session until September 21, 1944, but national campaigning began just a few weeks after the Allies invaded Normandy. On June 27, the Republicans, meeting in Chicago, nominated for President Thomas E. Dewey, the Governor of New York, and nominated Ohio's Governor John W. Bricker as Dewey's running mate. The Democrats also convened in the Windy City on July 20. They selected Roosevelt for a fourth term after the President said he did not seek but would not refuse another call to service while the war continued. Roosevelt dropped Henry Wallace from the ticket. The President, convinced that James Byrnes' record also was a liability, picked Senator Harry Truman as his candidate for Vice President. Both parties supported winning the war and establishing an international organization to secure the peace.

In this interval, planning for postwar peace and security became more definite. On July l, delegates met at the United Nations Monetary and Financial Conference at Bretton Woods in New Hampshire to arrange for postwar development.[71] During a 3-week session, conferees from 44 nations, but not the Soviet Union, agreed to establish an International Monetary Fund of $8.8 billion to stabilize national currencies and foster world peace. Conferees also founded an International Bank for Reconstruction and Development, capitalized at more than $9 billion, to extend loans to nations requiring economic rehabilitation. President Roosevelt, in his budget message to the new 79th Congress on January 3, 1945, urged the legislators to act on the proposals for the International Bank and International Monetary Fund as "integral parts of a broad program for cooperation among the United Nations."[72] On February 12, Roosevelt again urged Congress to adopt the agreements. He called for improved international economic cooperation as the basis for expanding world trade that would also discourage any future attempt by any nation to achieve "the control of cartels and the orderly marketing of world surpluses of certain commodities." The President specifically recommended securing international understandings on "civil aviation, shipping, and radio and wire communication" and "an international oil agreement."[73] Secretary Ickes, in his article in *Collier's* for December 1944, noted the Truman committee's report that "consumption had increased 28 percent (1939–1944), [but] proven reserves have increased only 15.7 percent." Assuming a desired rate of production could be maintained, the committee estimated these reserves "would be equivalent to only about a 14 years supply, based on current consumption."[74] Congress, agreeing to provide one-quarter of the monies for the Fund and 35 percent of those required for the Bank, ratified the agreements on July 31, 1945.

During the American political conventions in June and July 1944, major military and political crises occurred in Japan and Germany. American forces, after heavy fighting, captured Saipan on July 13 but at a cost of more than 16,000 U.S. casualties, proportional losses far greater than those at Tarawa. Prime Minister Tojo and his Cabinet resigned 5 days later. General Koiso Kuniaki took Tojo's place, and Admiral Yonai Mitsumasa, briefly Prime Minister in 1940, became Navy Minister and Deputy Prime Minister. These changes seemed to favor political moderation but Koiso, Yonai, and other hard-liners continued the war. On July 21, marines and soldiers assaulted Guam; 4 days later, other marines landed on Tinian, just south of Saipan. These islands, captured by August 10, provided additional bases that placed American strategic bombers within range of the Japanese home islands.

In Europe, as the Anglo-American armies strove to break out of Normandy and the Soviets continued their summer offensive, German Army plotters again tried but again failed to assassinate Hitler. Those implicated in the July 20 plot included Field Marshal Rommel, badly wounded in his vehicle on July 17; 3 months later, Rommel swallowed poison to save his family and avoid a trial by the Nazi's People's Court. In Normandy, meanwhile, reinforcements brought into the line the U.S. 12th Army Group, commanded by General Bradley, and its 1st and 3d Armies, the latter led by General Patton. On August 1, Patton's forces broke through the German left flank in Normandy. Aided by the MGU's and other trafficability maps, 3d Army troops spread rapidly west and southwest toward Brest, and the other naval and air bases in Brittany, and moved swiftly southeast toward Le Mans. Repelling Wehrmacht counterattacks, they trapped some German elements in the Falaise-Argentan pocket and moved rapidly toward the Seine River. Free French forces liberated Paris on the 25th. American, British, and French units of the 7th U.S. Army landed in Operation Dragoon in southern France on August 15. Brigadier General Garrison Davidson, still the Chief Engineer, and Reuben Newcomb, who led a water-supply company, participated in the invasion. Seventh Army troops rapidly pursued the Germans up the Rhone Valley.

On August 21, representatives of the United States, Great Britain, the Soviet Union, and China began a series of meetings at Dumbarton Oaks in Washington to discuss a draft charter for the permanent international organization designed to preserve world peace and security. Secretary Hull gave the opening address. Because the Soviets were not at war with the Japanese, Russian and Chinese delegates met with the others in separate sessions. On October 9, the conferees published a draft as the basis for continued discussion at a later meeting but they failed to agree on a veto policy for the proposed Security Council.

While advances continued in Europe and in the Pacific, American and British representatives signed the agreement on international trade on August 8. President Roosevelt transmitted the agreement to the Senate on August 24 for consideration as a treaty. Before the Senate's Committee on Foreign Relations could schedule a hearing, however, individuals and groups connected with the petroleum industry began to lobby against the agreement. On December 1, Secretary Ickes established a Departmental Petroleum Committee[75] that included the Directors of the USGS and the USBM, the General Land Office's (GLO's) Assistant Commissioner, the Assistant Solicitor, and, as chairman, Edward B. Swanson, Director of the PAW's Research Division since 1941. Ickes asked the Committee to review and coordinate the petroleum work by Interior's agencies and to recommend changes to increase effectiveness. On January 10, 1945, Roosevelt asked the Senate to remove the trade agreement from its legislative calendar, so that he could have it revised to eliminate any grounds for misunderstanding.

Also in August 1944, Congress began considering bills to change Byrnes' Office of War Mobilization (OWM) to the Office of War Mobilization and Reconversion (OWMR) and to regulate the disposal of surplus property if the war ended before the legislators enacted measures for permanent stockpiles. Congress passed both bills on October 3. The Surplus Property Act authorized any Federal agency to dispose of unneeded acquired lands. The new law also provided that federally owned strategic minerals and metals, when determined to be surplus, would be transferred to the Treasury's Procurement Division. The statute covered "copper, lead, zinc, tin, manganese, chromite, nickel, molybdenum, tungsten, mercury, mica, quartz crystals, industrial diamonds, cadmium, fluorspar, cobalt, tantalite, antimony, vanadium, platinum, beryl, graphite (and to which may be added aluminum or other minerals or metals in such quantities or amounts as the Army and Navy Munitions Board may determine to be necessary for the stockpile authorized by the Act of June 7, 1939)."[76] The new law also required the Army and Navy Munitions Board

to submit within 3 months a report to Congress recommending the maximum and minimum amounts of each strategic mineral or metal that, in its opinion, should be held in the stockpiles authorized in 1939. Roosevelt's Executive order,[77] issued the same day, transferred all records and property of the OWM at the pleasure of the Bureau of the Budget's Director. The War Production Board again reduced its stockpile objectives on October 31 to 3 months' total requirements or 6 months' imports, whichever was greater. At the same time, the WPB broadened the stockpile formula for federally held materials to include industry stocks in excess of safe working inventories. In March 1945, bills to amend the Strategic Materials Act of 1939 were introduced in both houses of Congress.

In mid-August 1944, the War Production Board authorized a partial conversion of war industries to civilian output. The WPB then underwent another metamorphosis in its top management. Late in August, WPB Chairman Donald Nelson departed on a special mission to China, as the President's personal representative, and Executive Vice Chairman Charles Edward Wilson resigned in September. Wilson, still known as "Electric Charlie," to distinguish him from General Motors' president Charles Erwin ("Engine Charlie") Wilson, returned to the presidency of General Electric that he left in September 1942. Vice Chairman Julius Krug, who led the WPB's Office of War Utilities and served as a Lt. Commander in the Navy since April, succeeded Wilson as the WPB's Acting Chairman. Krug became Chairman when Roosevelt accepted Nelson's resignation early in October. Although Krug made many changes in the WPB's personnel after September 1944, Charles Leith remained Chief of the Metals and Minerals Branch of the Office of Production Research and Development. Leith, Alan Bateman, and Foster Hewett continued as members of the Minerals and Metals Advisory Committee.

During this interval, Gifford Pinchot, who successfully opposed Harold Ickes' efforts to establish a department of conservation and public works, suggested to President Roosevelt that he convene in Washington a conference of united and associated nations to try to reach an international consensus about a worldwide policy for the conservation and use of natural resources.[78] Pinchot hoped that this conference would, like those at Bretton Woods and Dumbarton Oaks, yield results to aid securing a permanent peace. On October 24, Roosevelt sent Pinchot's idea to Edward Stettinius, Jr., who succeeded Sumner Welles as Under Secretary of State in 1943 and since then often served as Acting Secretary during Cordell Hull's illnesses. Stettinius, replying on November 10, favored making conservation part of a planned international discussion of economic policy under the auspices of the United Nations Economic and Social Council. Roosevelt disapproved, insisting on November 22 that the State Department "failed to grasp the real need of finding out more about the world's resources and what we can do to improve them."[79] Pinchot again appealed to Roosevelt on March 28 and April 10, 1945, the latter date just 2 days before the President died at Warm Springs, Georgia.

As discussions continued during 1944 about the wisdom of holding an international conference on conservation and resources, the Allies military position further brightened. The Allied armies crossed the Seine on August 27. Eisenhower favored an advance on Antwerp to replace the port facilities at the now distant Cherbourg and the Normandy beaches. Allied forces captured the Channel ports and the fixed sites in the Pas-de-Calais for the German V–1 cruise missiles launched against Britain since June 13. When the Allies subsequently overran the sites for V–1s in Belgium, Holland, and easternmost Germany, Luftwaffe crews continued to deploy these relatively inexpensive, 150-mile-range missiles from aircraft until December 24. The Allies captured Brussels on September 3. On the next day, they liberated Antwerp and its port wrecked by the Germans, who still held its approaches in the Scheldt estuary. The port reopened on November 27.

In September, the Germans added to their new aerial blitz the V–2 ballistic missiles—liquid-fueled, multistage, 46-foot-tall rockets, launched from ingenious transporter-erectors—that delivered a 1-ton warhead of conventional explosives. Historian Michael Neufeld described and analyzed how in the 1930s a German Army team, led by Captain (later Generalmajor) of Artillery Walter R. Dornberger and including designer-engineer Wernher M. von Braun, developed the later versions of the A-series of four liquid-powered rockets. Von Braun chose Peenemünde as a site for continued development and tests. The team moved there in 1937, successfully test-fired their gyroscope- and radio-controlled A–4 (V–2) rocket on October 3, 1942, and refined it during the following year to extend its range to 220 miles. On September 8, 1944, the Germans began launching the V–2s as a second terror weapon against London and Antwerp. Fighter aircraft and antiaircraft guns, aided by proximity fuse ammunition, shot down some of the V–1s during their 400-mile-per-hour flights, but those defenses proved helpless against airborne V–2s that reached 4 times the speed of sound during their 60-mile-high trajectories. British deceptive measures, however, did succeed in moving the Germans' general target areas to less populated locales. German Army crews continued to launch the V–2 missiles, nearly 2,000 in all, until March 27, 1945.[80]

The Germans' new attacks by air did not slow the Allied advances on the Continent. Allied forces in southern France linked up with Patton's 3d Army at Dijon on September 11, 1944; 4 days later, the U.S. 7th Army and French 1st Army were joined in the new 6th Army Group. American troops liberated Luxembourg and closed on the Siegfried Line in mid-September, although gasoline shortages severely limited their mobility. The Germans defeated an combined airborne-ground attempt during September 17–26 by Montgomery's troops to turn the Wehrmacht's northern flank by capturing Arnhem, but Allied forces, now more than 2 million strong, assaulted the Line on October 1, hoping to destroy German units west of the Rhine. By mid-December, the best gains came in the south, where Patton's troops took Metz and units of the 6th Army Group reached the Rhine in several places. On the Eastern Front, Soviet troops swept across eastern Poland to the gates of Warsaw, but then they stood by in August and September as German SS units crushed a revolt within the city by anticommunist underground forces. The Soviets concluded armistices with Romania on August 23 and with Bulgaria on September 8. Soviet forces occupied Bucharest and the damaged oil fields and refineries at Ploesti. When the Luftwaffe bombed Bucharest, Romania declared war on Germany. In the Balkans, Soviet and Bulgarian troops, and partisans led by Josip Broz (Tito), captured Belgrade on October 20 and advanced toward the Danube and Budapest. Soviet armies in the north reached the Baltic near Memel, cutting off German forces in Latvia.

