

1992 Annual Report on
Alaska's Mineral Resources



Frontispiece. Geologist collecting bulk rock samples near the Kurupa River, Colville Mining District, northern Alaska. USBM, USGS, and BLM geologists are preparing a cooperative study on the mineral potential of this region, to be incorporated in the BLM's Arctic District Land Management Plan. Photograph by M. Meyer.

1992 Annual Report on Alaska's Mineral Resources

DIEDRA BOHN and JILL L. SCHNEIDER, Editors

Prepared in cooperation with the Bureau of Land Management,
the Fish and Wildlife Service, the Minerals Management Service,
the National Park Service, the U.S. Bureau of Mines,
the U.S. Forest Service, and the Department of Energy,
as mandated by Section 1011 of the Alaska National Interest
Lands Conservation Act, Public Law 96-487, of December 2, 1980

A summary of mineral resource activities in Alaska during 1991

U.S. GEOLOGICAL SURVEY CIRCULAR 1091

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MANUEL LUJAN, Jr., Secretary



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Dallas L. Peck, Director

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CONTENTS

Summary	1
Energy resources	1
Oil and gas	1
Arctic National Wildlife Refuge	2
<i>Exxon Valdez</i> oil spill	2
Coal and peat	2
Uranium	3
Geothermal resources	3
Nonfuel-mineral resources	3
Metallic minerals	3
Industrial minerals	4
Introduction	4
Mineral programs	4
Department of the Interior	4
U.S. Geological Survey	4
U.S. Bureau of Mines	6
Minerals Management Service	7
Bureau of Land Management	7
Fish and Wildlife Service	8
National Park Service	8
Department of Agriculture	10
U.S. Forest Service	10
Department of Energy	11
Contacts for further information	11
Energy resources	11
Oil and gas resources	11
Overview of production and prices	11
Exploration	12
Production activity	14
North Slope	14
Cook Inlet	15
Leasing activity	15
Transportation	17
Activity by Federal agencies	17
Minerals Management Service	17
Leasing and exploration activity	17
Future sales	19
Oil and gas resource assessment	21
Data acquisition on the Alaskan OCS	21
Joint Federal-State studies	22
Environmental studies program	22
U.S. Geological Survey	23
North Slope	23
East-central Alaska	24
Nenana Basin	24
Thermal maturity map of Alaska	24

Energy resources—Continued	
Oil and gas resources—Continued	
Activity by Federal agencies—Continued	
U.S. Geological Survey—Continued	
Gas hydrates	24
U.S. Bureau of Mines	24
Bureau of Land Management	24
Fish and Wildlife Service	25
Kenai National Wildlife Refuge	25
Activities under Section 1008 of ANILCA	25
Resource activity impact assessment	25
Department of Energy	27
Petroleum research	27
Arctic National Wildlife Refuge	28
Activity by Federal agencies	28
Fish and Wildlife Service	28
Bureau of Land Management	28
Exxon Valdez oil spill	29
Activity by Federal agencies	29
Fish and Wildlife Service	29
Minerals Management Service	29
National Park Service	30
U.S. Geological Survey	30
U.S. Forest Service	30
Coal and peat resources	32
Activity by Federal agencies	34
U.S. Geological Survey	34
U.S. Bureau of Mines	34
Bureau of Land Management	34
Department of Energy	34
Uranium resources	35
Activity by Federal agencies	35
U.S. Geological Survey	35
Geothermal resources	35
Nonfuel-mineral resources	35
Metallic minerals	35
Industry activity	35
Economic and regulatory overview	35
Precious metals	38
Other metals	39
Activity by Federal agencies	40
U.S. Geological Survey	40
Alaska Mineral Resource Assessment Program	40
Precious metals	40
Strategic and critical minerals	43
Other metals	43
Cooperative programs with Soviet scientific agencies	43
Trans-Alaska Crustal Transect Program	44
National Petroleum Reserve—Alaska	44
U.S. Bureau of Mines	45
Minerals availability program	45
Policy analysis	45
State mineral activities	45
Mineral land assessment	47

Nonfuel-mineral resources—Continued	
Metallic minerals—Continued	
Activity by Federal agencies—Continued	
U.S. Bureau of Mines—Continued	
Research activities	48
Bureau of Land Management	49
Fish and Wildlife Service	49
Minerals Management Service	49
OCS mining program, Norton Sound Lease Sale	49
National Park Service	50
U.S. Forest Service	51
Tongass National Forest	51
Chugach National Forest	53
Industrial minerals	53
Activity by Federal agencies	54
U.S. Bureau of Mines	54
Bureau of Land Management	54
Fish and Wildlife Service	54
U.S. Forest Service	54
References cited	54
Appendix 1. Alaska mineral reports released during 1991 and early 1992	57
Department of the Interior	57
U.S. Geological Survey	57
U.S. Bureau of Mines	59
Minerals Management Service	60
Bureau of Land Management	60
Fish and Wildlife Service	61
Department of Energy	61
Non-Federal reports	61
Alaska Division of Geological and Geophysical Surveys	61
Additional non-Federal publications	61
Appendix 2. Roles of Federal agencies in mineral programs	63
Department of the Interior	63
U.S. Geological Survey	63
U.S. Bureau of Mines	63
Minerals Management Service	63
Bureau of Land Management	64
Fish and Wildlife Service	64
National Park Service	64
Department of Agriculture	65
U.S. Forest Service	65
Department of Energy	65

FIGURES

1. Map of Federal land ownership in Alaska 5
2. Photograph of MMS geologist with silicified trunk of a tree (palm?) buried in Eocene tuffaceous sand along shoreline of Chinitna Bay, lower Cook Inlet 7
3. Map showing national wildlife refuges in Alaska 9
4. Photograph of historic cabin at a placer mine along Glen Creek in Denali National Park and Preserve 10
5. Map showing locations of exploratory oil wells, oil and gas fields, and possible petroleum-bearing onshore sedimentary basins 13
6. Map showing oil and gas planning areas and lease sale history 16

7. Map showing areas proposed for future oil and gas lease sales or geological and environmental studies, 1992-1997 20
8. Photograph of MMS geologist examining bedded sandstone and siltstone 23
9. Map showing onshore favorable petroleum provinces and locations of DOE-funded research in 1991 26
10. Photograph of a soil burner used to incinerate soil contaminated at Beaver Creek Oil Field, Kenai NWR 27
11. Map showing areas sampled in Prince William Sound for oil contamination 31
12. Map showing areas of potential coal, uranium, and geothermal resources 33
13. Map showing areas of significant industry activity involving metallic minerals (excluding uranium) in 1991, and mine and deposit locations 36
14. Map showing status of U.S. Geological Survey level III AMRAP quadrangle studies as of January 1992 41
15. Map showing locations of U.S. Geological Survey level IV AMRAP metallic-mineral and TACT studies in 1991 42
16. Photograph of placer mine operation to recover gold in Chicken Creek of Fortymile District 44
17. Map showing locations of U.S. Bureau of Mines mining district studies and studies of strategic and critical minerals in 1991 46
18. Photograph of USBM geologist mapping location of mineral deposit at Drenchwater Creek by plane-table survey 48
19. Photograph of historic miner's tool shed and wagon along Caribou Creek in Denali National Park and Preserve 51
20. Photograph of Kensington mining project 53

TABLES

1. Comparison of Alaska to countries ranked by daily oil production 12
2. Fluctuation in price of Alaska North Slope crude oil 12
3. Alaska exploratory oil wells drilled in 1991 14
4. Comparison of Alaskan oil and gas production, 1991 15
5. Alaska Outer Continental Shelf leases and wells drilled, 1976-1990 17
6. Proceeds from lease sales on Alaska Outer Continental Shelf planning areas 17
7. Exploratory wells drilled on the Alaska Outer Continental Shelf in 1991 18
8. Producing oil leases, Beaufort Sea planning area 19
9. Proposed activity, current as of January 1, 1992, by Alaska Outer Continental Shelf region and planning area, 1992-1997 21
10. 1990 assessment of undiscovered economically recoverable oil and gas resources, Beaufort Sea, Chukchi Sea, and Hope Basin planning areas 22
11. Mining production in Alaska, 1988-1991 37
12. Level IV studies of the U.S. Geological Survey Alaska Mineral Resource Mineral Resource Assessment Program and related projects active in 1991 43
13. U.S. Bureau of Mines activity in mining districts and at strategic and critical mineral localities in 1991 47

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SUMMARY

Section 1011 of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 requires that "On or before October 1, 1982, and annually thereafter, the President shall transmit to Congress all pertinent public information relating to minerals in Alaska gathered by the United States Geological Survey, Bureau of Mines, and any other Federal agency." This report has been prepared in response to that requirement.