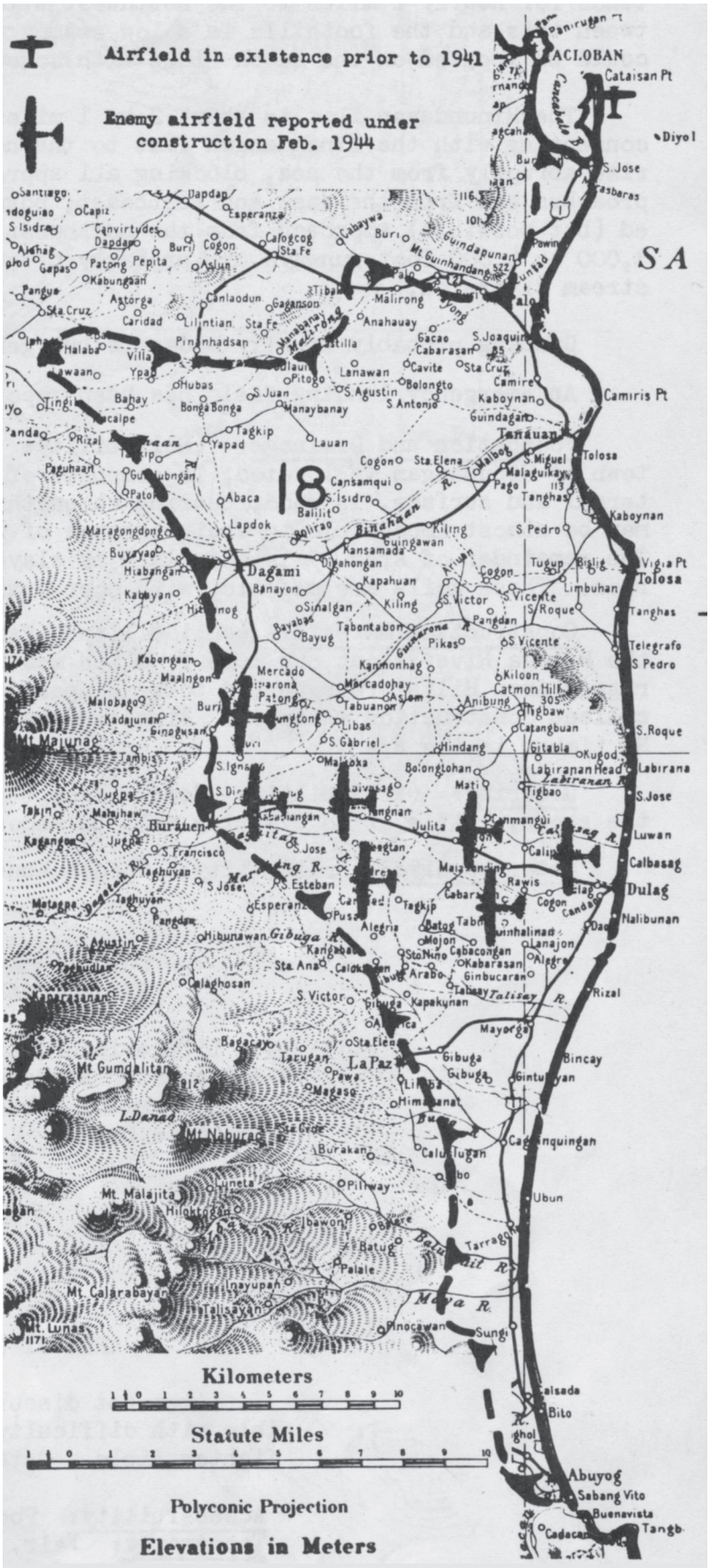
As the American part of the Allies' campaign in France progressed, the advance toward the Rhine River led to requests for a summary of Germany's coal deposits and for terrain reports for the anticipated U.S. sector of Germany. SHAEF's Information Section moved to Rennes in August 1944 and then to Paris in September. Using German printed sources and recent aerial photographs, the Section's staff prepared reports for each of four 1:250,000 map sheets covering an area in Germany west of the Rhine. The maps classified the terrain into five categories of expected movement and also showed corridors and additional obstacles. The Section's members also assessed the Rhine's bottom sediments and adjacent quarries, studied the foundations of the river's bridges destroyed or damaged by Allied or German actions, and produced 1:100,000 trafficability maps of the Lower Rhine Plain. When Edwin B. Eckel and two other members of the MGU arrived in Paris, on an engineering geology "mission not directly connected with current military operations," and "saw the limited facilities of the military-geology group in

the Information Section,"[81] they offered the MGU's help. Beginning in mid-January 1945, the MGU prepared for the Information Section 1:100,000 trafficability maps that displayed slope and soil factors for the entire U.S. sector north of the Alps. In April, additional 1:100,000 maps of the Bavarian and Austrian Alps addressed Eisenhower's concern about an effective last-ditch resistance from a National Redoubt in those ranges.

In the Pacific, the Allies also moved ahead of their original schedule. Roosevelt, Leahy, MacArthur, and Nimitz met at Pearl Harbor in July 1944 to plan new offensives against Japan. The President, moved by considerations both military and political, allowed MacArthur and his staff to plan for recapturing the Philippines, which the Navy now wished to bypass, beginning with Mindanao. Roosevelt authorized Nimitz and his staff to prepare to invade Yap, follow with a joint assault with MacArthur's troops on Leyte (in December), and go on to take Iwo Jima (Sulfur Island) and then Okinawa. Between April 27 and July 30, MacArthur's troops captured additional Japanese bases on and islands off New Guinea. MacArthur's forces invaded Morotai, northwest of New Guinea, on September 15, the same day the III Amphibious Corps' marines attacked Peleliu in the Palau Islands. U.S. Navy aircraft supported both operations and also raided Yap and the Philippines. Other American units occupied Ulithi, another atoll in the Carolines to the northeast and near Yap, and turned Ulithi's lagoon into the Navy's major fleet anchorage in the Western Pacific.

On the Asian Continent, meanwhile, Japanese troops started a major offensive in May against Allied tactical- and strategic-bomber fields in eastern China. From some of these forward airstrips, Boeing B–29 Superfortresses, the new strategic bombers successfully promoted by General Arnold in a $3 billion program, of XX Bomber Command began to attack targets in Formosa, Kyushu, and southern Manchuria in June. By November, the Japanese captured 7 of the 12 Chinese bases used as staging fields by B–29s flying from Calcutta and Assam. To increase the economy and effectiveness of the raids on Japan, Arnold authorized the transfer in October of XX Bomber Command, now under Major General Curtis E. LeMay (who led the Regensburg raid), from India to the new operational fields in the Marianas, already the home of the B–29s of XXI Bomber Command. LeMay took over XXI Bomber Command and, in November, began a series of high-altitude raids on Japanese industries. The B–29 crews, struggling against the jet stream, icing, fog, and Japanese fighter aircraft from Iwo Jima and Japan, incurred losses as high as 6 percent on these missions.

On September 10, 1944, as the Allies advanced in Europe and the Pacific, Roosevelt, Churchill, and their military staffs met in the Octagon Conference in Quebec. The leaders agreed to continue concentrating on the campaign in France and avoid additional efforts in southeastern Europe, where Churchill continued to believe that an American and British presence would better position them for dealing with the Soviets in the postwar world. As some of the attendees thought that Germany would surrender by year's end, the conferees also planned for occupation zones in Germany and how to govern that country. In late October, the Big Three agreed to recognize General de Gaulle's Committee for National Liberation as France's provisional government. The British, also heavily involved in recapturing Burma, promised to cooperate fully in defeating Japan in the Pacific; the Combined Chiefs of Staff estimated that victory there could be won in 18 months. When Admiral Halsey's pilots encountered lighter-than-expected resistance by Japan's depleted air forces in the Philippines, Halsey recommended and Nimitz approved canceling the invasions of Mindanao and Yap and moving up the date for the landings on Leyte. Nimitz also offered to loan ships and troops to aid MacArthur's forces and sent the proposals to the Joint Chiefs of Staff (JCS). MacArthur, as urged by the JCS, accepted Nimitz's offer.



This map (originally at about 1 inch = 4 miles) of Area 18 (Tanauan) on eastern Leyte in the Philippines was prepared by the USGS Military Geology Unit (MGU) as part of its Strategic Engineering Study (SES) folio 131. The map includes the invasion beaches, inland terrain, and airfields built before 1941 or in progress by February 1944. The airfields included the seven under construction by the Japanese in the central part of Area 18 between Dulag and Burauen. Runways on those fields were expected to be up to 6,000 feet long and capable of accommodating two-engine aircraft. In August 1944, maps in SES 131 depicted the airdrome sites, climate, construction materials and maintenance, geology, soils, terrain, vegetation, and water supplies of Samar and Leyte. The MGU produced SES folios for all of the Philippines' major islands. (From U.S. Geological Survey, Military Geology Unit, 1944b, p. 55; also published in Nelson, C.M., and Rose, E.P.F., 2012, fig. 6.)

This low-oblique photograph, a view looking northwest, shows the prewar airfield at Cataisan Point in eastern Leyte. Tacloban is in the middle distance at left. In 1944, the USGS Military Geology Unit (MGU) assessed the airfield, with its less than 5,000-foot-long runway for single-engine aircraft, as good but decided that the runway could not be lengthened to accommodate larger planes. Unlike the Sicily folios, Strategic Engineering Study (SES) 131 for Samar and Leyte used recent Allied aerial-reconnaissance photographs to supplement the ground images, maps, and tables. (Photograph from U.S. Navy, Office of Naval Intelligence, 1657574; printed in U.S. Geological Survey, Military Geology Unit, 1944b, p. 55; also published in Nelson, C.M., and Rose, E.P.F., 2012, fig. 7.)

The MGU and Gilluly's team assessed terrain on all the Philippine islands, concentrating on selected sites and areas in eastern Leyte. On October 20, 1944, troops of the U.S. 6th Army's X and XXIV Corps landed on the northeastern shore of Leyte, between Dulag and Tacloban, the island's administrative center. An Engineer Terrain Intelligence team and an Army water-supply section accompanied each Army division. The Army forces, supported by Navy gunfire and aircraft, moved inland against units of the single Japanese division, later heavily reinforced, that garrisoned Leyte and into difficult terrain, heavy vegetation, and then the rainy season to capture existing airfields and sites recommended by Gilluly's team. Gilluly, Putnam, and Sayre landed on Leyte on D+1 and served under fire with the 5201st Engineer Construction Brigade. Sayre's work there earned him the Army's Medal of Freedom. The improved but still small airfield at Tacloban reopened in mid-October; those at Dulag (improved) and Tanauan (new) began operations in late November and mid-December; Burauen and the two other sites to the west were abandoned.[82] Gilluly's group worked at Tacloban, aiding planning for the invasion of Luzon, while operations continued until western Leyte fell late in December. The U.S. 6th and 8th Armies assaulted Luzon in January 1945. Gilluly's team shifted to Manila, after the city was secured on 4 March, before returning to the United States.

The Japanese thought keeping the Philippines, no less than Formosa and the Ryukyus, vital to maintaining the flow of oil and other materials from the Southern Resources Area, and so they fought all out for Leyte. The Imperial Army reinforced its garrison on the island, and the Imperial Navy sortied to crush the U.S. 7th Fleet that supported MacArthur's forces ashore. The Japanese plan, no less complex than

theirs at Midway, drew on four groups of warships in harbors in Borneo, Malaya, Japan, and the Ryukyus. As in the Midway and Philippine Sea battles, the Japanese plan fell apart after operations began. In four separate actions with Admiral Halsey's 3d Fleet and the 7th Fleet, a total conflict larger and far more decisive than Jutland in World War I, the Japanese lost 4 fleet carriers and 3 other capital ships, 23 smaller warships, and more than 500 planes. Complete control of the waters around the Philippines passed to the U.S. Navy, at a cost of 3 small aircraft carriers, 3 smaller warships, and some 200 planes. Japanese kamikaze ("divine wind") aircraft initially appeared in planned suicide sorties during the battle's later stages; thereafter they attacked in increasingly greater numbers and effectiveness. Leyte fell to MacArthur's 6th Army on December 25, at a cost of nearly 16,000 American casualties; the Japanese lost more than 70,000 men. By then, 6th Army forces continued their attack on Samar and captured Mindoro, where Army Engineers promptly built the needed airstrips to support MacArthur's return to Luzon.

While the struggle for Leyte continued, OSRD Director Vannevar Bush (who appeared as General of Physics on the cover of *Time* for April 3, 1944) continued to oppose the new agency for scientific and technical mobilization proposed by Senator Kilgore and other Members of Congress earlier in 1944. On November 17, after more than a month of administration preparations approved by Harry Hopkins, Roosevelt asked Bush for his own views on such an agency. Roosevelt, in his letter to Bush, who reviewed a draft version, claimed that

> **[n]ew frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life.[83]**

The President termed the OSRD "a unique experiment of team-work and cooperation in coordinating scientific research and in applying existing scientific knowledge to the solution of technical problems paramount in war." He then asked Bush to apply profitably OSRD's lessons "in times of peace"[84] by giving him personally Bush's considered judgment, after consulting "with your associates and others" on four principal questions. Roosevelt inquired what could be done (1) "consistent with military security, * * * to make known to the world as soon as possible the [wartime] contributions * * * to scientific knowledge," (2) "to organize a program" to continue the war work "done in medicine and related sciences," (3) to provide Federal aid to "research activities by public and private organizations," and (4) to propose "an effective program * * * for discovering and developing scientific talent in American youth," to assure that the country maintained scientific research comparable to that "done during the war."[85]

Congress reconvened on November 14, just a week after President Roosevelt's reelection to a fourth term. The polling proved closer than in 1940, but Roosevelt still beat Dewey by nearly 3.6 million popular votes and 333 electoral votes.[86] Although the Democrats lost two seats in the Senate, they easily retained control of that body; they gained 24 seats in the House to increase their margin there to 52. Roosevelt's special message to Congress on September 20 asked the legislators to establish a Missouri River Basin Authority similar to the TVA, but the legislators took no action before recessing the next day. The Senate took up the flood-control bill passed by the House in May. Rather than begin an authority for the Missouri, the Senators wrote into the flood-control bill a joint plan for that river basin prepared by the Army Engineers and the Bureau of Reclamation. The Senate amended the bill to require that its authorized projects should not conflict with navigation of waters arising in States lying wholly or partly west of the 98th meridian or with any beneficial use of these waters for domestic, municipal, stock-raising,

irrigation, mining, or industrial purposes. The bill fully established the principle of multipurpose development for Federal reservoirs by providing for hydroelectric power and irrigation where feasible on Army Engineers' projects and also, for the first time, recreational facilities. Both houses passed the amended bill on December 12, and Roosevelt signed it into law 10 days later. The Flood-Control Act of 1944 authorized projects in many parts of the United States as well as formally approving the Pick-Sloan Plan for the Missouri River Basin; the new law provided for the most comprehensive river program yet undertaken.[87] The statute also authorized appropriations of $200 million each to the USBR and the Army Engineers. Working together, the two agencies planned to build more than 100 new dams, some 150 irrigation units to serve about 6 million acres, 30 powerplants with 2.5 million kilowatts of capacity, and hundreds of miles of levees and dikes. Their effort would furnish water supplies for at least 19 cities and deepen the river to provide 760 miles of uniform navigation.

Two days before Roosevelt signed the Flood-Control Act, Wrather took another step in strengthening his staff and developing the USGS postwar persona by announcing on December 20, 1944 (effective the next day), the appointment of Thomas Nolan to fill the newly established position of Assistant Director. Nolan later decided Director Walter Mendenhall "was about the best Director the Survey ever had * * * in providing both personal and scientific leadership,"[88] but Nolan, wishing to continue active fieldwork, declined Mendenhall's request to become his principal deputy in 1942. "I would have done the same thing with Wrather," Nolan later recalled, "if he hadn't been so new."[89] In the midst of war and with USGS postwar organization at stake, Nolan decided he could not, "out of the sense of duty," refuse Wrather's request. "We all liked Bill Wrather" but, Nolan continued, "he wasn't, first of all, familiar with the Survey programs and people, and, second, he was unaccustomed to managing or administering a large organization."[90] Nolan would, Wrather said,

> **serve as principal assistant to and deputy of the Director, with commensurate authority, in the general administration of the Geological Survey with particular reference to the planning and preparation of broad programs of scientific and engineering work, to coordination of the functions of the several operating branches in the execution of such programs, and to making the results of the Survey's work more widely useful to other Federal and State agencies and the public.[91]**

Nolan would "also act as representative and deputy of the Director to serve on official or technical committees or in conferences with officers of the Department, of other Federal agencies, or of cooperating State agencies."[92] In essence, the Director delegated to the Assistant Director the supervision of internal operations and reserved to himself only the broader phases of congressional, public, and professional relations. "In corporate terms, Nolan was the Chief Executive Officer of the Survey and Wrather the Chairman of the Board."[93] Wrather handled the congressional budget hearings, most other "outside relationships," and "presided at the Advisory Committee meetings"[94] convened at his request. As suggested by Secretary Ickes and the National Academy of Sciences (NAS), Wrather also formed the five-member USGS Science Advisory Committee. The new Committee included Donald McLaughlin, president of Homestake Mining, as chairman; Eliot Blackwelder, professor emeritus at Stanford; William Heroy, a partner in Beers and Heroy and vice-president of the Geotechnical Corporation; Morris M. Leighton, chief of the Illinois State Geological Survey and an adviser to the War Production Board and the Navy; and Abel Wolman, professor of sanitary engineering at Johns Hopkins, a consultant to the WPB, and an adviser to the Army, the Navy, and the

National Resources Planning Board. The USGS Science Advisory Committee also met with Ickes while in Washington, but they received no Federal funds for travel to or service in the Capital. Nolan appeared at the BoB hearings, which usually sought more details about USGS programs than the congressional appropriations subcommittees, and occasionally represented Wrather at other committees' meetings. The pair also developed a policy of alternate visits to field sites, to gain perspective and try to raise morale, so that one of them "would always be in Washington."[95] In working regularly with Nolan, Wrather quickly found that "I could nearly always agree with his judgment."[96]

On January 2, 1945, less than 2 weeks after President Roosevelt signed the Flood-Control Act, the Army and Navy Munitions Board (ANMB) submitted its report on strategic and critical materials as required by the Surplus Property Act. In addition to the mineral commodities listed in the act, the ANMB believed that several fibers, chemicals, drugs, and oils also should be stockpiled. Strategic and critical materials, as defined on March 6, 1944, included the materials required for essential uses in a war emergency when their procurement in adequate quantities, qualities, and times would be sufficiently uncertain for any reason to require prior provision for supplying them. Using that definition, the ANMB grouped strategic and critical materials into categories A, B, and C. Category A included materials for which stockpiling seemed the only satisfactory means of ensuring an adequate supply for a future emergency: asbestos (Rhodesian chrysotile and South African amosite), bismuth, celestite, columbite, corundum, iridium, kyanite, monazite, rutile, sapphire and ruby, talc, and zirconium ores. Category B comprised commodities whose stockpiling was practicable; the ANMB recommended their acquisition only to the extent that they might be available for transfer from Federal agencies because adequate supplies could be ensured either by stimulating North American production or by partially or completely using available substitutes. Category B included bauxite, English chalk, emery, osmium, palladium, rhodium, ruthenium, selenium, and ground steatite. Category C held commodities not recommended for permanent stockpiling because storage difficulties outweighed any advantages gained thereby. These items comprised asbestos (Canadian chrysotile), iron ore, petroleum and petroleum products, radium, and iron and steel scrap. Although category C's materials could not be stockpiled, the ANMB noted that the availability of adequate supplies for future emergencies required advance planning of stocks.

The ANMB recommended constant review and revision of lists of strategic and critical materials, and of stockpile objectives, to reflect technologic developments and shifts in political and economic factors that affected the materials' strategic status. For some of the materials in categories B and C, the members felt that constant checks would best be secured if the military maintained permanent advisory committees of technical personnel from industry and Federal civilian agencies. In March 1945, the chairmen of the Committees on Military Affairs of the Senate and the House of Representatives introduced identical versions of a bill to amend the Strategic Materials Act of June 7, 1939, that related to acquiring stocks of strategic and critical materials for purposes of national defense. The bill would establish a permanent stockpiling program to include freezing postwar surplus stocks of strategic and critical materials, procuring adequate additional supplies after the war ended, and encouraging the conservation and development of sources of these materials within the United States.

Two months earlier, on January 6, President Roosevelt concluded his State of the Union Message by suggesting that "1945 can be the greatest year of achievement in human history." Roosevelt hoped the new year would see the end of the "Nazi-Fascist reign of terror in Europe," the closing in of forces "about the center of the malignant power of imperialistic Japan," and "the substantial beginning

of the organization of world peace."[97] A few days later, the President's budget message indicated that actual expenditures during the fiscal year beginning July 1 depended on the course of the war. Estimates of war expenditures were less than in the preceding year, ranging from $60 billion to somewhat more than $80 billion. More money would be spent for other purposes than in any fiscal year since 1939. Roosevelt, in his fourth inaugural address on January 20, again promised to "work for a just and honorable peace, a durable peace. * * * We can gain it only if we proceed with the understanding and the confidence and the courage which flow from conviction."[98]

As Congress debated the new stockpiling bills in March 1945, few doubted that the war in Europe was nearing its end. The Kriegsmarine's development for its U-boats of acoustic torpedoes, multiple antiaircraft guns, snorkel devices to recharge batteries while submerged, advanced but passive detectors of radar and sonar, hydrogen-peroxide fuel, and more streamlined hulls did not achieve victory in the Battle of the Atlantic or in battles in other oceans, during which nearly 650 boats and most of their crews were lost. Allied bombs, gunfire, and mines left a heavy cruiser as the Kriegsmarine's largest operational warship. Allied 1,000-bomber raids continued on German military and civilian targets; the one on Dresden, during February 13–14, created a firestorm, like Hamburg's in 1943. Even the new Me-262 jet fighters and the rocket-powered and delta-winged Me-163 Komet interceptors did not enable the Luftwaffe to regain air superiority over Germany. Plagued by fuel shortages, incompletely trained pilots, and heavy losses, the Luftwaffe could not even delay the Allies' aerial onslaught.

Hitler and his Wehrmacht did not end their struggle without mounting one last major offensive, this time in the West. In December 1944, Roosevelt promoted Leahy, Marshall, King, MacArthur, Nimitz, Eisenhower, and Arnold (in that order of seniority) to five-star rank to mark the value of their contributions toward victory; Halsey's similar promotion followed a year later. Eisenhower learned of his advancement to General of the Army on December 16, just hours before the Germans shattered Allied optimism and complacency by attacking thinly spread American forces along an 80-mile front in the Ardennes in Belgium and Luxembourg. Hitler planned to have his troops split the Allied army groups in the West, drive to Antwerp, and solve the Wehrmacht's desperate need for fuel by capturing some of the Allies' vast stores of gasoline now stockpiled in Belgium. The Germans waited for an interval of bad weather to ground the Allied air forces before beginning their assault. Although initially successful in the Battle of the Bulge, the German drive stalled on the penetration's flanks, especially at the rail and highway junctions at Bastogne and St. Vith. When skies cleared on the seventh day of the offensive, Allied planes filled the air and attacked everything German. The next day, Patton's realigned 3d Army began the Allied counterstrokes that halted the Wehrmacht's advance on Christmas and repelled it after New Year's Day. Before January 20, the Germans were back where they started, having lost 100,000 men, 600 tanks and armored artillery, many other vehicles, and most of their remaining aircraft. Allied losses from all causes exceeded 60,000 men and more than 700 armored vehicles, but their armies then pushed deeper into the Rhineland and the Ruhr. To the east, Soviet forces, advancing steadily westward, reached the Oder River on the last day of 1944 and captured Warsaw on January 17, 1945.

As Soviet forces moved toward Berlin, Roosevelt, Churchill, Stalin and their principal diplomatic and military advisers met in the Magneto Conference at Yalta in the Crimea during February 4–11. Roosevelt, now obviously ill,[99] ignored Churchill's warnings about Soviet intentions worldwide and continued the efforts he began at Tehran to charm and manipulate Stalin as he did so many American

and other politicians. When the President failed to do either, he decided to compromise by recognizing existing realities, including the Soviet forces in most of Poland, Hungary, and Yugoslavia. The Big Three's specific discussions at Yalta, many of which were not made public until after the war ended, related mostly to the time after combat stopped in Europe, the postwar borders of Poland and some other European countries, the disposition of territory and resources in the postbellum world (including four occupation zones in Germany and Austria and four occupation sectors in Berlin and Vienna), and the conduct of the United Nations. Stalin repeated his pledge to enter the war against Japan, after Germany's surrender, in return for territory and influence in the Far East and in Eastern Europe. The leaders reaffirmed their unconditional-surrender formula and pledged themselves to install freely elected postwar governments in all the liberated countries of Europe. They also agreed to send representatives to San Francisco to discuss on April 25 the United Nations Charter and try to resolve several remaining differences, including the nature of voting in the Security Council.[100]

Roosevelt, in reporting to Congress on March 1 the results from Yalta and from his meetings with King Ibn Saud of Saudi Arabia, King Farouk of Egypt, and Emperor Haile Selassie of Ethiopia, asserted that "We have made a good start on the road to a world of peace."[101] The President assured the German people that unconditional surrender did not mean "destruction or enslavement" but it did require "temporary control" by the Big Four, the end of Nazism, "complete disarmament,"[102] and "reparations in kind for the damage which has been done to the innocent victims of its aggression." "The final decisions"[103] about areas "of political confusion and unrest,"[104] the President cautioned, "are going to be made jointly; and therefore they will often be the result of give-and-take compromise"[105] for "a more stable political Europe than ever before."[106] In the Pacific, Roosevelt added, "It is still a long, tough road to Tokyo," but "the unconditional surrender of Japan is as essential as the defeat of Germany."[107] Destroying both militarisms would keep "the sons and grandsons of these gallant fighting men" from having "to do it all over again in a few years."[108] "On the problem of Arabia [Palestine]," Roosevelt noted, "I learned more about the whole problem—the Moslem problem, the Jewish problem—by talking with Ibn Saud for five minutes than I could have learned in the exchange of two or three dozen letters."[109] The President did not report the King's query about giving Arab lands to the Jews or his suggestion that the Jews instead receive lands in Germany. Roosevelt also did not mention Ibn Saud's warning that the Arab countries would fight to prevent any increase in or further dispersion of the Jewish population in Palestine, beyond the British-specified areas, and respond in kind if Jews killed Arabs. Less than 2 weeks after the Yalta conference, delegates from 20 Latin American countries convened in Mexico City at the Inter-American Conference on Problems of War and Peace. Conferees signed the Act of Chapultepec to enhance regional security until the global conflict ended.

On March 1, 1945, the House appropriations subcommittee began its hearings on the Interior Department's budget for fiscal year 1945–46. Secretary Ickes, while appearing before the subcommittee, expressed his concern regarding the Nation's policy about and supplies of mineral resources and about the related roles by Interior and the USGS during the postwar interval:

> **We will be required, after this war, to make important decisions concerning the extent to which our mineral supplies will meet our needs for a period of years; the degree within which foreign sources should be utilized; and the amount which we should maintain in reserves of strategic minerals. The programs of this Department dealing with the discovery and recovery of strategic minerals should be considered in the light of this country's need for the development of a long-term mineral resources policy.[110]**

Ickes also recalled that:

> **This war caught us with most inadequate knowledge of our topography and our water resources. As a result, millions of dollars have been expended under emergency conditions to obtain information essential to the location and construction of military reservations and war production facilities. * * * There is no means of accurately measuring the total losses which have resulted from planning structures and facilities without proper knowledge as to terrain or the surface and ground water available to serve such facilities, but it is certain that it represents many times the amount of money which would have been involved in obtaining and maintaining the topographic and water resources data which are essential to sound engineering planning.**[111]

The budget estimate for Interior for fiscal year 1945–46, $133 million, exclusive of the amount for the Solid Fuels Administration for War and the War Relocation Authority, clearly anticipated a relatively early end to the war in providing for an increase of more than 50 percent over the amount in the previous year's request. Interior's estimate included nearly $1,073,000 to support development in Alaska. Ickes presented the new program as a postwar effort in the Territory "to fill gaps in available information, to provide for intensive work in the areas considered most favorable for immediate settlement, and to examine the possibilities for servicemen and other settlers to develop agricultural, aquatic, mineral, and timber resources as a means of livelihood."[112] The USGS estimate totaled some $8,555,000, an increase of more than $1.8 million over the appropriation for the year underway. Its three largest items were $3,075,000 for topographic surveys, nearly $1,896,000 for streamgaging, and about $1,338,000 for geologic surveys, but only the first two included substantial increases; most of the items, except for publication costs, actually had been reduced. Interior's Alaska development program included $410,000 for topographic mapping, streamgaging, mineral-resource studies, and classification of lands by the USGS, bringing the total requested for the agency to about $8,965,000.