This circular is the eleventh in a series of annual ANILCA reports. The report provides information about current Alaskan mineral projects and events during 1991; the emphasis is on Federal activity. The report addresses both onshore and offshore areas of Alaska.

The U.S. Geological Survey (USGS), U.S. Bureau of Mines (USBM), and Minerals Management Service (MMS) are the principal Federal agencies that publish information about energy and mineral resources in Alaska. Their reports and data form the basis for decisions by other Federal agencies regarding land use, access, environmental impacts, and mining claim evaluation. The time required for sample analysis, data synthesis, and publication is lengthy; as a result, scientific reports are generally issued a year or more after initial sample and data collection. Other sources of information for this report include additional Federal and State publications, trade and professional journals, newspaper articles, presentations at public meetings and hearings, and press releases.

Information is provided for two broad categories of minerals: energy resources and nonfuel-mineral resources.

Energy Resources

Oil and Gas

Alaskan oil production in 1991 totaled 680 million barrels of oil and natural gas liquids, an increase of 2.2 percent over 1990. This increase reverses a two-year decline, but production was still below peak levels of

1988. Alaska provided 25 percent of the total United States production in 1991. Dry natural gas production in 1991 declined 3 percent to 199 billion cubic feet. North Slope oil prices during the year averaged \$17.96 per barrel (West Coast) and ranged from a high of \$23.77 in January to a low of \$15.73 in March.

The Alaska Oil and Gas Conservation Commission issued 157 drilling permits in 1991, a 14-percent decrease from 1990. Thirteen exploratory wells were active during 1991. In the Cook Inlet basin, two oil pools and a gas field extension were discovered; a third oil discovery in a 1990 exploratory well on the North Slope was announced. Seven lease sales were held: the State of Alaska held three sales on the North Slope and one in Cook Inlet; the Minerals Management Service held two sales offshore from the North Slope; and the University of Alaska held a sale in northern Cook Inlet. High bonus bids at these sales totaled nearly 60 million dollars for slightly over one million acres.

The MMS completed a draft program for a 5-year plan on the management and leasing of natural gas and oil on the Alaskan Outer Continental Shelf (OCS), and revised estimates for undiscovered oil and gas resources in the Chukchi Sea, Beaufort Sea, and Hope Basin. The MMS issued no permits for surveys in OCS waters in 1991 as data acquisition on the OCS reached a 28-year low. Cooperative studies in 1991 by the MMS and the Alaska Division of Geological and Geophysical Surveys (ADGGS) focused on the Prudhoe Bay area, the foothills of the Arctic NWR, and the western range front of the Brooks Range. Continued environmental studies on the OCS shifted emphasis to study possible environmental effects following exploration activities and oil and gas drilling.

In 1991, the USGS continued its evaluation of oil potential on the North Slope and in the Kandik basin of east-central Alaska, and on the energy potential of the Nenana basin. Researchers made technical presentations at 4 national symposia in 1991 and one in early 1992. The USGS completed a thermal maturity map of Alaska and continued investigating the potential production of gas from hydrate complexes.

The USBM determined the availability of land for oil and gas leasing in Alaska in 1991 and examined regulatory policies governing lease activities.

The Bureau of Land Management (BLM) updated its estimates of recoverable resources in the Arctic National Wildlife Refuge (Arctic NWR) to reflect new well information and reprocessed seismic data. The BLM also began a resource assessment in the Forty Mile/Black River planning area and completed oil and gas assessments in the Utukok and Teshekpuk Lake Special Areas of National Petroleum Reserve—Alaska (NPR). In addition, the BLM continued to work toward a possible oil and gas lease sale in NPR and completed several oil and gas appraisals for land exchange parcels. Other ongoing activities include North Slope mineral assessments, mining claim patent evaluations, and oil and gas lease management. The BLM continued its Alaska Inspection and Enforcement program for leasehold oil and gas operations on producing Federal leases in the Cook Inlet Basin. In 1991, both the Trans-Alaskan Pipeline pipe replacement project in Atigun Pass and the construction of oil spill contingency facilities along the pipeline were completed.

Minerals-related activities for the Fish and Wildlife Service (FWS) during 1991 included environmental monitoring, permit review and comment, and contaminant analysis both on and off refuges. On refuges, the FWS maintained oversight for remedial cleanup programs and issued special use permits for exploration and development activities. The FWS reviewed 53 permit applications for oil and gas activities off refuges and issued 47 special use permits for activities on refuges. Four Federal OCS environmental impact statements and seven State oil and gas lease sales were reviewed.

In 1991, the Department of Energy (DOE) continued to sponsor seminars presenting new technological petroleum research findings, to coordinate interagency petroleum research, and to study the applicability of recovery techniques to gas-hydrate reservoirs in the Arctic.

Arctic National Wildlife Refuge

The FWS and BLM continued to respond to public and Congressional inquiries regarding the resource potential and likely impacts to surface resources in the ANILCA 1002 area, a 1.5-million-acre strip within the coastal plain of the Arctic NWR. Visits to the area by congressional and industry groups were numerous in 1991. The BLM updated the estimated economic recoverable resources within the Arctic NWR based on information not available for their 1987 report. Geologists and geophysicists continue to supplement their Arctic NWR studies by reviewing all pertinent geoscience information. The BLM supplied documents and affidavits to the FWS for the administrative record in response to two lawsuits. The FWS completed the fourth year of its 5-year continuing studies in the 1002 area, inventorying the vegetation, water availability, birds, mammals, and fish,

in order to better understand the area's ecosystem. This knowledge will be used to avoid, minimize, or rectify adverse impacts from oil drilling, should it occur in the 1002 area.

Exxon Valdez Oil Spill

The oil tanker T/V *Exxon Valdez* ran aground on Bligh Reef on March 24, 1989, spilling more than 11 million gallons (262,000 barrels) of Prudhoe Bay crude oil into eastern Prince William Sound; the oil eventually spread south and west as far as the Alaska Peninsula. Containment efforts failed, and in October 1991, the Exxon Corporation and Exxon Shipping Company agreed to pay a record \$1.25 billion in fines, restitution, and civil damages to the Federal and State governments. Federal and State agencies continue to monitor and assess the long-term impact of the oil spill.

During the third year following the *Exxon Valdez* oil spill, the FWS remained actively involved in response activities, assessing the status of national wildlife refuge shorelines, monitoring cleanup activities, and protecting Department of the Interior (DOI) trust resources. The FWS also continued its Natural Resource Damage Assessment and Restoration Planning activities on migratory birds and sea otters, those species most severely impacted by the spill.

The MMS provided staff and some funding to assist in the cleanup and monitoring of the oil spill. In 1991, MMS researchers continued to collect information on the long-term social, economic, and cultural consequences of the spill, to be released in a report in late 1992.