As the House subcommittee evaluated Interior's budget request, the Allies continued their successful advances on all fronts. In Europe, Allied units crossed the Rhine at Remagen and completed plans to break through Italy's Gothic Line in April. Finland joined the Allies. The Soviets cleared Poland and continued advancing toward Berlin and Vienna. In Southeast Asia, the Army Engineers completed the Ledo Road and its accompanying oil pipeline.[113] Major General Raymond A. ("Spec") Wheeler supervised that work and the construction of the Assam airfields from December 1942. Wheeler, the principal Allied administrative officer in the theater from November 1943 and a Lt. General in February 1944, became Admiral Mountbatten's deputy commander in November. Brigadier (later Major) General Lewis Pick directed on the ground the 2-year completion of the road that linked the Assam railhead at Ledo with Mogaung station on the Burmese railway. After the Allies captured the railway's northern terminus at Myitkyina, Pick's Army Engineers extended the Ledo Road through Bhamo to tie it to the new road from Kunming built by American troops and Chinese laborers that opened late in January 1945. The initial convoy over the Ledo-Burma Road reached Kunming on February 4, reducing the load carried by the USAAF's transports that lifted personnel and supplies from Assam over the Himalaya's 15,000-foot-high "Hump" to China. In central Burma during March, British and Commonwealth troops recaptured Mandalay, the former capital, Meiktila, and the Yenangyaung oil fields. Continuing south, they retook Rangoon on May 3.

In the Philippines, units of the U.S. 6th Army began landing on Luzon at Lingayen Gulf on January 9 and moved south, reinforced by the 8th Army. After bitter fighting, MacArthur's soldiers freed Manila on March 4. U.S. troops captured

Corregidor on April 17 and then continued operations northward into the mountains. Charles G. Johnson, assigned to the staff of the 6th Army's Chief Engineer, received the Medal of Freedom for his work with the troops in northern Luzon. The Japanese lost 200,000 men during the campaign; American casualties totaled about 40,000.

In March 1945, as Gilluly's team left MacArthur's command, the MGU organized a similar but larger group to replace them. General Casey returned to the Philippines as Chief Engineer of MacArthur's Southwest Pacific Area and (later) Army Forces Pacific. He established the MGU team as a separate Section with completely delegated responsibility under a new standing operating procedure that defined its missions, organization, responsibilities, and work. Fritiof Fryxell led the second team to Manila. Fryxell, as Chief of the Research Division, reported to Major (later Lt. Colonel) Hubert G. Schenck, head of the Branch of Research and Reports in the Intelligence Division, and on leave from Stanford since 1943. Fryxell led the terrain research by two teams as part of Allied preparations for Operation Downfall, the invasions of two of the Japanese home islands intended to force a nationwide surrender. Fryxell's Team 1—USGS geologists Walter White and Vincent McKelvey, Army Captain Roger Baker, War Department geologist George Kemmerer, soils scientist James Thorp of the USDA's Soil Conservation Service (SCS, now Natural Resources Conservation Service), and Australian Leopold W. Stach—evaluated southeast Honshu's Kwanto Plain and reported their preliminary results on July 15 to the generals planning Operation Coronet, scheduled to begin in March 1946. Team 2, a group of Army Engineer officers, assessed southern Kyushu as part of plans for Operation Olympic set to commence in November 1945.

During 1944–45, the MGU in Washington also provided strategic-intelligence studies for Kyushu (SES 125, at 1:900,000 and, separately, at 1:250,000, its southern and northern halves), Honshu (SES 126, 1:1,250,000), the Tokyo area (SES 174, 1:250,000), Hokkaido (SES 127, 1:1,000,000), and Formosa (SES 137a–c) before invading that island disappeared from the Allied war plan. Esper Larsen 3d led the Honshu team that Ralph Roberts joined in July 1945 after returning from Central America. Roberts also replaced Edward Sampson in the group, which included Stanford geologist Konrad B. Krauskopf and soils scientist Marion M. Striker (SCS), that solved the Army Engineers' problems with the SCR–625 mine detector in Sicily, Italy, and the Pacific. The team's members demonstrated that the mine detector registered signals from soils containing maghemite (oxymagnite), a strongly magnetic iron oxide.[114] They helped to develop a more sensitive instrument by testing controlled soils of different origins, textures, and natural and supplemented magnetic susceptibilities and later field checked the detector in fortified areas in Honshu.

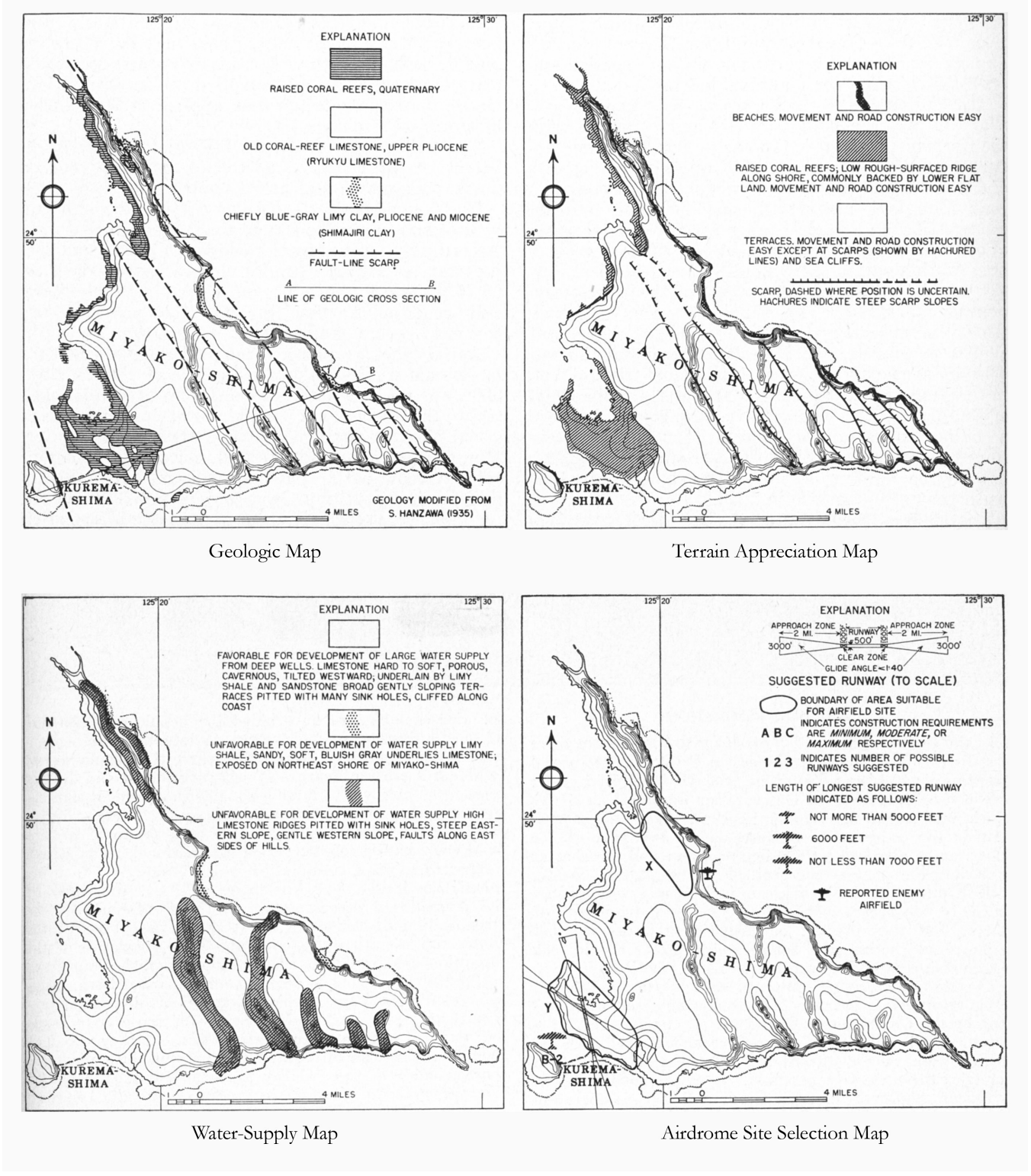
To serve the Pacific Ocean Areas command, Charles Hunt recommended to the Army Engineers that the MGU form a second Terrain and Intelligence Team and send it to Admiral Nimitz's headquarters in Hawaii. The Engineering and Terrain Intelligence Team led by Philip Shenon arrived on Oahu during November 19–21, 1944. Shenon and his team reported to Nimitz's Joint Intelligence Center, were attached to the 30th Engineer Battalion for quarters and workspace, and served there until September 1945. The initial members of Shenon's team included John G. Cady, soils and engineering; John T. Hack, geology and terrain analysis; Elmer Hertzler, roads and bridges; John Rodgers, beaches; Frank A. Swenson, water supplies; and Horace Wilcox, ports and harbors. A second group arrived on Oahu during April 23–May 3 and consisted of Robert M. Garrels, beaches; Harold James and John H. Moss, geology; Charles Johnson, water supplies; W. Bradley Myers, terrain; Sherman K. Neuschel, construction materials; Victor P. Sokoloff, soils; and Philip M. Stephenson, roads and bridges. Hertzler and Wilcox returned to the United States on May 7.

Shenon's team completed more than 120 tactical-level reports for (1) the Joint Intelligence Center; (2) Vice Admiral R. Kelly Turner, the commander of all of Nimitz's amphibious forces; (3) Herbert Loper, a Brigadier General since November 11, 1944, and now Chief Engineer on the staff of Lt. General Robert C. Richardson, Jr., who from August 1944 commanded all Army forces in Nimitz's theater; and (4) the chief engineer of the 10th Army, led by Lt. General Simon B. Buckner, Jr. Richardson, who headed the Alaskan command during 1940–43 before replacing General Emmons in Hawaii in 1943, specifically asked for Loper's transfer from Washington in March 1944, and Loper arrived on Oahu in June. By February 1945, the MGU team's reports provided intelligence, from aerial photographs and the resulting maps, on the offshore conditions and beaches of Iwo Jima in the Volcano Islands (Kazan-retto), but most of them focused on Okinawa and other islands in the Ryukyus (Nansei-shoto). When Shenon's initial group members finished their reports on Okinawa, they joined the second team for joint work on southern Kyushu. By March, the combined team on Oahu completed reports about terrain conditions offshore and on southern Kyushu and about beaches on Honshu.

The MGU then consolidated its Pacific teams in Manila. Beginning in July 1945, Morris F. Austin (SCS), Robert Bryson, John J. Collins, Wallace de Laguna, Edward Sampson (Princeton and USGS), Major Spillers (now Schenck's Executive Officer), Philip Stephenson (from the team on Oahu), and Frank C. Whitmore, Jr. (the MGU's Chief Editor), arrived in Manila. They assisted or replaced members of Fryxell's teams in completing the ongoing reports, and in preparing 15 additional mixed-topical reports, mostly on mineral resources, for a total of more than 190 products. The teams continued to benefit from user critiques. Field checks by the MGU field teams provided data for Charles Hunt's critique in April 1945 of Washington's Strategic Engineering Study on Samar and Leyte (SES 131, at 1:300,000) and, later, those on Luzon (SES 124, 1:300,000, and SES 148, 1:63,000), Southern Luzon (SES 135, 1:500,000), and other islands in the Philippines. The combined group completed Preliminary Terrain Estimate (PTE) reports on the Kwanto Plain (PTE 33, Tokyo and vicinity, July 15) and three other areas on Honshu (Aomori, Shimonoseki, and the Kobe-Kyoto-Osaka triangle), the Ishikara area (northwest of Sapporo), and the Keijo-Jinsen (Inchon) region of the Korean Peninsula. SES 149 included an assessment of Korea's terrain at 1:1,000,000. Schenck and Fryxell then briefed the generals involved in preparing the Army's part in the planned invasion of Honshu and the possible assaults on Hokkaido and Korea.

While MacArthur's forces struggled on Luzon, units of the V Amphibious Corps landed on the black-ash beaches of Iwo Jima on February 19. In furious fighting, marines of three divisions captured the island by March 11. Frank Swenson, who left Oahu on February 22 for duty on Iwo Jima, found good groundwater,[115] part of the freshwater lens underlying the island for which the Japanese garrison searched without success, provided advice on gravel and quarry sites, and earned a Bronze Star for his efforts under fire. The marines declared the island secure on March 16. Taking Iwo Jima brought U.S. forces within 800 miles of Japan, but the campaign cost the marines and supporting sailors more than 25,000 casualties, a total greater than the island's 22,000 Japanese, of whom fewer than 5 percent surrendered. Beginning on March 4, Iwo's improved and extended airstrips served as a haven for General LeMay's Superfortresses returning damaged from raids on Kyushu and Honshu, and, after March 11, Iwo Jima was a base from which long-range fighter aircraft escorted the B–29s to their targets. More than 2,300 damaged bombers and their crews landed safely on Iwo; the number of American airmen saved thereby almost equaled the total of marines and sailors lost. Pre-invasion operations by air and sea against Okinawa began on March 14.

While conflict continued in the major theaters of war, both the USGS and the House appropriations subcommittee clearly anticipated the end of the war



Geologic Map

Terrain Appreciation Map

Water-Supply Map

Airdrome Site Selection Map

The USGS Military Geology Unit (MGU), in part I of its Strategic Engineering Study 119, suggested in August 1944 these two potential sites for airfields (bottom right map) on Miyako-shima (Miyako-jima); this island is the northernmost of the southern Sakishima Islands group of the Ryukyu Islands. Map site X occupied an area just west of a reported Japanese field for two-engine aircraft. On map site Y, to the southwest, two runways (each not less than 7,000 feet long) could be built for four-engine planes with only moderate construction requirements. The three other maps, also products of the MGU's overall evaluation of terrain intelligence of Okinawa and the rest of the Ryukyu Islands, show Miyako-shima's geology, terrain appreciation, and water supply. (From Whitmore, F.C., Jr., 1954, p. 214–215; the maps from Whitmore were originally at about 1 inch = 4.75 miles; they were derived from maps at about 1 inch = 1.5 miles in U.S. Geological Survey, Military Geology Unit, 1944a.)

but in vastly different ways. To Wrather and his principal managers, who appeared before Jed Johnson's subcommittee on March 21, 1945, the end of hostilities meant returning to the mapping and science activities set aside to help the war effort. To the subcommittee, the war's finish implied a return to a prewar budget. The USGS asked for an additional $11,150 in administrative salaries to cover the reallocation of three positions, the costs of within-grade promotions and seven full-time slots filled late in the first half-year, and a new Current-Information Unit. Chief among the seven slots was the post of Assistant Director, about which the committee still held some doubts. Did the USGS not get along without a formal deputy until then? Julian Sears protested that during his 21 years in the Director's Office, the agency "consistently starved the central administration and held down the 'overhead costs' so every penny possible could be put into actual production in the field and in the laboratories,"[116] but there came a time when economy ceased to be a virtue. Wrather intervened, recalling that one of his initial observations on joining the USGS in 1943 involved understaffing in his office. No substantial change in the Director's Office staff occurred since the appointment of the Administrative Geologist in 1912. The Director's Office was now almost the worst bottleneck in the whole USGS, whereas the agency's war-related work demanded the greatest possible expedition and efficiency. Wrather, believing he must act, established the position of Assistant Director. Representative Michael Kirwan then observed mildly he was "under the same impression that you are, Doctor, that when the personnel has jumped from 800 to 2,400 or 2,500, and your budget had gone up to $12,000,000, it is almost time you came in front of the Appropriations Committee and ask to improve your own back yard or staff."[117] No amount of explanation convinced the subcommittee that the Current-Information Unit, intended as a small group tasked to prepare reports requested by Congress, other agencies, or the public about USGS activities, was needed and not just a publicity scheme.

The USGS estimate for its topographic surveys in fiscal year 1945–46, more than twice its appropriation for 1944–45, excited considerable attention during the House subcommittee hearing. The increase included additional funds to match larger cooperative offerings from the States, but most of it would be used to complete U.S. maps begun with funds transferred from the War Department when invasions were feared. The remaining monies would fund the procurement of aerial photographs, the purchase of photogrammetric equipment, and the start of extensive mapping in the Columbia River Basin requested by the Army Engineers, pursuant to the Senate Committee on Commerce's directive of September 24, 1943, to develop water resources in the postwar period. The USGS also expected to start a topographic-mapping program in the Missouri River Basin, although funds for that effort were in the Bureau of Reclamation's budget request. In March 1945, Roosevelt asked Congress for nearly $5.5 million to enable Interior to prepare plans for developing the Missouri River Valley. In April, the USBR submitted a 10-year program of western water development costing $5 billion. Congress authorized $3.2 million, of which the USGS received $936,000, for the Missouri Basin to allow Interior agencies to begin economic and engineering studies and prepare plans for development. Kirwan now asked the perennial question, should all mapping agencies be in one department? His colleague William Norrell suggested that the USGS convene all the directors of Federal mapping agencies to see if they could be consolidated into "what might be designated as the mother agency?"[118]

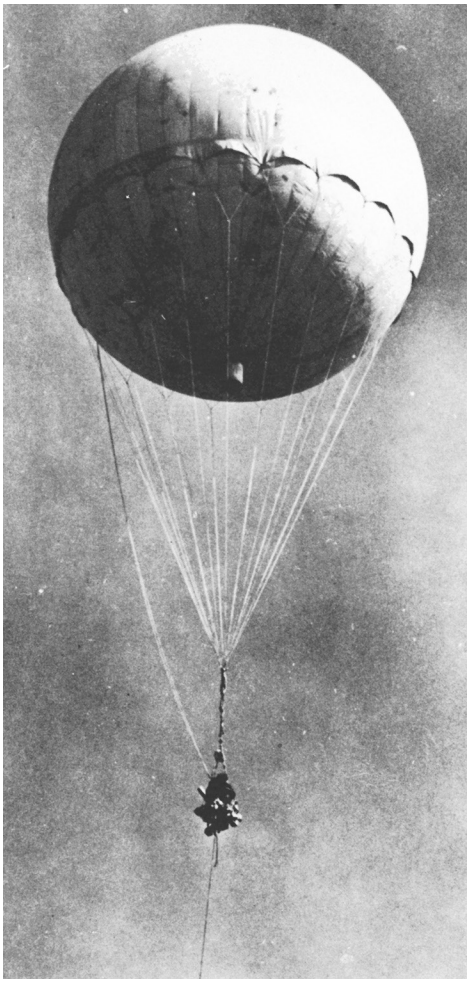
The estimate for geologic surveys by the USGS in fiscal year 1945–46 remained unchanged from the previous year, but the request included $150,000 for what Chief Geologist Bill Bradley, making his initial appearance before the House subcommittee, circumspectly described as "a new high-speed method of geophysical exploration using certain classified equipment of the armed forces."[119] He enthusiastically characterized it as "a pretty 'hot' development."[120] Of that sum, $70,000 would purchase an airplane, and $48,000 would provide for its operation

and maintenance. The word "magnetometer" did not appear in the hearing's transcript, and the subcommittee's members asked Bradley no questions, at least none for the record. The legislators did say that the War Department ought to gladly supply one of its many aircraft, since the USGS would be using it for war work. During antisubmarine searches with the airborne magnetometer, Navy personnel recorded peculiar anomalies when the instrument was used along several sections of the coast. Responding to the Navy's request for an explanation, James Balsley and geophysicist Homer Jensen, an engineer with the Naval Ordnance Laboratory (NOL), used the Navy SNB–1 aircraft to complete, during July 22–September 14, additional aeromagnetic surveys in these areas. The magnetometer, Balsley and Jensen noted, also would be useful in geological investigations.

The USGS estimate for its strategic-minerals investigations in fiscal year 1945–46 was only half of the 1944–45 appropriation. The agency, having nearly completed its initial surveys, shifted that work's emphasis to aid sustaining production and meeting quick changes in needs such as the recent sharp upswing in the demand for mercury. The same thing, Bradley said, was about to happen with tungsten. He added that requests for fluorspar also were high. "Another program," Bradley continued, "is tied up with [a] similar element—rather elements—and that is in the same situation, but it is in an effort to sustain production that we are requiring these funds now."[121] He trailed off without mentioning uranium or any related element; again, the subcommittee's members did not press him for more information. Some of the security measures regarding USGS activities, however, had been lifted. Bradley drew the legislators' attention to Martin Sommers' article about the Military Geology Unit, prepared in cooperation with the MGU and the Army Engineers and published in the *The Saturday Evening Post* for March 24. Sommers described the unit's origin, composition, and work, and touted its achievements, especially the Sicily folios and the Leyte report. The article's last sentence claimed that "some of the Army engineer officers figure that the Military Geology Unit of the Geological Survey is the biggest bargain the Army ever made in wartime."[122] Kirwan arranged to have the whole promotional article placed in the record.

The MGU's ongoing work included another unmentioned effort, one aimed at pinpointing the sites from which the Japanese Army launched hydrogen-filled balloons and their attached instruments and ordnance against North America. The balloons, riding the jet stream discovered by the Japanese in 1926, represented their only large-scale operational reprisal for the Doolittle raid.[123] Robert C. Mikesh and Yoshiro Koichi later individually described and analyzed the "Fu-Go" (balloon bomb) project, and Michael White melded their findings from documents and interviews in a later film.[124] The Fu-Go project, a multiyear effort, cost the equivalent of more than $2 million and required the labor of many adults and teenage women, under the overall supervision of Major General Kusaba Sueyoshi, assisted by Major (Technical) Takada Teiji. The Japanese mass-produced the lacquered mulberry-paper, A-type balloon, as it was lighter in weight than the rubberized-silk, B-type version. Each of these balloons, some 32 feet in diameter and holding nearly 20,000 cubic feet of hydrogen, carried five small bombs—one high-explosive device and four thermite incendiaries. The improved A-type balloon, ready by late 1943 and proved in trials from China, went into production in the Tokyo area for deployment from sites in eastern Honshu selected in August 1944. By then, the British were ending their 2-year operation that launched nearly 100,000 propaganda and incendiary balloons against German-occupied Europe.

On November 3, 1944, units of the Japanese special balloon regiment launched the first of these free-flight but ingenious devices into the winter-strong jet stream. The unit sent some 9,300 balloons skyward in the next 5 months. Reaching altitudes of 30,000 to 40,000 feet, the aneroid-barometer-equipped, height-adjusting, and radio-tracked balloons rode the jet stream eastward for about 5,500



Between early November 1944 and early April 1945, personnel of a Japanese Army's special regiment launched about 9,300 of these A-type balloon bombs from sites on the southeast coast of Honshu. Each mulberry-paper balloon was hydrogen filled and some 32 feet in diameter; it carried as part of the open gondola two aluminum rings bearing many ballast bags (each with 7 pounds of sand), four thermite incendiary bombs, and one explosive bomb. These balloons, powered by the winter-strong jet stream and maintaining their altitude by venting gas (daily) and dropping ballast (nightly), soared some 5,500 miles across the Pacific. They were designed to release their ordnance over forests and other wide-area targets in western North America. The balloon bombs failed as a military or terror weapon, and the Japanese did not deploy their pathogen-filled and soft-case bombs produced before the war ended. (Photograph from National Archives and Records Administration, Still Picture Branch, as A 37180C; published in Mikesh, 1973, fig. 3.)

U.S. Navy personnel examine the two aluminum O-rings from the open gondola of 1 of the 285 recorded Japanese balloon bombs that reached land; they were found principally in the Western United States and also in Alaska, Canada, Hawaii, and Mexico. The Japanese Army launched about 9,000 of its A-type balloons, and the Japanese Navy added 300 of its rubberized-silk, but less efficient, B-type balloons. The balloon's ordnance shown here includes one (at left) of four thermite incendiaries and the single high-explosive bomb (center). Analyses by USGS scientists of microfossils and heavy minerals from the sand in the balloons' 7-pound ballast bags (one shown at right) enabled these specialists to locate the launch sites on southeastern Honshu for aerial attack. (Department of the Navy photograph, National Archives and Records Administration, Still Picture Branch, as 80–G–326354; published in Mikesh, 1973, fig. 35.)

miles during their crossings of the Pacific lasting more than 60 hours. Appearing over wide areas of western North America, they reached 16 States and sites as far distant and separated as northeastern Alaska, southern Manitoba, southwestern Michigan, and northwestern Mexico. They also traveled to the waters off Oahu's northeastern coast and to Attu in the westernmost Aleutians. The United States responded by detailing troops to fight forest fires, distributing decontamination materials to farmers and other citizens, monitoring their homes and animals, experimenting with captured balloons, plotting Japanese radio signals, establishing a radar-warning line along part of Washington's coast, and flying intercepts by day- and night-fighter aircraft. The Japanese expected about 10 percent of their weapon balloons to reach North America. U.S. and Canadian personnel recovered parts or all of 285 of them during the war, and another 40 in postwar years, most from locations between 40 and 50 degrees north latitude and from the West Coast eastward to the 105th meridian.

The War Department sought to end these attacks by discovering and bombing the balloons' fabrication and launching sites. In January 1945, the War Department asked the USGS to have its military geologists try to determine the location of the sands used as ballast for the balloons. In the MGU, Julia Gardner and Kenneth and Katherine Lohman analyzed mollusks, diatoms, and foraminifers (no corals appeared), and Clarence Ross examined the hypersthene-rich heavy minerals in ballast from two balloons that grounded in Alaska and Wyoming. Their results and similar studies by Canadians, who found blast-furnace slag, indicated that the beach sands came from Shiogama (a flight-following station northeast of Sendai) and Ichinomiya (south of Ohara on the Chiba Peninsula southeast of Tokyo). Although Ichinomiya lacked a hydrogen-generating plant, it was one of the three launch areas on the coast of southeastern Honshu. As the jet stream's strength declined, the Japanese ceased launching weapon balloons in late April. Aside from an article in *Newsweek* in January, the U.S. Office of Censorship successfully stopped all but one other public mention of the balloons. The B–29 raids on Tokyo on April 12–13 destroyed many of the balloon-production facilities and the other two hydrogen-generating plants, along with key parts of the uranium-isotope-separation facilities of physicist Nishina Yoshio. The Japanese knew by radio-tracking and a notice in a Wyoming newspaper, repeated by the Chinese, that their balloons were reaching North America but not where, in what numbers, or the degree of their physical and psychological impacts. They also did not know that their weapon diverted some Allied personnel and resources from the combat theaters. Specifically, the balloons imposed a 3-day delay on the plutonium reactor at the Hanford Engineer plant in Washington, when, on March 10, shrouds landed on powerlines, started two minor fires elsewhere, and, on May 5, killed a woman and five children who disturbed the payload while picnicking in Fremont National Forest near Bly in south-central Oregon.

The Japanese balloon project failed as a military and terror device program, but its impact might have been greater if the Japanese, as they intended, had succeeded in transforming some balloons into biological weapons. The instruments' saltwater-solution battery contained no pathogens, but the Japanese developed and tested successfully a soft-cased bomb designed to contain plague-carrying fleas expected to survive the small detonation and then spread widely. Only the conflict's end prevented the bacterial bomb's production and deployment from aircraft.[125]

As the MGU analyzed the balloon ballast, the USGS Water Resources Branch responded to a major challenge to one of its important operations. Of the $305,000 the USGS requested for its studies of water resources during fiscal year 1945–46, $200,000 would support preparing plans and specifications for gaging-station work deferred during the war and $60,000 would match increases in cooperative funds for that purpose. The initial item, labeled "post-war planning,"[126] immediately created a problem. In January 1945, the USGS announced

its postwar program of water-resources investigations. Lee Rogers, president of Minnesota's Lane-Western Company, one of several regional firms in the Lane national conglomerate, promptly complained in a letter to Representative Walter H. Judd (R–MN). Certain groundwater studies by the USGS, Rogers asserted, competed directly with those of private industry. In particular, he claimed, the agency's groundwater men were soliciting municipalities to drill for water, thus taking business away from firms such as Lane-Western. Judd gave Rogers' letter to Iowa's Ben Jensen, still a member of Jed Johnson's House subcommittee. The whole program of USGS water-resources work, rather than the budget item, which clearly pertained to surface waters, became the subject of the House subcommittee's inquiry. Chief Hydraulic Engineer Glenn Parker acknowledged that his Branch's postwar program included "test drilling" and explained that in the past, well-drilling companies helped the USGS by furnishing data from their wells, but the agency did not know whether these firms would be drilling in the areas where it wanted information. The USGS, Parker continued, lacked its own drilling equipment, although the agency sometimes operated equipment purchased by some of the States in connection with the cooperative programs. He concluded "that if the companies can do it more cheaply than we can do it, we must assuredly arrange for the companies to do that test drilling."[127] The subcommittee, satisfied with the response, turned Rogers' letter over to the USGS for reply and restored the groundwater funds temporarily withheld but added restrictive language to prevent the agency from ever operating as alleged.