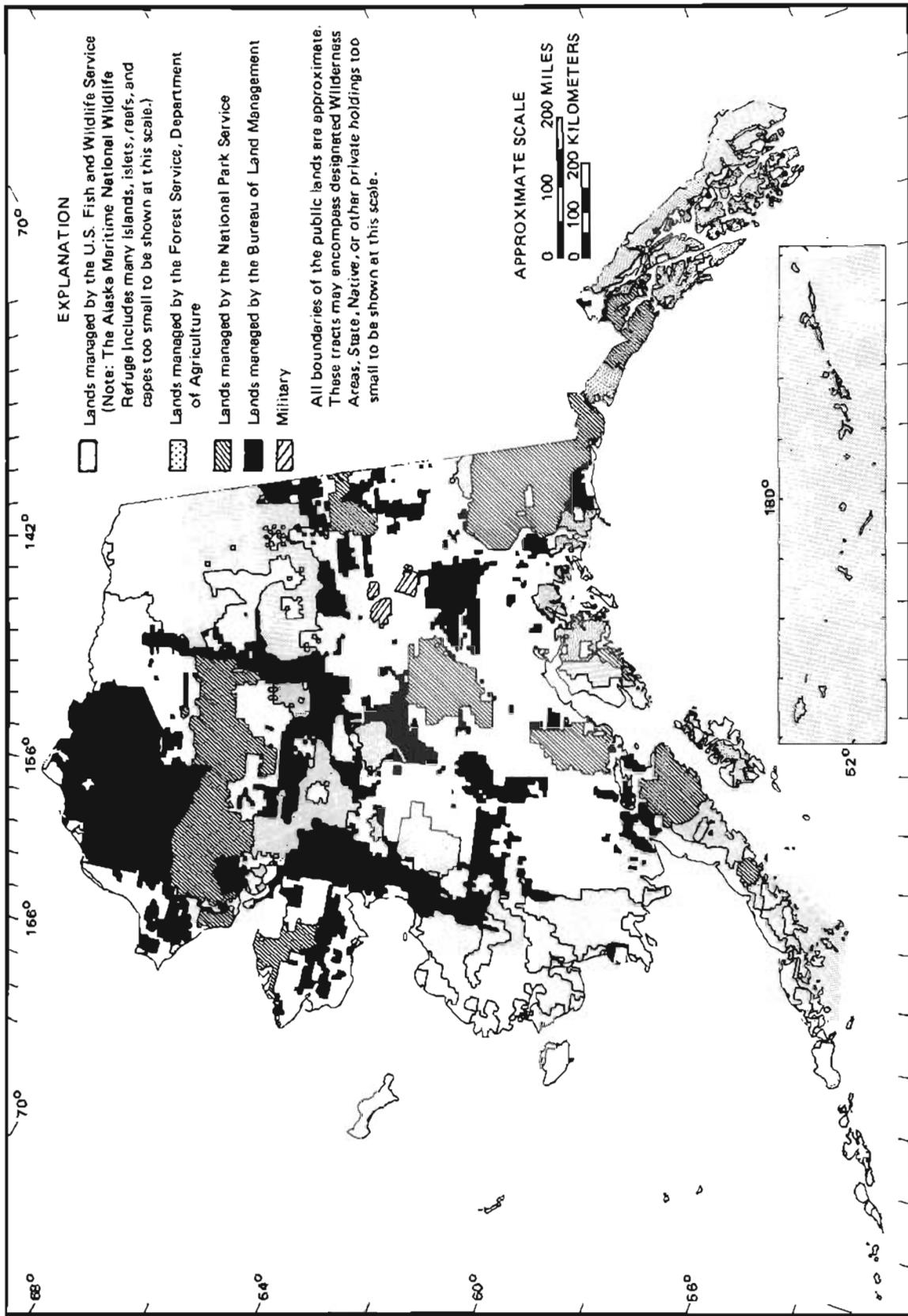
In 1991 for the three national parks damaged by the oil spill, the National Park Service (NPS) finished cleanup activities and focused on damage assessment and restoration. In addition, the NPS responded to subpoenas filed against the NPS by Exxon and by private plaintiffs with actions pending against Exxon.

The USGS published a report analyzing oil and tar collected in beach and deeper water sediments in Prince William Sound 17 months after the oil spill.

Personnel from the U.S. Forest Service (USFS) continued to monitor oil spill damage in interagency teams and in cleanup crews along USFS beaches in Prince William Sound.

Coal and Peat

Alaskan coal production, following a national decline in coal production for 1991, fell by 4 percent to 1.52 million short tons, down from a record high in 1990. The 1991 coal production is valued at \$45 million. At present, all production comes from one mine in central Alaska; however, in 1991 further work on development plans was done for five additional mine sites. Production



Base from maps prepared by the Bureau of Land Management in 1987.

Figure 1. Federal land ownership in Alaska (boundaries as of June 1987).

goal of this program is a systematic investigation of the State's mineral resources through four progressively more detailed levels of study. Geologic studies at level I cover the whole State, and at level II cover large areas. Studies at level III draw on many geologic disciplines to produce resource assessments at scales of 1:250,000 and 1:125,000. Level IV research focuses on detailed studies of specific mining districts, mineral deposits, or topics relating to the genesis of mineral deposits. In 1991, level III studies were under way in 30 quadrangles, and a total of 26 level IV studies were in progress.

USGS AMRAP publications are a key source of information about Alaska's geology and resource potential. AMRAP studies are essential for the determination of the distribution and potential of national mineral and energy endowments, for the formulation of public policy affecting resource and land management, and for the improvement of resource assessment technology in minimizing potential impacts from development. These studies, which develop the concepts, models, and techniques needed to identify new mineral deposits, are vital to the minerals exploration industry.

The USGS performs its resource-assessment work in Alaska through several programs in addition to AMRAP. Among the programs active in 1991 were (1) studies of mineral resources on public lands, (2) the Development of Assessment Techniques Program, which has a goal improving the ability to identify and evaluate mineral resources, (3) the Strategic and Critical Minerals Program, for identifying the potential of these resources to meet national military and economic needs, and (4) the Oil and Gas Investigations Program, which focuses on studies of petroleum-forming processes and potential source regions in order to produce reliable estimates of undiscovered petroleum resources. The mineral-related aspects of many of these programs are more fully described in later sections of this report.

Other USGS programs that are not mineral-specific include (1) the Earthquake Hazards Reduction Program, which seeks to mitigate earthquake losses through providing data and evaluations for land-use planning, engineering, and emergency preparations, (2) the Volcano Hazards Program, which includes studies on the assessment, reduction, and prediction of volcanic hazards, and helps fund the Alaska Volcano Observatory, (3) Deep Crustal Studies, which investigates the geology and geophysics of the volcanic eruption of 1912, and the resulting vent and Novarupta dome in Katmai National Park, and (3) the Geologic Framework Program, involving both general and specialized research on the regional geology of Alaska. In addition, the Trans-Alaska Crustal Transect (TACT) program is a multidisciplinary approach to study the Earth's crust along a corridor from the Pacific Ocean to the Arctic Ocean. This program is coordinated with the Trans-Alaska Lithosphere Investiga-

tion, which utilizes earth scientists from the ADGGS, University of Alaska, other universities, and private industry.

Information for mineral deposits and occurrences in the United States and worldwide is available through computerized files of the USGS Mineral Resources Data System (MRDS). In Alaska, there are presently 4,155 records in 100 1:250,000-scale quadrangles throughout the State. Data in these files include up to 200 entries related to record identification, location, geology, deposit type, exploration and development, mine workings, commodity, production, reserves, resources, and references. Geologic and deposit information from the Alaska MRDS files can be used to complement economically oriented data from the Mineral Availability System (MAS) computerized files of the USBM, discussed in the next section. Further MRDS information can be obtained from Ray Arndt, MRDS Project Chief, U.S. Geological Survey, 920 National Center, Reston, VA 22092-0001.

U.S. Bureau of Mines

During 1991, the Alaska Field Operations Center (AFOC) and various research centers of the USBM were active in the programs listed below; further information on the scope and nature of these programs can be found in appendix 2.

Minerals availability.—The two computerized components of the minerals availability program are the MAS and the MILS data bases. MAS contains information on reserve estimates, mineral extraction and beneficiation methodologies, environmental constraints on mining, and cost analyses for selected major mineral deposits. MILS lists basic information on the identification and location of known mineral deposits.

Policy analysis.—The policy analysis program compiles analyses of mineral data with respect to local and national needs. Technical, institutional, political, social, and economic criteria are used to identify mineral issues.

State mineral activities.—A USBM Alaskan State Mineral Officer compiles and analyzes mineral data to report on activities and trends within Alaska's mining industry.