The USGS response to Rogers uncompromisingly defended test drilling by the agency; it remained "an indispensable tool" in investigations of groundwater resources. These studies provided a means of collecting rock samples for study and introducing instruments to determine the direction and rate of movement of waters, their chemical character, and the supplies the rocks would yield. Well drillers who kept records of their operations cooperated with the USGS and furnished information of much value, but, where no wells existed, or where data from drilled wells proved inadequate, test holes must be drilled. Moreover, the USGS intended the systematic test drilling it supervised "to define the groundwater conditions of specific areas, such as counties, groups of counties, or drainage basins," and to obtain "exact and comprehensive information for an entire State." The USGS did not supervise drilling to locate sites for producing wells and did "not drill wells for the production of water supplies but only test holes in connection with its technical studies"[128] as part of gathering information. Wrather repeatedly refuted continued charges, including those by the Water Well Drillers Association, and finally convened in his office employees of Lane-Western and other companies. The USGS would honor existing agreements with the States but in any new cooperative contracts would not purchase drilling equipment with Federal funds. The agency also planned to advertise for bids on wells to be drilled, thereby avoiding in-house drilling equipment and their crews. The USGS promised that it would try to turn production drilling over to the commercial drillers, but when the agency needed drilling for research, the agreement allowed the agency to arrange to drill wells on its own. That compromise later formed the pattern the USGS followed with the commercial aerial-photography firms in arranging and executing contracts for air-photo coverage to advance topographic and related mapping.

The report by the House subcommittee greatly disappointed USGS management. Jed Johnson's subcommittee disallowed more than 75 percent of the requested increases, including the funds for all new staff positions, and recommended a total of just over $6,852,000 for the agency, including $1 million for geologic surveys, about $2,047,000 for topographic surveys, and just under $1,636,000 for streamgaging. Disapprovals included the $150,000 for airborne-geophysical exploration, $200,000 for postwar planning, and $60,000 for cooperative investigations of water resources. By cutting nearly $188,000 from the 1945–46 base for

geologic surveys, the subcommittee ensured that the USGS would have to curtail fieldwork in investigations of fuels, metals, and nonmetals. Publication funds also were reduced, and the legislators disallowed all funds for Alaska development. With respect to the USGS Alaska program, the subcommittee, noting the availability of information in the Library of Congress (LC) and the GLO, observed that the USGS request for funds gave the clear impression that the general research proposed would be of little or no practical value toward securing homes and providing employment for veterans in the coming months and likely not for 1 or 2 years. In June 1944, Congress and the President demonstrated their concern by providing wide-ranging benefits to all returning veterans in the Servicemen's Readjustment Act.[129] That statute's clauses included a generous program of college education, better known as the G.I. Bill of Rights.

At the time the House subcommittee filed its report, Allied forces continued to advance everywhere. In Europe, they rapidly pushed forward from west and east into Germany. In April 1945, one of General Patton's units discovered a huge collection of archival and library materials in a deep "potash mine in Heringen"[130] near the Werra River in easternmost Hessen southeast of Kassel. This collection, transferred from Berlin a year earlier, included the German Patent Library, portions of the Prussian State Library, and military geology materials. Nearly 23,000 military geology items—books, maps, and reports in German, Polish, and Russian; photographs; and other documents—later passed to the Army Engineers' Intelligence Division. General Eisenhower decided against an all-out drive for Berlin; Allied troops continued to push into central and northern Germany to await the arrival of Soviet forces at the Elbe River. Soviet forces began their final drive on Berlin on April 6.

In the Pacific, Allied aircraft continued to strike targets in Japan and their amphibious forces invaded Okinawa. General LeMay modified the tactics of his B–29 strikes, by eliminating most of his planes' guns to increase their bomb loads and range, changed to incendiaries, and began low-level raids at night against major Japanese cities. Superfortress losses fell below 2 percent. On the night of March 9–10, some 330 B–29s dropped napalm (gasoline-gel) bombs on Tokyo. The resulting firestorm, like those at Hamburg and Dresden, was devastating; it killed or injured more than 180,000 people and burned out nearly 16 square miles of the city. LeMay's B–29s, reinforced from April by those of XX Bomber Command from India, went on to destroy the facilities and populations of most of the industrial and adjacent areas in Japan's six largest cities—Kawasaki, Kobe, Nagoya, Osaka, Tokyo, and Yokohama—but spared Kyoto, the ancient and venerable capital. The U.S. submarine and mine campaign against Japanese shipping increasingly isolated the home islands from the Southern Resources Area and other sources of construction materials, food, and oil supplies, but the Japanese continued to transfer home air and ground forces from China and elsewhere, train additional militia units, and stockpile aircraft and fuel for a fight to the bitter end.

On April 1, nearly 180,000 marines and soldiers of the five divisions in General Buckner's U.S. 10th Army—III Amphibious Corps and XXIV Army Corps—invaded Okinawa. Frank Swenson and USGS groundwater geologist D. John Cederstrom, who had worked with Harold Stearns in Hawaii, went ashore on Okinawa to advise construction troops. Cederstrom's contributions to the campaign earned him a Bronze Star. Okinawa held a Japanese garrison of 130,000 men, and their commander chose not to oppose the landings but to defend the south one-third of the island from the Shuri Line. On June 10, units of the 10th Army reached this principal defensive zone. When the Allied fleet stayed off Okinawa to support the troops while they assaulted the Shuri Line, kamikaze aircraft killed and wounded many sailors and sank or heavily damaged three American carriers and many destroyers and smaller warships on radar-picket duty.

The invasion of Okinawa and the Soviet Government's denouncement on April 6 of its 5-year nonaggression pact with the Japanese brought down the Koiso-Yonai Government. Former Admiral Suzuki Kantaro returned as Prime Minister on April 7. Although Suzuki hoped the Soviets would mediate the conflict, and new Foreign Minister Togo Shigenori had long opposed the war, the militarist majority continued the struggle. They depended principally on the home islands' 2.5 million troops, some 30 million real and potential militia, and rugged terrain. The U.S. 10th Army secured Okinawa on June 22, after losing more than 38,000 marines and soldiers killed and wounded. Kamikaze attacks caused an additional 10,000 Navy casualties, sank 36 ships, damaged another 370 vessels, and destroyed 760 planes. Okinawa cost the Japanese 70,000 killed and more than 50,000 wounded or missing, but some 7,000 others surrendered. Winning the war, the Allies decided, reluctantly, required invading the Japanese home islands,[131] although assaulting Kyushu and southeastern Honshu might cost the Allies an estimated 500,000 casualties, one-fourth of whom likely would be killed. They based this figure on the losses, proportional to the Japanese defenders, already incurred on Leyte, Luzon, Iwo Jima, and Okinawa, and elsewhere in the Pacific, and their estimate of the Japanese home forces. To form part of the more than 1 million men required for these operations in 1945–46, veteran U.S. Army air and ground units would be transferred after the war ended in Europe.

On April 12, 1945, as Allied forces moved forward on all fronts, Vice President Harry Truman presided over the Senate while Members discussed ratification of the year-old treaty with Mexico for sharing the waters of the Colorado and Rio Grande Rivers. When the session recessed, Truman went to the downstairs sanctum of his good friend Samuel T. Rayburn (D–TX), the Speaker of the House since 1940. There, Truman returned a call from the White House and learned that Roosevelt suffered a cerebral hemorrhage and died at 3:35 p.m. in the Presidential retreat at Warm Springs, Georgia. A few minutes after 7 p.m., Truman took his oath of office in the White House as the 33d President of the United States. When President Truman asked Eleanor Roosevelt if there were anything he could do for her, she asked whether she could do anything for him as the inheritor of FDR's crushing responsibilities.[132]

Truman immediately began changes in his Cabinet. He offered to nominate James Byrnes, Director of the Office of War Mobilization and Reconversion, to be Secretary of State, replacing Edward Stettinius, who took over after Cordell Hull officially resigned effective November 27, 1944. Nearly 2 months earlier, Hull made his last visit to the White House to oppose successfully Treasury Secretary Henry Morgenthau Jr.'s plan to punish Germany by levying reparations harsher than those assessed at Versailles in 1919 and making the country a solely agricultural nation. After Stettinius signed the United Nations Charter late in June 1945, Byrnes followed him into office in July as Morgenthau resigned his post at the Treasury. Truman nominated Fred Vinson as Morgenthau's successor, and the President advanced Dean Acheson to be Byrnes' Under Secretary. Before Byrnes left the OWMR, the President also issued an Executive order[133] providing for the release to the public of some scientific information gained during the war; 2 months later, Truman amended the order to include captured scientific and industrial data. In September, Secretary of War Stimson retired, and Under Secretary Robert Patterson replaced his schoolfellow, friend, and colleague, whom he followed into that Department in 1940.

The war in Europe, now in its climactic phases, did not pause at these peaceful passages in the United States. Between April 9 and 20, 1945, units of the Allied 15th Army Group broke through the Gothic Line in northern Italy and pushed

northwest toward Genoa, north against Milan, and northeast toward Venice. Soviet forces took Vienna on April 13 and surrounded Berlin 12 days later. As American and other Soviet forces met at Torgau on the Elbe on the 25th, representatives of 50 nations, but not Spain, assembled in San Francisco to begin the United Nations Conference on International Organization. Units of the 6th Army Group met 15th Army Group troops and closed the Brenner Pass between Austria and Italy. After Hitler committed suicide in his underground bunker on April 30, the leadership of the Third Reich passed to Grand Admiral Karl Dönitz, who personally directed the U-boats' long campaign until he took over the Kriegsmarine in 1943. On May 2, Berlin fell to Soviet troops, and German forces in Italy surrendered, as did those in The Netherlands, Denmark, and northwestern Germany later that week. General-oberst Alfred Jodl signed an unconditional capitulation in Allied headquarters in Rheims early on May 7.

Germany's surrender formally ended the war but not the suffering in Europe. As the Allied armies moved into Germany from the west and through Poland and into Germany from the east, they liberated an increasing number of the German concentration and extermination camps. There they learned the true horrors of what the Nazis inflicted on some of their own and captured peoples since establishing Dachau near Munich in 1933. The Nazis originally founded the camps to house Communists and other political enemies, Gypsies, homosexuals, physically or mentally handicapped persons, and Seventh-Day Adventists, Jehovah's Witnesses, and other religious dissenters, particularly the conscientious objectors to the war. Those condemned to the camp system came increasingly to include the Jews of Germany (and then all Europe), Poles, and Serbs. The camps' cast-metal gates carried the promise of ARBEIT MACHT FREI (work liberates), but the Germans delivered for most inmates only the freedom of death. At the Wannsee Conference held in a Berlin suburb in January 1942, Nazi officials proposed to solve their Jewish problem through extermination. Some information about the growing extent of the disaster, received from escapees and diplomats, reached the Allied leaders, but plans to bomb the more than 20 camps or the rail lines leading to them proved unrealistic in view of the goal of defeating the Wehrmacht first. On March 24, 1945, Roosevelt's public condemnation of German and Japanese war crimes at least held the perpetrators accountable. The President's plea to the German people to stop the savagery and help the victims, or at least to serve as future witnesses, did nothing to end or even abate the Nazis' comprehensive murder of Europe's Jews. Auschwitz, Bergen-Belsen, Mauthausen, Sobibor, Treblinka, and the names of other camps throughout Europe also entered the historical gazetteer of mankind's inhumanity to its own. More than 10 million persons, including 6 million Jews, 3 million Poles, 1 million Serbs, and hundreds of thousands of Germans and other Europeans, died in this Holocaust.[134] Some 4 million Soviet soldiers also perished in German prisoner-of-war camps, except for those who chose to fight their countrymen; others died in the Soviet Union's own gulag of undesirables. So too did hundreds of thousands of German troops captured by Soviet forces and sent eastward to labor and die before the few survivors were returned.