Mineral land assessment.—The USBM's major emphasis in Alaska is the development of areal and commodity-oriented mineral assessments. An integral part of this program focuses on evaluations of mining districts in the State, including assessments of the type, quantity, distribution, reserves, and beneficiation characteristics of specific mineral deposits. The program also emphasizes site-specific investigations of deposits that contain strategic and critical minerals and advanced materials. USBM scientists locate, map, and estimate the size and grade of mineral deposits; they also collect samples for ore characterization and beneficiation research.

Minerals research—Minerals research in Alaska includes efforts to improve mining technology, mineral extraction, and environmental aspects of the mineral industry, while considering Alaska's distinctive climate and geologic conditions. Research is administered by one or more of nine USBM research centers in the lower 48 States or by Washington headquarters, as is the case with the cooperative programs with universities such as the Mineral Institutes. Although funded by the USBM, the Mineral Institutes utilize university staff and facilities to conduct their work. Researchers from the University of Alaska at Fairbanks Mineral Institute were active in Alaska in 1991.

Much of the USBM's work involves highly speculative, long-range research that promises major technological improvements. Corporate industry often cannot afford to conduct such research; the Nation, however, cannot afford to do without it. A primary goal of this research mission is the communication of USBM research results to industry, government, and the general public.

Minerals Management Service

The primary mission of the MMS in Alaska is the management of mineral resource exploration and development on Federal OCS lands. Management efforts are largely focused on leasing of offshore areas for oil and gas exploration and development. However, the MMS also has the authority to lease OCS lands for mining of hard minerals.

Prior to an OCS lease offering, the MMS appraises the economic worth of leasable offshore lands and assesses the environmental risks associated with development of resources on or beneath these lands. Following a thorough process of public review and comment, the MMS selectively makes these lands available to interested parties through competitive OCS lease sales. The MMS then regulates post-lease exploration, development, and production activities to ensure that operations are conducted in a safe and environmentally acceptable manner. The MMS inspects operations to ensure compliance with applicable laws, regulations, and lease terms. Finally, the MMS is responsible for the collection and accounting of royalty and rental revenues generated by the leased properties. At present, no minerals are being developed or produced on the Alaska OCS.

The MMS does not oversee the onshore exploration and development of mineral commodities on Federal land in Alaska. It is responsible, however, for the collection of royalties, bonus payments, and lease rentals generated from onshore Federal and certain Native lands. Productive leases in the Beaver Creek and Swanson River Oil and Gas Fields as well as the Beluga, Cannery Loop, and Kenai Gas Fields provide the bulk of this kind of rev-

enue. Specific data on production and revenues from these fields may be obtained from the Minerals Management Service, Royalty Management, Lakewood, CO 80225.

The MMS also conducts regional studies of the geologic history and petroleum potential of Alaska's offshore basins for the National Resource Assessment, the MMS-USGS inventory of America's oil and gas resources (fig. 2). Results of these studies have been published as part of the MMS OCS report series. Appendix I lists these titles. Copies of the reports may be obtained from the MMS regional office library in Anchorage.

Bureau of Land Management

The principal activities of the BLM related to Alaska's onshore mineral and energy resources are (1) assessment of the mineral potential of BLM planning areas and, through the planning process, identification of how the minerals can best be managed under the multiple-



Figure 2. MMS scientists study outcrops exposed along shoreline of Chinitna Bay, lower Cook Inlet, as part of a geologic assessment program. MMS geologist pictured points to silicified trunk of a tree (palm?) buried in Eocene tuffaceous sand. Photograph by J. Larson.

use concept, (2) development of the terms and conditions, through the planning process and environmental review in accordance with the National Environmental Policy Act (NEPA), for mineral exploration and development on BLM lands, (3) providing mineral resource and economic evaluations to determine mineral values for lease sales, land exchanges, and Federal land disposal, (4) issuance and management of Federal leases in coordination with the responsible surface-managing agency, (5) administrative maintenance and adjudication of Federal mining claims, determination of the validity of claims, critical review of Federal mineral validity reports, and issuance of mineral patents, (6) regulation of mining activities on BLM lands to protect the environment, (7) regulation, permit and agreement approval, inspection of oil and gas leasehold operations, and enforcement of onshore orders for Federal leases producing oil and gas in the Cook Inlet Basin, in compliance with the BLM's National Inspection and Enforcement Strategy, (8) active participation in the State's Abandoned Well Site Closure Program for plugged and abandoned wells on Federal lands, and (9) protection of public mineral resources through an active program to identify, analyze, and study oil and gas drainage patterns.

The BLM is responsible for enforcing the environmental and technical stipulations of the Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline System (TAPS); the overall goal of this effort is to maintain a continuous supply of energy via pipeline integrity and to ensure public safety by minimizing environmental impacts. In addition, the BLM issues land-use authorizations and conducts mineral materials sales to support the operations and maintenance of TAPS, as well as preconstruction activities for the planned natural-gas pipeline and other projects. The BLM has also provided assessments of mineral-potential studies for other land-managing agencies, such as the FWS and NPS, and for input to Congressional initiatives, such as the opening of the Arctic NWR to leasing.

Administrative responsibilities for minerals require close coordination with other surface-management agencies. Generally, in the case of onshore leases, the BLM issues leases and integrates leasing with other land uses in cooperation with the surface-management agency. To assure proper surface and subsurface protections after a lease is issued, the BLM enforces the regulations of 43 Code of Federal Regulations (CFR) 3160 with respect to the lease stipulations and permit conditions for exploration and development activities.

Fish and Wildlife Service

In Alaska, the FWS manages 77 million acres of national wildlife refuge lands and an additional 18 to 22 million acres of lands within the refuge boundaries which

have been selected by the State or by Native corporations, but have not yet been conveyed to them. The FWS is also responsible for research and monitoring of contaminants in fish and wildlife resources; for law enforcement of federal wildlife laws on and off refuges; and for coordination and comment under the Fish and Wildlife Coordination Act, which provides for review and comment of Federal permitting and development activities in waters and wetlands. This latter function includes the investigation, review, and comment on Federal permits and environmental impact statements.

Mineral activities may be allowed under permit on national wildlife refuges provided that the activity is compatible with the purposes for which the refuge was established. Under Section 810 of the ANILCA, if an activity would significantly restrict subsistence use of Federal lands, the agency must give notice and hold hearings to determine (1) that the restriction is necessary, (2) that a minimum amount of land is effected, and (3) that reasonable steps are taken to minimize adverse impacts upon subsistence uses and resources. The location of the 16 national wildlife refuges in Alaska is shown in figure 3.

The FWS makes recommendations to other Federal agencies for mitigating adverse impacts to fish, wildlife, and habitats from Federally constructed, funded, or permitted projects. The FWS reviews Army Corps of Engineers (ACE) and Environmental Protection Agency (EPA) permit applications under Sections 402 and 404 of the Clean Water Act of 1977, as amended, and under Section 10 of the Rivers and Harbors Act of 1899, as amended. These permit requirements apply to both public and private lands and waters.

The FWS manages migratory birds, listed threatened and endangered species, and certain marine mammals. When an agency is considering permit applications for exploration or development activity, that agency must determine if listed species are present within the area of activity. When a listed species is present, and it is determined that the proposed activity may adversely affect that species, the agency must consult with the FWS in accordance with the Endangered Species Act of 1973, as amended.

The FWS manages three marine mammals species in Alaska: polar bear, sea otter, and Pacific walrus. Section 101(a)(5) of the Marine Mammal Protection Act of 1972, as amended, authorizes the Secretary of the Interior to allow a U.S. citizen engaged in a specified activity in a specified region the incidental, but not intentional, taking of small numbers of marine mammals.

National Park Service

Under its Congressionally mandated mission, the NPS manages all units of the National Park System so as "to conserve the scenery and natural and historic objects

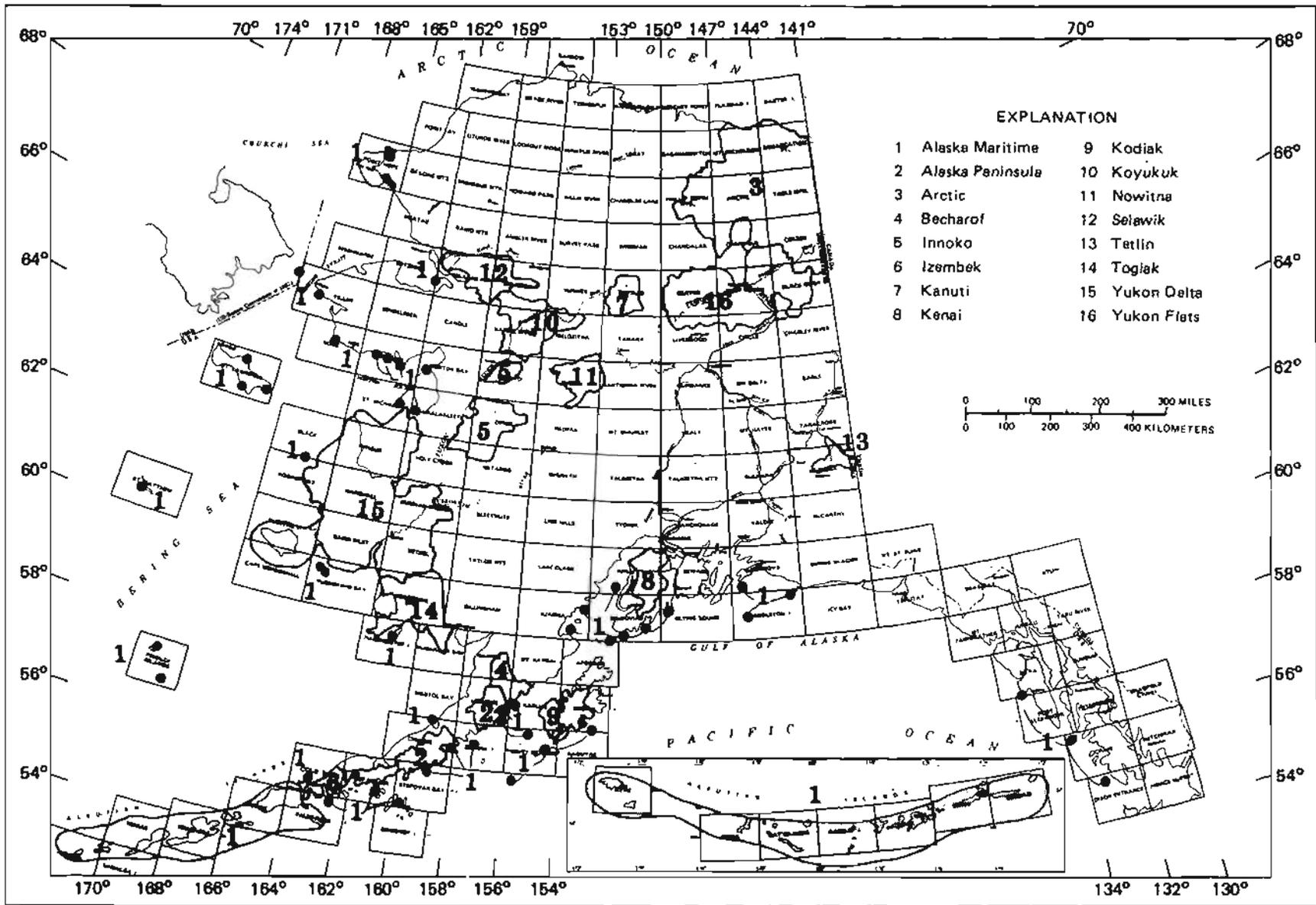


Figure 3. National wildlife refuges in Alaska. 1:250,000-scale quadrangles are outlined and labeled.

and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 U.S.C. §1 *et seq.*). With three exceptions that exist in the continental 48 States, Congress has coupled this mandate with a prohibition against Federal mineral leasing in parks. Congress has also universally closed all park units to the location of mining claims under the 1872 Mining Law. As a result, the NPS does not manage minerals in the same sense as other Federal agencies. The Service protects park resources and values from the adverse impacts associated with mineral development of "valid existing rights." Valid existing rights may exist in a park either because they stem from Federal authorization predating the establishment of the park or they consist of rights under private (which includes rights held by Native Corporations) or State ownership. Examples of such rights include valid mining claims located under the 1872 Mining Law prior to the establishment of the park unit or non-Federal oil and gas rights. Where valid rights exist, the NPS regulates mineral development in order to minimize adverse impacts to park resources and values.

The NPS carries out a variety of minerals management functions; such as mineral examinations to determine claim validity; the evaluation of proposed mining plans including completeness determination, engineering analysis, impact assessment, and bonding; compliance monitoring of approved operations; mineral valuation

appraisals; and mining claim acquisition and site reclamation, where appropriate. Major programs have been undertaken to survey, take aerial photographs, and map mining claims; to prepare topographic maps of mining claims (scale 1:1,200, 10-foot contour interval); to inventory abandoned mineral lands (fig. 4); to perform hydrologic monitoring; to reclaim abandoned and acquired mining claims; and to conduct reclamation research. Guidelines for NPS management and regulation of mineral-related activities are discussed in appendix 2.

Department of Agriculture

U.S. Forest Service

Under a memorandum of understanding with the BLM, the USFS jointly administers the general mining laws on its own lands in Alaska. An example of this joint responsibility is the patent issued to U.S. Borax and Chemical Company for mining claims at the Quartz Hill deposit near Ketchikan. The BLM issued this patent on the basis of favorable findings in a mineral report prepared by USFS mineral examiners.

The USFS cooperates with DOI agencies, particularly the BLM, in issuing mineral leases and assuring mitigation of surface impacts of lease activities. The USFS also cooperates with State agencies and the private sector in development of energy and mineral resources on



Figure 4. Historic cabin, circa 1930, at a placer mine along Glen Creek in Denali National Park and Preserve, inventoried for the NPS Alaska Region's Cultural Resource Mining Inventory and Monitoring Program. Photograph by NPS staff, Cultural Resource Mining Inventory and Monitoring Program.

inholdings. One such inholding is the Bering River Coal Field, which is under consideration for possible development in a joint venture by Chugach Alaska and others.

In Alaska, 23 million acres of land is administered by the USFS (fig. 1), whose regional office is in Juneau. Offices for the Chugach National Forest are located in Anchorage, Girdwood, Seward, and Cordova; Tongass National Forest offices are in Sitka, Ketchikan, and Petersburg.

Department of Energy

In Alaska, the DOE is focusing its efforts on petroleum and coal resources. The DOE in Alaska administers current petroleum acts and congressional mandates relating to energy, monitors grants, and oversees contracts for energy-resource studies. DOE funding helps support USGS resource-assessment studies and research by the University of Alaska.

To develop a better understanding of both conventional and unconventional petroleum resources and to provide fundamental information to accelerate utilization of these resources, the DOE emphasizes resource and technological investigations that continue to expand the body of essential and basic scientific knowledge concerning conventional and heavy petroleum, shale oil, tar sands, and gas hydrates. Gas hydrates are a specific target of DOE research in Alaska.

The DOE is working to evaluate Alaskan coal in terms of its contribution to total national resources. Coal research currently centers on utilization methods suitable to Alaskan coals and conditions.

The DOE closed its regional office in Anchorage in 1985. Requests for information about DOE Alaskan activities should be addressed to the office listed below.