Only a few hours after the German surrender at Rheims, the Senate appropriations subcommittee began its hearings on the Interior Department's budget. Although the United States no longer faced a two-front war, Secretary Ickes minced no words in asking the Senators to restore the cuts made by the House. The Representatives' action on the USGS budget, Ickes said, "not only disregarded the primary role which the mineral industries must play in completing our victory in the Pacific, it also failed to recognize the fact that our future security is related directly to our mineral-resource position."[135] Hayden's subcommittee considered the USGS budget on May 14. Wrather asked the subcommittee to restore funds for

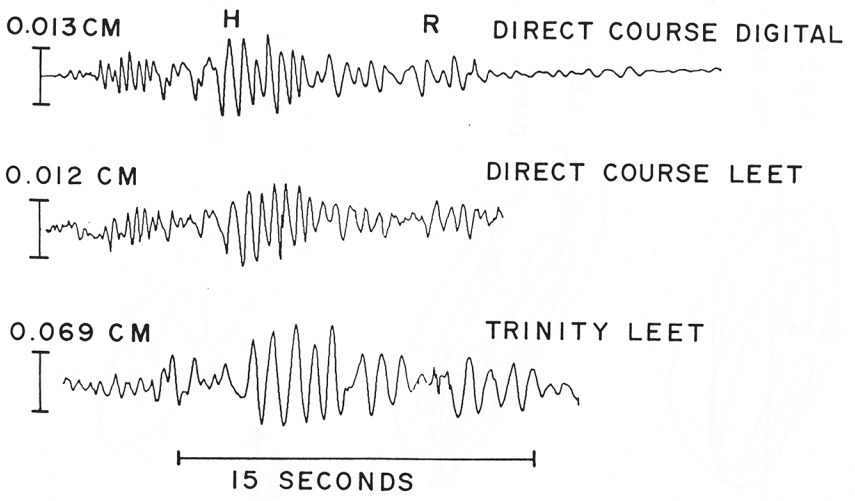
the Assistant Director's post and an accompanying secretarial position and to undo the cuts in monies for topography, geology, and water resources. Hayden, while noting that the House complimented the USGS, repeated the Representatives' reasons for significantly reducing appropriations when "it is definitely known that the problems of a two-front war no longer exist"[136] and activities were expected to taper off during the next fiscal year. Echoing Ickes, Wrather replied that "as a war agency," the USGS held

> **numerous arrearages of things that we have had to put on the shelf. The war has made such inroads on our supplies of mineral raw materials, including underground water supplies, and has so focused attention on our need for accurate and modern maps that if Congress sees fit to appropriate the funds, there are, in my opinion, very few of these activities that could be totally dispensed with. * * * if we had the opportunity for reduction in any respect, we will do our best to take advantage of it. However, we have not seen that as yet.[137]**

These appeals by Ickes and Wrather did not convince the Senate subcommittee, the joint conference committee, or the full House and Senate to restore all of the budget cuts. Rather than $141,346,000 for Interior and most of its agencies during fiscal year 1945–46, the Department received on July 3 a little less than $102,603,000, a reduction of nearly $38 million. Of Interior's sum, Congress and the President provided the USGS with about $7,314,000 in direct appropriations[138] for salaries, including the Assistant Director's, and expenses but some $1,086,000 less than the requested amount. The July 3 appropriations included about $208,000 for salaries and expenses, nearly $2,147,000 for topographic surveys, about $1,188,000 for geologic surveys, $325,000 for strategic- and critical-mineral studies, nearly $158,000 for investigations of Alaskan mineral resources, almost $1,796,000 for water-resources investigations, $213,400 for classifying lands, nearly $476,000 for mineral-leasing supervision, and $275,000 for publications. Compared to the array of direct appropriations for fiscal 1944–45, those for 1945–46 both rose and fell: funds for topographic surveys and water-resources investigations increased, but funds for geologic surveys declined. To help the USGS meet its current obligations, the legislators provided an advance of $400,000, pending reimbursement from cooperating agencies, to be returned to the Treasury within 6 months after the close of fiscal 1945–46. They also authorized any Federal department or agency with "funds available for scientific and technical investigations within the scope and functions of the Geological Survey"[139] to transfer them to the USGS for its authorized work, provided the sum shifted did not exceed 5 percent of the direct appropriation for that purpose. The USGS received a total of more than $15.1 million from all sources during fiscal 1945–46, or $2,508,000 more than the total for fiscal 1944–45. The total sum for fiscal 1945–46 provided nearly $803,000 for administrative and publications support, almost $2,608,000 to the Geologic Branch, slightly more than $350,000 for investigations in Alaska, about $5,086,000 to the Topographic Branch, some $5,150,000 to the Water Resources Branch, and nearly $1,104,000 to the Conservation Branch.

On June 26, 1945, 4 days after the Allies declared Okinawa secured, delegates to the United Nations (U.N.) conference in San Francisco signed a charter that provided for an international organization with six principal executive, legislative, and judicial units.[140] The executive units included a Secretariat, with a Secretary-General and other administrators; a General Assembly of all member nations; and a Security Council, with Britain, China, France, the Soviet Union, and the United States as permanent members, each with individual veto power, and six other nations, each sitting for 2 years. An Economic and Social Council (of 18 countries); an International Court of Justice, at The Hague, with 15 judges elected

This diagram compares the seismologic record that Harvard's L. Don Leet recorded during the Trinity test of the atomic bomb in New Mexico in 1945 with those from a restored Leet mechanical seismograph and the digital instrument used in 1983's Direct Course experiment. In Direct Course, 500 tons of TNT was exploded on a tower less than 4 miles from the Trinity site. The 1983 test produced "good correlation between the surface wave phases (both 'Hydrodynamic' and Rayleigh) for the digital and Leet Direct Course records" but only a qualitative similarity to Leet-Trinity. (From Reinke and Olsen, 1984a, p. 10 and fig. 5.)



by the General Assembly and the Security Council; and a Trusteeship Council of the Security Council's 5 permanent members, plus other nations each with 3-year terms of office, completed the U.N.'s organization. The U.S. Senate ratified the U.N. Charter on July 21, President Truman signed it on August 8, and Cordell Hull received the Nobel Peace Prize on November 12 for his continued efforts toward establishing the new organization. John D. Rockefeller, Jr., donated nearly 18 acres on the East River's west shore in New York City to the U.N. as a site for its permanent headquarters.

Five days before the Senate approved the U.N. Charter, the $2 billion and countless hours spent by a peak force of 125,000 persons on General Groves' Manhattan Project paid off in the Trinity test. On July 16, 1945, MED personnel successfully detonated a plutonium-implosion device atop a 100-foot steel tower at a site on the Alamogordo Bombing Range (now the White Sands Missile Range), in the Jornada del Muerto desert east of the Rio Grande and some 200 miles south of Los Alamos in New Mexico. Observers included physicist Luis W. Alvarez, who designed the detonator at Los Alamos; Hans Bethe; Vannevar Bush; James Chadwick; James Conant; Enrico Fermi; George Kistiakowsky, the explosives expert; Ernest Lawrence; Edwin McMillan; Robert Oppenheimer; MIT physicist Isidor I. Rabi; Edward Teller; and Richard Tolman. They looked, with mixed emotions, at the fireball and the mushroom cloud rising from an explosion equivalent to almost 19,000 tons of TNT.

Before the Trinity test, some members of the Manhattan Project were concerned about blast damage to nearby towns and thought the test might produce an earthquake. Fermi feared wider destruction and even a runaway chain reaction that might set the atmosphere on fire. Nothing could be done about the latter possibility but, in April 1945, to address the concern about an earthquake, the MED brought in as a consultant L. Don Leet, Director of the Harvard Seismographic Station since 1930. Leet, fascinated by the Tokyo earthquake of 1923, spent a year in Tokyo as a secretary with the Young Men's Christian Association (YMCA) and examined shock damage and records. Leet's interest led to studies at Harvard and a Ph.D. in 1930 for his "Empirical Investigations of Surface Waves Generated by Distant Earthquakes." Thereafter, Leet and Columbia's W. Maurice Ewing investigated the velocity of elastic waves in granite and norite. Leet also examined the vibrations and ground effects of dynamite blasts in quarrying.

Leet studied "geologic maps of the [test] area, as well as seismic records obtained from a 100-ton calibration shot fired [earlier from a smaller tower] near Trinity's ground zero." Only "little possibility of seismic damage from * * * [the

test] outside the 5,000-yard range, even if the yield of the blast were to be as high as 50,000 tons,"[141] Leet concluded, but air-transmitted shock waves might be another matter. Distant observers in buildings might not be able to distinguish between those shock waves and ground-transmitted vibrations. Leet, who developed a three-component, strong-motion portable seismograph, recommended that five of these instruments be installed in the surrounding area at San Antonio (northwest of the test site); Carnzozo, to the northeast; Tularosa, to the southeast; Elephant Butte, to the west; and a location 9,000 yards north of the Trinity tower. Beno Gutenberg also prepared to receive signals at Caltech. Leet gained a "particularly excellent and complete record"[142] of the test from the last-named of these seismometer sites, and Gutenberg obtained the best detonation time[143] after standard timing equipment malfunctioned at the Trinity site. Leet described the explosion as "producing 'a simple single instantaneous vertical impact on the ground' so that there was no question of a 'succession of primitive shocks' as had been proposed by [British seismologist Horace] Lamb as a possible explanation for the complicated nature of observational seismograms."[144] Leet's analysis also suggested that he observed what he named a Hydrodynamic wave, "a new wave to seismology"[145] with "distinctive particle motion which was prograde, in the opposite sense to that of the classical Raleigh wave, and possessed of an inclined elliptical orbit."[146]

America did not need its nuclear weapon for use against Germany, as the Wehrmacht reached the end of its meaningful resistance without gaining an atomic weapon. If Germany had developed an nuclear bomb, it might have been delivered by a V–2 or, more likely, by the specially modified Heinkel He-77A Griffin bomber—able to carry 6.6 tons—found in Prague at war's end. One of the Luftwaffe's new four-engine bombers—the operational jet Arado Ar-234C Lightning, or the prototype Junkers Ju-290 and Ju-390—also might have been used to deliver a nuclear weapon, provided its weight remained within their lesser payload capacities.

Richard Rhodes described how Groves, lacking reliable information, decided to determine German progress on the ground.[147] He sent to London in 1944 an MED scientific-intelligence team incautiously code-named Alsos ("Groves" in Greek). Lt. Colonel Boris T. Pash, an Army officer trained by the Federal Bureau of Investigation (FBI), led the Alsos team, which included Dutch-American physicist Samuel A. Goudsmit, educated at Leiden and by Niels Bohr, who spent 2 years at MIT's Radiation Laboratory before being recruited for Alsos by Vannevar Bush and his colleagues.

Aerial surveillance of suspected nuclear sites in Germany began in July 1944. Lt. Colonel Pash's team reached Frédéric Joliot-Curie's laboratory in Paris on August 25. Late in November, the Alsos team's members read documents in Carl von Weizsäcker's laboratory at Strasbourg, but they missed the fleeing von Weizsäcker. These materials indicated that results of the Germans' nuclear efforts badly trailed those of the Manhattan Project, and they also helped to fix the location of the former's experimental site in an area across the Rhine on the Black Forest's eastern edge. The Strasbourg records enabled Bush, then at Eisenhower's headquarters ending concerns about possible captures of Allied proximity fuses, to assure the chief of staff that the Germans would not deploy a nuclear weapon. The Strasbourg documents also aided Allied efforts to track down the facilities and materials in the German nuclear program. Allied forces captured an operating cyclotron at Heidelberg in March 1945 and a small amount of uranium ore, but no separated uranium-235, at Stadtilm. In April, another team of Anglo-Americans, serving with the U.S. 9th Army in Bradley's 12th Army Group, discovered near Stassfurt, west of the Elbe River, the remaining 1,100 tons of uranium ore and concentrates, but again no uranium-235, confiscated by the Germans in Belgium in

1940. The Allies sent another 30-odd tons of ore, liberated earlier at Toulouse, to Oak Ridge to be used in extracting additional uranium-235 for use in completing their uranium-gun bomb.

The Germans decided to begin applied work on nuclear reactors, for power and plutonium production, and isotope separation, for uranium-235, by centrifuge, after Heisenberg's initial report in November 1939 and his subsequent reports through February 1942 to Wehrmacht Army Ordnance that nuclear fission could produce bombs as well as manageable energy for powering submarines. The nuclear project passed in April 1942 to the Ministry of Education and Science's Reich Research Council. In June, Heisenberg briefed Minister of Armaments and Munitions Albert Speer before Speer met with Hitler. When Heisenberg said he would need at least 3 to 4 years' work and took only a portion of the funds Speer offered for heightened work, Speer decided that the results would not affect the war's outcome and released 1,200 tons of uranium for use as ammunition cores. Accidents at and bombs on the preliminary reactor sites in Berlin and Leipzig during 1943–44 caused physicist Walter Gerlach of Munich, who now led the effort, to move Diebner, Heisenberg, other nuclear physicists, and their equipment and materials to Hechingen and to Haigerloch, 10 miles to the west, in the upper reaches of the Neckar River system near the Swabian Alps. Gerlach's group left behind in Berlin significant amounts of metallic uranium, uranium oxide, and heavy water that the Soviets captured on April 29. In March, Heisenberg reported a sevenfold increase in neutron generation, but the pile, he estimated, remained about 50 percent short of reaching a controlled chain reaction.

Lt. Colonel Pash, Goudsmit, and the Alsos team, now supported by a battalion of combat engineers from the 7th Army's VI Corps, reached the Hechingen-Haigerloch area on April 23, 1945. In Hechingen, they rounded up Otto Hahn, Paul Harteck, Max von Laue, Carl von Weizsäcker, and other nuclear physicists and located hidden stashes of the project's research papers, uranium ingots, and drums of heavy water. At Haigerloch, within a locked cave below an overlying cliff, the Alsos team found one of the two German uranium machines. The atomic pile, in a lined cylindrical pit, comprised more than 600 uranium cubes fixed to chains attached to a graphite and metal plate and suspended in 1.5 tons of heavy water. Diebner, Gerlach, and Heisenberg had fled, but the Allied team found and took them into custody during May 1–3. The second reactor was captured at Frankfurt. When the submarine *U–234* surrendered at sea at war's end in Europe, the 1,200 pounds of uranium-oxide ore in its cargo of materials and technology went not to Japan but to Oak Ridge to produce additional uranium-235.

Although the Nazi nuclear bomb proved to be a chimera, arguments continued over whether or not Heisenberg and his colleagues really intended to make such a weapon. Diebner, Gerlach, Hahn, Harteck, Heisenberg, von Laue, von Weizsäcker, and three of their coworkers, along with Dornberger, von Braun, and other scientists and technicians, left Germany for confinement in Britain at Farm Hall, northwest of Cambridge. Manfred von Ardenne and a few other German nuclear (and rocket) scientists were captured by Soviet forces and established uranium-enrichment facilities on Georgia's Black Sea coast. Heisenberg and his colleagues heard with surprise and dismay British news broadcasts about the atomic bombs the Americans dropped on Japan. Jeremy Bernstein, an American physicist and historian of science, later demolished the myth the internees quickly devised that claimed they knew how to make a weapon but chose not to do so. The content of Heisenberg's lecture to the detainees on August 14, Bernstein demonstrated, showed that Heisenberg did not how to make a nuclear bomb.[148]

The German physicists held by the West returned in 1946 to (West) Germany, but the Soviets did not release von Ardenne and his colleagues to (East) Germany until 1954. Bohr, Gerlach, Hahn, Heisenberg, von Laue, and von Weizsäcker spoke

privately and publicly against West Germany's efforts to build nuclear weapons. Dornberger and von Braun went to the United States and became naturalized citizens; von Braun and more than 100 colleagues he selected, protected by Project Paperclip,[149] began work at Fort Bliss in Texas toward producing American guided missiles.