Contacts for Further Information

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ENERGY RESOURCES

Oil and Gas Resources

Overview of Production and Prices

Oil and gas remain by far the most valuable commodities produced in Alaska. Alaska's two oil-producing areas, the Arctic North Slope and the Cook Inlet, provided a total of 680.2 million barrels (1 barrel = 42 U.S. gallons) of oil and natural gas liquids, 199 billion cubic feet of dry natural gas, and 2,193 billion cubic feet of casing head gas in 1991 (Alaska Oil and Gas Conservation Commission Bulletin, February 1992). This represents an increase of 2.2 percent from 1990 oil levels, but a 3-percent decrease in dry gas production. Daily oil production in 1991 averaged 1.86 million barrels per day (bbl/d), about 40,300 bbl/d more than in 1990, but still below the peak production of 1.98 million bbl/d in 1988. About 98 percent of Alaska's oil comes from North Slope fields. The significance of Alaskan oil is illustrated by a tabulation of the world's oil-producing countries (table 1): if Alaska were a separate country, it

Table 1. Comparison of Alaska to countries ranked by daily oil production

[Adapted from Beck, 1992]

Rank	Country	Daily production (x1000 barrels)
1	USSR	10,300
2	Saudi Arabia	8,158
3	United States	7,372
4	Iran	3,358
5	China	2,800
6	Mexico	2,774
7	United Arab Emirates	2,417
8	Venezuela	2,351
9	Nigeria	1,867
(10)	(Alaska)	(1,860)
11	Norway	1,848
12	United Kingdom	1,774
13	Libya	1,509
14	Canada	1,494
15	Indonesia	1,431

would rank tenth in oil production, ahead of Canada, the United Kingdom, Libya, and Norway.

Alaska North Slope crude oil prices in early 1991 continued their rapid decline from the \$32.54/bbl high in October 1990 (all prices quoted here are West Coast prices). January's price of \$23.77/bbl was the highest for the year; the year's lowest price of \$15.73/bbl occurred in March (table 2). Subsequently, prices rose slightly and, for the remainder of the year, fluctuated in a relatively narrow range. The average 1991 price was \$17.96/bbl, 14.6 percent below the 1990 average price of \$21.03/bbl. Alaska's treasury is especially vulnerable to crude oil prices because 83 percent of its current income is derived from royalties and taxes paid on State-owned oil and gas leases (Alaska Department of Natural Resources, 1986). Each \$1 change in the price of crude oil translates to an approximately \$150-million gain or loss in State revenues.

Exploration

Drilling.—Thirteen exploratory wells were active in 1991, the same as in 1990: four wells were drilled on the North Slope, four in the adjacent Beaufort and Chukchi Seas, and five in the Cook Inlet region (fig. 5, table 3). Two oil pools and a gas field extension were discovered in Cook Inlet; the other exploratory wells were plugged and abandoned.

Permitting.—The Alaska Oil and Gas Conservation Commission approved 157 drilling permits in 1991, for 127 development wells, 16 exploratory wells, and 14 service wells (Alaska Oil and Gas Conservation Commis-

Table 2. Fluctuation in price of Alaska North Slope crude oil

[Data from Alaska Report: BP Exploration's Alaska North Slope contract crude oil price, based on previous month's average spot market price, represents 95 percent of production. WC, delivered to West Coast; GC, delivered to Gulf of Mexico]

Date	Cost per barrel	
	WC	GC
12/5/90	\$28.74	\$29.64
1/1/91	23.77	25.01
2/1/91	20.62	21.20
3/1/91	15.73	16.08
4/1/91	16.90	17.71
5/1/91	17.55	18.16
6/1/91	16.73	18.01
7/1/91	16.33	17.58
8/1/91	17.32	18.30
9/1/91	17.18	18.49
10/1/91	17.31	19.05
11/1/91	18.52	20.05
12/1/91	17.56	19.16
1/1/92	14.84	16.47
1991 average price	\$17.96	\$19.07

sion, May 1992). This was a 14-percent decrease from the 182 drilling permits issued in 1990.

Cook Inlet.—Renewed exploration activities that began in 1990 after a hiatus of several years paid off in 1991 when two oil discoveries and the extension of a gas field were announced. These are the first Cook Inlet oil discoveries since 1965. ARCO Alaska and partner Phillips Petroleum drilled a \$30-million test well near the North Cook Inlet Gas Field (Anchorage Daily News, October 25, 1991); this well, Sunfish No.1, tested at rates of 1,100 barrels of oil and 1 million cubic feet of gas per day (No. 8, fig. 5, table 3). Stewart Petroleum's W. McArthur River No. 1, located on the west side of Cook Inlet about 3 miles southwest of the McArthur River Oil Field (No. 9, fig. 5, table 3), was announced as a Hemlock reservoir oil discovery; partners in the well included Stewart Petroleum, Ssangyong Oil Refining of Seoul, South Korea, and several private Alaskan investors (Anchorage Daily News, December 13, 1991). On the east side of Cook Inlet about 15 miles south of the Swanson River field, Cook Inlet Region, Incorporated (CIRI) Production Company, an Anchorage-based Native corporation, announced a successful stepout well to the West Fork Gas Field. The West Fork 1-21 well measured a flow of 10 million cubic feet of gas per day on tests of a Tertiary zone (Anchorage Daily News, February 2, 1991). This field had been abandoned by Seagull Energy in 1986 after producing 1.5 billion cubic feet of gas.

North Slope.—Conoco and partner Petrofina Delaware reported an oil and gas discovery in their Badami No. 1 well (fig. 5) drilled in 1990. During a 4-hour test,

Table 4. Comparison of Alaskan oil and gas production, 1991

(Data from Alaska Oil and Gas Conservation Commission Bulletin, February 1992)

Field	Production (barrels/day)	Percent change from 1990
Endicott -----	116,499	+ 10.1
Kuparuk -----	311,046	+ 5.9
Milne Point -----	20,432	+ 12.5
Prudhoe -----	1,375,582	+ 0.035
Total North Slope -----	1,823,559	+ 1.6
Total Cook Inlet -----	42,090	+ 37.6
State Total -----	1,863,650	+ 2.2

field's first development well, DS 1-1, due to high maintenance costs. The DS 1-1 well started flowing oil in 1970 and produced more than 19 million barrels of oil over the last 21 years (Anchorage Times, December 27, 1991). The well's production piping, known as a "christmas tree," was left in place as an historic marker. ARCO Alaska is proceeding with its \$1.5-billion Gas Handling Expansion Phase 2 (GHX-2) project, announced in 1990. The project is expected to increase production by another 100,000 barrels of oil per day when the plant comes on line in 1995, and to allow an additional 330 to 450 million barrels of oil to be recovered over the life of the field (Alaska Journal of Commerce, May 13, 1991). A total of 9.4 billion barrels was originally predicted as recoverable from the 24-billion-barrel Prudhoe Bay field, but with water flooding, high-pressure fracturing, and gas reinjection, estimates for total recovery are now about 12 billion barrels (Alaska Journal of Commerce, June 17, 1991).

Kuparuk River.—The Kuparuk River field, the Nation's second largest oil field, marked its 10th anniversary in 1991 and showed an increase in production by nearly 6 percent over the previous year (table 4). Production records for the field were set in 1991, including output for a single day (352,950 bbls), for a single month (10,068,358 bbls), and for the highest average daily rate ever produced for a given calendar month in nine consecutive months. Originally, production from this field was expected to peak at 250,000 bbls/d with ultimate recovery of 1.2 to 1.5 billion barrels; today, engineers expect to recover 1.8 billion barrels (Alaska Journal of Commerce, April 8, 1991; January 6, 1992).

Endicott.—The Endicott field is the largest active offshore oil field in the United States and the only offshore field now producing in the Arctic; production from the field increased by 10 percent in 1991 (table 4). BP Exploration requested the Alaska Oil and Gas Conserva-

tion Commission to establish rules for the new oil pool that was discovered in the Sadlerochit and Lisburne reservoirs adjacent to the Endicott field. Known as the Sag Delta pool, this accumulation is estimated at 6.5 million barrels of recoverable oil, 80 percent of which is believed to be in the Sadlerochit reservoir. Peak production from this pool would be about 8,000 bbls/d (Fairbanks Daily News-Miner, March 27, 1991).

Point McIntyre.—Details of the Point McIntyre field, discovered in 1988 beneath the waters of Prudhoe Bay by ARCO Alaska, were released in 1991 by the Alaska Oil and Gas Conservation Commission. Information included well data, reports, and logs (Alaska Report, September 18, 1991). Production from the field will be delayed until sometime in 1993, rather than 1992 as previously anticipated, because equity and facility sharing are still being debated by the field's three owners, ARCO Alaska, BP Exploration, and Exxon (Alaska Report, April 3, 1991).

Niakuk.—The Niakuk field, containing 58 million barrels of recoverable oil, is the smallest field considered economic in the Prudhoe Bay area. Discovered in 1985, this field lies about one mile offshore from the eastern side of Prudhoe Bay (fig. 5). Development has been stalled due to problems in getting a permit for a causeway from shore to production island(s). BP Exploration, the field's owner, is now conducting feasibility studies to develop the field from onshore at Heald Point. The company estimates that 80 percent of the recoverable oil can be extracted from this location. A critical part of the plan is the use of existing Lisburne facilities to process Niakuk production (Anchorage Daily News, July 27, 1991).

Cook Inlet

Unocal Corp. will temporarily cease operations at Dillon, one of the four platforms in the Middle Ground Shoal field, due to declining yield. The daily production of only 250 barrels of oil is uneconomic. If a drilling program on nearby Baker platform is successful, similar work will be done at Dillon, and operations may resume. This is the first platform to be shut down in Cook Inlet due to declining production (Fairbanks Daily News-Miner, October 11, 1991). Over the past 25 years, daily Cook Inlet oil production has dropped from a peak of 200,000 bbl/d to under 40,000 bbl/d (Alaska Journal of Commerce, October 21, 1991).

Leasing Activity

Federal Government.—The Minerals Management Service held two Outer Continental Shelf lease sales in 1991: Beaufort Sea 124 and Chukchi Sea 126. Combined high bonus bids were \$23,924,329 for 436,214 acres (Alaska Journal of Commerce, July 8, 1991; Anchorage Times, August 29, 1991).

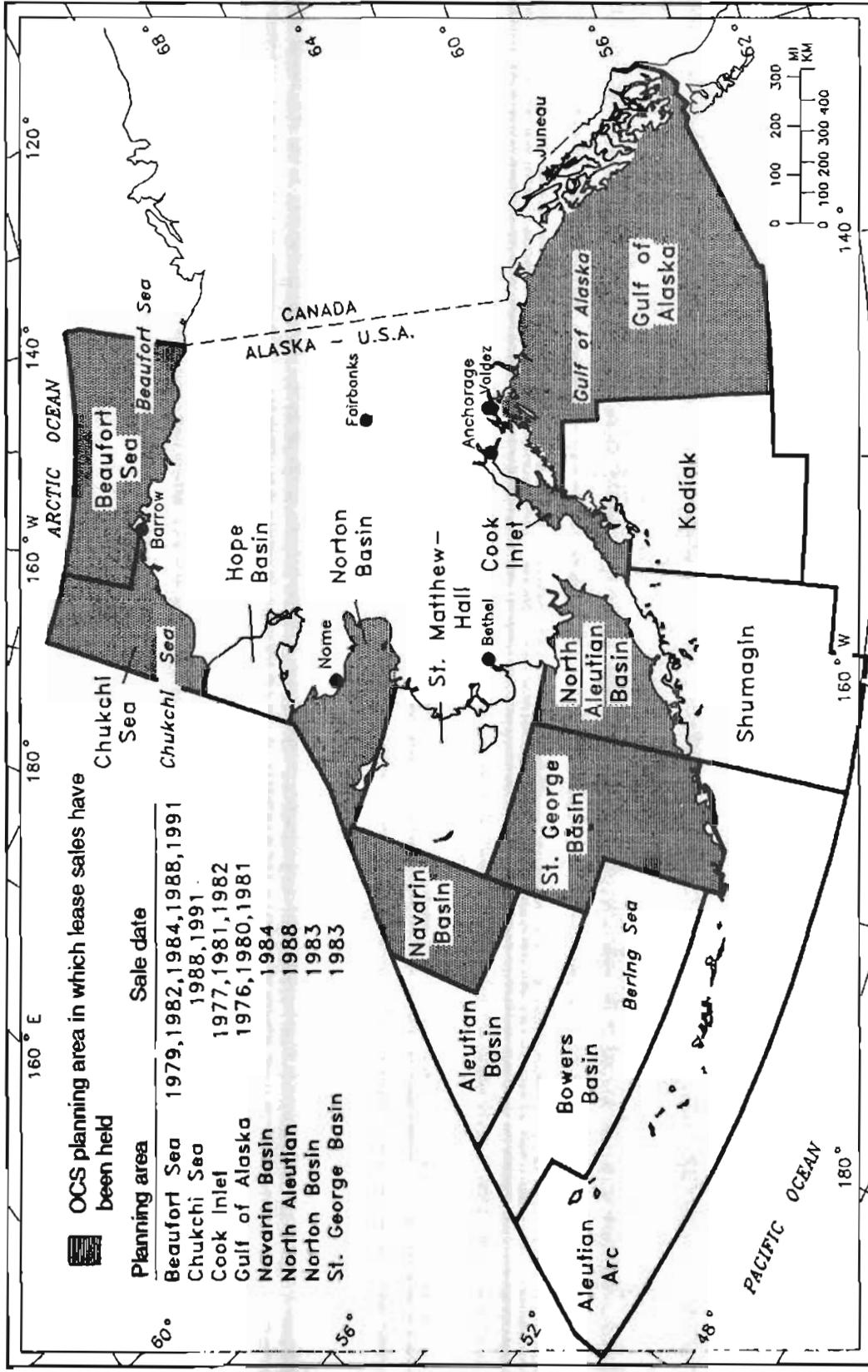


Figure 6. Alaska Outer Continental Shelf Region planning areas and lease sale history.

Table 5. Alaska Outer Continental Shelf leases and wells drilled, 1976–1990

[DST, Deep Stratigraphic Test well]

Planning area (sale dates)	Total tracts leased	Number of wells drilled ¹	Number of leases held
Beaufort Sea ----- (1979, 1982, 1984, 1988, 1991)	631	25	446
Chukchi Sea ----- (1988, 1991)	378	4	378
Cook Inlet Basin ⁽²⁾ ----- (1977, 1981, 1982)	100	14 (1 DST)	0
Gulf of Alaska ----- (1976, 1980, 1981)	112	13 (1 DST)	0
Kodiak Shelf -----	0	6 (6 DST)	0
Navarin Basin ----- (1984)	163	9 (1 DST)	2
North Aleutian Basin ⁽³⁾ ----- (1988)	23	1 (1 DST)	23
Norton Basin ----- (1983)	59	8 (2 DST)	0
St. George Basin ----- (1983)	96	12 (2 DST)	16

¹Total includes both exploratory and DST wells.

²Includes Lower Cook Inlet and Shelikof Straits.

³The leases are currently under a 1-year moratorium and concurrent 1-year suspension of operations until September 30, 1992.

State of Alaska.—The State of Alaska held four lease sales during 1991: Beaufort Sea 65, Cook Inlet 74, Kavik 64, and Kuparuk Uplands 70A. High bonus bids totaled \$35,264,730 for 654,179 acres. These were the first State lease sales in two years (Alaska Report, March 4, 1992).

Other.—The University of Alaska at Anchorage held a lease sale on acreage near Wasilla in northern Cook Inlet. This sale drew \$134,192 in high bonus bids for 3,643 acres (Anchorage Daily News, October 16, 1991).