As U.S. nuclear-weapon development continued in May 1945, a special committee began selecting potential targets in Japan. From May 31, Stimson chaired meetings of an Interim Committee composed of Bush, Byrnes, Karl Compton, Conant, Under Secretary of the Navy Ralph A. Bard, Assistant Secretary of State William L. Clayton, and Alternate Chairman George L. Harrison, another of Stimson's special consultants. Harvey Bundy, Arthur Compton, Fermi, Groves, Lawrence, Marshall, Oppenheimer, and Arthur W. Page, of American Telephone and Telegraph, attended as invitees. The Interim Committee considered control of the nuclear weapon during the war and after the peace, international competition, additional research and development, the release of information to the public, and possible legislation required to secure a permanent organization. Committee members recommended a domestic program to "Build up suitable stock piles of [fissionable] material for military use and for industrial and technical use."[150] On June 25, Stimson's committee accepted the recommendation of "direct military use"[151] made 9 days earlier by their Science Panel's Arthur Compton, Fermi, Lawrence, and Oppenheimer. The "weapon should be used against Japan at the earliest opportunity," "without warning," for greatest psychological effect, and "on a dual [military and civilian] target"[152] as the least detestable alternative of plans to end the war and save lives.

On July 17, as a special group of B–29 crews continued training in Utah to deliver atomic bombs on Japan if it continued the war, a petition signed by 77 nuclear scientists asked President Truman not to authorize the use of the bombs without giving the Japanese a chance to yield. On the same day, the Terminal Conference began in Potsdam, near Berlin, after the 1-day's delay that Truman requested to be certain of Trinity's outcome. On July 21, General Marshall gave Truman a copy of General Groves' report of July 18 describing the successful Trinity test. Truman learned about the Manhattan Project's existence in 1943, after his committee tried to decide if Hanford might be another Canol, but he agreed with Secretary Stimson's request on June 17 not to investigate the project. Stimson and General Groves briefed Truman on the details of S–1 on April 25, 1945. Groves' report now warned that even the Pentagon was not a safe shelter from the atomic bomb but he, like Teller, thought a successful combat test would provide the real deterrent. The news, Truman recalled, gave him fresh assurance[153] and a significant advantage in the meeting's efforts to organize the postwar world, especially as he tartly told Vyacheslav Molotov to live up to Soviet agreements made at Yalta and elsewhere.

Truman asked his principal advisers at the Potsdam conference to confirm estimates of the number of Allied casualties they expected would occur in invading Japan if the nuclear weapon was not used; in responding, most agreed that the bomb must be dropped. With the total of Americans killed in combat now nearing 300,000, the Army's manpower pool drying up, and estimates of Japanese home-islands forces rising, Truman declined to see the fighting on Iwo Jima and Okinawa replayed in Japan with far greater losses. On July 24, with Truman's and Stimson's approval, General Thomas T. Hardy, the Army's Acting Chief of Staff, ordered General Carl A. Spaatz to use the first of the new weapons. The instructions told Spaatz, now leading the U.S. Army Strategic Air Forces against Japan, to drop the weapon when good weather enabled visual (not radar) bombing after August 3 on Hiroshima, Kokura, Nagasaki, or Niigata. Other atomic bombs, the orders continued, would be dropped on these cities or additional targets when they

were prepared by the MED's staff.[154] Stimson, unhappy about the fire bombings in Europe as well as those in Japan, specifically removed Kyoto from the list of targets.[155] Although Kyoto housed the Mitsubishi and other war factories, his decision spared Japan's ancient capital and its art and culture.

On the day that Spaatz received his orders, Truman, still at Potsdam, mentioned in passing to Stalin that the United States possessed a new and powerful weapon.[156] The revelation did not surprise Stalin because he knew all the important details of the Manhattan Project. Beginning in 1941, some British and American scientists and other Soviet sympathizers directly or indirectly passed to or allowed to reach their colleague-moles, handlers, or runners detailed data about the Allied nuclear-weapons program. Fearing a Nazi bomb and (or) wishing to make Soviet military power equal to the Allies, in part to ensure a postwar peace by restoring a balance of power, Niels Bohr, who arrived at Los Alamos in December 1943, Enrico Fermi, Klaus Fuchs, Robert Oppenheimer, Leo Szilard, and others circumvented General Groves' massive security precautions and consciously or inadvertently passed information that proved vital to the success of the Soviets' own project. How pervasive Soviet spying was in America before and after 1945 only became generally known when the Venona transcripts were declassified in the 1990s. Stalin responded to Truman's alert by expressing his pleasure at the news and his hope that the weapon would be used effectively on the Japanese.[157] Churchill observed the conversation and asked Truman about it.[158] The President replied that Stalin had asked no questions.[159] Only 4 days earlier, Stalin strengthened the Soviet nuclear program, restarted in 1943, by replacing Molotov with Lavrenti P. Beria, the head of the Soviet secret police and the project's chief of intelligence.[160] In February 1945, the Russians used captured German documents to discover new deposits of high-grade, if limited, uranium near Bukova, south of Sofia, in Bulgaria's West Rodopi Mountains. Stalin urged Beria, physicist Igor V. Kurchatov, and weapons-expert General Boris L. Vannikov, later termed the Soviet "Groves" by assassin-spymaster Pavel A. Sudoplatov, to speed their work, including the All-Union search for Soviet uranium deposits, isotope separation, and building a reactor.

The Terminal conferees also dealt with affairs in Europe. On June 5, the European Advisory Commission, founded by the Big Three Powers on January 1, 1944, divided Germany and Berlin, and Austria and Vienna, each into American, British, French, and Soviet (eastern) zones and sectors of occupation; the Soviets also controlled ground routes to Berlin. Truman, Churchill, and Stalin established a Council of Foreign Ministers from Britain, China, France, the Soviet Union, and the United States to oversee the Allied Control Councils for the two countries, which, in turn, monitored the military occupation of their zones. Attendees at Potsdam also discussed draft treaties with the European Axis Powers, trials for accused war criminals, German reparations in capital equipment and its economic future, the forced removal of some 6.5 million Germans from Czechoslovakia, Hungary, and Poland, and the repatriation of Soviet troops who joined the Wehrmacht. They agreed to have the Council of Foreign Ministers meet in London to refine the postwar arrangements.

During the Terminal Conference, Clement R. Attlee, the Labour Party's leader since 1935, replaced Winston Churchill as Prime Minister and in the delegation at Potsdam, following the Conservatives' defeat in the khaki (veteran-influenced) election. On July 26, 1945, Truman, Attlee, and Stalin sent a demand to the Japanese Government. Avoid Germany's fate, they urged, by following "the path of reason" that would end the war by surrendering unconditionally, accepting an Allied occupation to destroy Japan's war-making power, and returning to their rightful owners all lands conquered since 1895. The new Big Three made no mention of the Emperor Hirohito and his postwar status but promised that they would not make slaves of the Japanese or obliterate their nation.[161] The Allies' occupation

would end when they accomplished their goals[162] and the Japanese people freely established a government of peace and responsibility. War criminals must face justice. Japan also must revive and strengthen its democratic impulses[163] and establish basic freedoms and human rights. Japan's only other option, the proclamation emphasized, was a quick and complete destruction.[164] On July 29, Prime Minister Suzuki's government responded with an equivocal message that the Allies translated as declaring their ultimatum beneath notice. Japan's reply convinced Truman, following his desk's buck-stops-here dictum, to let stand the order of July 24. On August 6, the crew of the *Enola Gay*, a B–29 from Tinian, dropped the "Little Boy" uranium-gun bomb on Hiroshima in southwestern Honshu. The area contained a communications center, military bases, and the 2d General Army's headquarters. The slender, 5-ton, Little Boy bomb was derived from the earlier Thin Man version. The bomb's 12.5-kiloton air blast devastated Hiroshima and its inhabitants.

On June 13, 1944, Roosevelt and Churchill expanded their agreement of the previous September by founding a Combined Development Trust to explore, survey, and control sources of uranium and thorium supplies. The two leaders further pledged on September 19, 1944, not to share information about Tube Alloys with any country and, when the bomb became available, and, after careful review, to use it against the Japanese, following a warning that other and similar bombs would be dropped until they surrendered. On August 6, 1945, the White House released Truman's statement about Hiroshima that again cautioned the Japanese to accept the Allies' terms or endure an aerial assault unprecedented in the history of war,[165] followed by invasions of the home islands. Two days later, Soviet forces invaded Manchuria on three fronts and pushed rapidly east, south, and west onto the Manchurian Plain and into Korea. The Soviets also attacked southern Sakhalin, Japanese-controlled since 1904, and the northern Kurils.

When the Japanese Government did not respond to the Hiroshima atomic bomb, the United States struck another of Japan's cities on August 9. With the primary target Kokura and its arsenal obscured by clouds, the crew of the B–29 *Bock's Car* unloaded the "Fat Man," a spherical, plutonium-implosion bomb, over Nagasaki, the secondary target in central-west Kyushu. Nagasaki's hills helped to confine and increase the air-blast's effects. Although dropped some 1.5 miles away from the aiming point, the 5-ton bomb's 21-kiloton explosion still destroyed parts of the city, its major port, the Mitsubishi shipbuilding yards, torpedo factories and other arms works, and electrical-equipment facilities. The two nuclear blasts killed outright nearly 120,000 civilians and military personnel, injured another 95,000 people, of whom some later died from the effects of radiation, and devastated more than 50 percent of the two cities. Truman, appalled by casualties among children, halted further atomic-bomb strikes to give the Japanese another interval in which to surrender. The next nuclear weapons would not be ready until August 19, but destructive conventional-bomb raids by Allied land-based and naval aircraft continued, and the Japanese retaliated by torturing and killing downed crews.

To end Japanese die-hard military resistance and the horrors of the conventional and nuclear bombings, Emperor Hirohito, who long supported the war, now openly declared for peace in meetings of the Supreme War Council during August 8–14. He ordered Prime Minister Suzuki and his ministers to terminate the conflict by accepting the Potsdam Declaration. Suzuki, now using the Swiss as intermediaries, offered to surrender if Hirohito kept his throne. In a disingenuous message recorded for radio and broadcast on August 14, the Emperor admitted that the war was not going in Japan's favor, deplored the enemy's use of its new and horrendous bomb, whose overwhelming power took the lives of many innocent civilians, and accepted the Allies' joint declaration."[166] Therefore, Hirohito decided to make a path to an unending peace by enduring and suffering an unthinkable end to the war.[167]

Peace meant survival for Allied and Japanese forces and prisoners; it also meant life for their descendants. On August 28, General MacArthur and his initial units arrived in Tokyo by air. Five days later, representatives of Japan's civilian government and its military arm signed the formal instrument of surrender on the deck of Admiral Halsey's flagship, the battleship *Missouri*, one of 260 Allied warships anchored in Tokyo Bay. MacArthur presided over the multinational ceremony as Supreme Commander for the Allied Powers in the Pacific. He expressed his profound concern for future security and civilization's survival in the atomic era. MacArthur called upon all nations to rise above past racial and other hatreds to reach the goals of what FDR called the united nations—keeping a world at peace, securing basic rights for all peoples, providing humanitarian aid, and promoting economic and social development.[168]

Under the capitulation's terms, a U.S. army of occupation controlled Japan's home islands and most of the remaining Japanese possessions in the Pacific, including those annexed or acquired by treaty before 1914, or mandated by the League of Nations after World War I. Formosa returned to China. Australia added the Bismarcks, the Admiralties, and Bougainville to its Papua New Guinea. Stalin, influenced by his agreement at Yalta and the present military realities, ordered his troops on the Kurils and southern Sakhalin not to invade Hokkaido. Roosevelt hoped that Korea would become a Big Four trusteeship, as a step toward the independence promised at Cairo, Yalta, and Potsdam, but the Soviets demurred. Soviet troops began to occupy northern Korea on August 10. Three days later, to keep the Soviets from gaining the entire peninsula, the United States proposed to accept all Japanese surrenders south of the 38th parallel and the Soviets quickly agreed to do the same north of that line. These decisions, as the Americans intended, gave them control in September of Seoul, Korea's capital since the late 14th century.

The fiscal year that began on July 1, 1945, thus comprised two distinct intervals of unequal length. The Allies won the war in Europe some 7 weeks before the beginning of fiscal year 1945–46. Seven weeks after the new fiscal year began, the Pacific-Asia war ended, and America and the USGS abruptly entered the postwar world and encountered both old and new domestic and international realities of an atomic age. During World War II, of the 16 million men and women who served in the U.S. armed forces, some 292,000 died in combat and another 100,000 perished from combat-related causes. Of the additional 800,000 wounded, captured, or missing, about 572,000 survived—many saved by plasma transfusions, sulfa, and penicillin—and 110,000 returned from captivity. During the conflict, more than 50 million persons died in combat or from war-related causes. After war-crimes trials in London, Nuremberg (Nürnberg), and Tokyo, nearly another 1,000 individuals, of some 5,700 brought before the bar and 4,400 convicted, would join them by execution.

Most of the Allies now hoped that the United Nations would work zealously and effectively to preserve global peace. On August 6, when President Truman announced the Hiroshima bomb's detonation, and again called for Japan's surrender, he pledged to continue to withhold from the public and from Britain, contrary to the Roosevelt-Churchill agreement, the atomic bomb's "technical processes of production or all the military applications, pending further examination of possible methods of protecting us and the rest of the world from the danger of sudden destruction." Truman also vowed to ask Congress to "consider promptly the establishment of an appropriate commission to control the production and use of atomic power within the United States."[169] Truman, echoing Churchill's hope, further recommended to the legislators how such power

> **can become a powerful and forceful influence towards the maintenance of world peace.[170]**