Transportation

Trans-Alaska Oil Pipeline.—The General Accounting Office (GAO), an investigative arm of the U.S. Congress, issued a report critical of Federal and State oversight of the Trans-Alaska Pipeline System for the 5 years prior to the 1989 oil spill in Prince William Sound (Anchorage Daily News, August 5, 1991). The report also faulted the agencies for their failure to hold regularly

Table 6. Proceeds from lease sales on Alaska Outer Continental Shelf planning areas

Planning area	Sale	Year	Proceeds (in dollars)
Beaufort Sea -----	BF ⁽¹⁾	(1979)	488,691,138
	71	(1982)	2,055,632,336
	87	(1984)	866,860,327
	97	(1988)	115,261,636
	124	(1991)	16,807,025
Chukchi Sea -----	109	(1988)	478,032,631
	126	(1991)	7,117,304
Gulf of Alaska -----	39	(1976)	559,836,587
	55	(1980)	109,751,073
	RS1	(1981)	170,496
Lower Cook Inlet -----	CI	(1977)	398,471,313
	60	(1981)	4,405,899
	RS2	(1982)	0
Navarin Basin -----	83	(1984)	516,317,331
North Aleutian Basin --	92	(1988)	95,439,500
Norton Basin -----	57	(1983)	317,873,372
St. George Basin -----	70	(1983)	426,458,830

¹Held jointly with the State of Alaska; sale revenues totaled \$1,056,082,635.

scheduled oil spill cleanup and containment drills and for the lack of independent review of Alyeska Pipeline Service Company's corrosion prevention system. The GAO urged the establishment of an oversight office to monitor and review Alyeska's operations. The State of Alaska derives a revenue of about \$2,000 per minute from the pipeline when flowing at full capacity.

Activity by Federal Agencies

Minerals Management Service

Leasing and Exploration Activity

Since 1976, the DOI has held 17 oil and gas lease sales on the Alaskan OCS (fig. 6, table 5), offering over 135 million acres. The DOI has leased 8.5 million acres (1,562 leases) and has accepted \$6.5 billion in high bonus bids (table 6). A total of 697 leases have been relinquished or have expired, leaving 865 leases still held by oil companies. Two lease sales for oil and gas were held on the Alaskan OCS in 1991: Sale 124 in the Beaufort Sea planning area and Sale 126 in the Chukchi Sea planning area.

Fourteen Deep Stratigraphic Test (DST) wells and 78 exploratory wells have been drilled on the Alaskan OCS (table 5). In 1991, two exploratory wells were completed in the Beaufort Sea planning area that tested the Gallahad

Table 7. Exploratory wells drilled on the Federal Outer Continental Shelf in 1991

[P&A, plugged and abandoned]

Company	Lease No. (well name)	API No.	Location	Date completed	Remarks
Shell	OCS-Y-1320 (Crackerjack)	55-382-0003	71°25' 08" N. 165°32' 30" W.	8/91	P&A
Chevron	OCS-Y-0996 (Diamond)	55-322-0001	71°33' 29" N. 161°67' 97" W.	10/91	P&A
Amoco	OCS-Y-1092 (Gallahad)	55-171-0007	70°56' 07" N. 144°95' 95" W.	10/91	P&A
ARCO	OCS-Y-0747 (Cabot)	55-262-0001	71°19' 27" N. 155°12' 44" W.	Completion anticipated in early 1992	

and Diamond prospects (table 7). Drilling of a third well (ARCO's Cabot prospect) in the Beaufort Sea commenced on November 1, 1991, but is not expected to be completed until early 1992. In the Chukchi Sea planning area, drilling of the Crackerjack (OCS-Y-1320) well, temporarily suspended since October 1990 because of ice conditions, was completed in August 1991.

The majority of the exploratory wells drilled on the Alaskan OCS have been permanently plugged and abandoned. However, eight leases have been classified as "producible" (table 8), although none of them are considered to be economically productive under current economic conditions. (As defined by MMS regulations Title 30 CFR Part 250.11, a "producible" lease is one from which oil, gas, or both, can be produced in quantities sufficient to yield, after completion of the well, a return in excess of the cost of producing the hydrocarbons at the wellhead.) All of these producible leases lie within the Beaufort Sea planning area; four of them have been relinquished.

Beaufort Sea planning area.—Fifty-seven leases were awarded in OCS Sale 124 in the Beaufort Sea planning area in June 1991. High bids for the sale totaled \$16,807,025. Prior lease sales were held in the Beaufort Sea planning area in 1979, 1982, 1984, and 1988. A total of 631 tracts have been leased, with 446 remaining active to date. The status of an additional 20 blocks that received bids remains undetermined subject to questions of U.S.-Canadian jurisdiction. OCS Sale 144 is tentatively scheduled for the Beaufort Sea planning area in late 1993.

Twenty-four exploratory wells have been drilled in Federal waters in the Beaufort Sea planning area. An additional well, the ARCO Cabot (OCS-Y-0747) well, was spudded east of Barrow in November 1991, and drilling is expected to be completed in early 1992. Two exploratory wells were completed in the Beaufort Sea planning area in 1991: Amoco drilled the OCS-Y-1092 No. 1 well on the Gallahad prospect north of Camden

Bay, and Chevron completed the OCS-Y-0996 No. 1 well on the Diamond prospect 60 miles northwest of Wainwright.

Chukchi Sea planning area.—The first lease sale in the Chukchi Sea planning area, OCS Sale 109, was held in 1988. During Sale 109, 350 leases were awarded, and all remain active. Sale 109 leases are scheduled to expire in 1998.

A second lease sale, OCS Sale 126, was held on August 28th, 1991. Bidding activity at this sale was low, with companies placing only 30 bids on 28 tracts. High bids for the sale totaled \$7,117,304. A third lease sale, OCS Sale 148, is tentatively scheduled for 1994.

Four exploratory wells have been drilled in the Chukchi Sea planning area. The Klondike (OCS-Y-1482 No. 1) well was completed in 1989; the Burger (OCS-Y-1413 No. 1) and Popcorn (OCS-Y-1275 No. 1) wells were completed and plugged in 1990. Drilling of the Crackerjack (OCS-Y-1320 No. 1) well, started in 1990 and temporarily suspended due to ice conditions, was completed in August 1991. Data obtained from the Klondike well were released to the public by MMS in October 1991 in accordance with Title 30 CFR, Part 250.3.

Cook Inlet planning area.—In the Cook Inlet planning area, a total of 100 leases were awarded in two sales held in 1977 and 1981. In August 1982 a third lease sale in the area failed to attract any bids. A fourth lease sale, OCS Sale 88, initially scheduled for December 1984, was postponed indefinitely by the Secretary of the Interior because of the poor exploration results to date and the subsequent relinquishment of many existing leases by the industry. All leases in the Cook Inlet planning area have been relinquished or have expired.

Thirteen exploratory wells and one DST well were drilled in the Lower Cook Inlet and Shelikof Strait between 1977 and 1985. All have been permanently plugged and abandoned.

Table 8. Producing oil leases, Beaufort Sea planning area

Lease number	Prospect name	Number of wells drilled
OCS-Y-0181	Seal	1
¹ OCS-Y-0191	Salmon	2
² OCS-Y-0195	Tern	1
² OCS-Y-0196	Tern	1
³ OCS-Y-0197	Tern	1
OCS-Y-0370	Sandpiper	1
OCS-Y-0371	Sandpiper	1
OCS-Y-0849	Hammerhead	2

¹Relinquished 12/88²Relinquished 7/90³Relinquished 6/90

Gulf of Alaska planning area.—A total of 112 leases in the Gulf of Alaska planning area were awarded in three OCS sales held in 1976, 1980, and 1981. All of these leases have been relinquished or have expired. OCS Sale 114, a joint Gulf of Alaska/Lower Cook Inlet lease sale originally scheduled for March 1992, was postponed indefinitely in May 1989 to allow additional time to assess the effects of the *Exxon Valdez* oil spill.

Twelve exploratory wells and one DST well were drilled in the Gulf of Alaska between 1975 and 1983. All of these wells have been permanently plugged and abandoned.

Kodiak Shelf planning area.—Six DST wells were drilled on the Kodiak shelf in 1976 and 1977 in order to delineate the geological framework and hydrocarbon potential of the area. Four lease sales have been tentatively scheduled for the Kodiak planning area since 1980, but have not been held due to low interest by industry and to administrative postponements. No lease sales are presently scheduled for this area, although MMS plans to conduct additional studies to gain a better understanding of the hydrocarbon resources of this area.

Navarin Basin planning area.—In the Navarin Basin planning area, 163 leases were awarded in OCS Sale 83 in April 1984. Seventeen additional blocks located within an area of disputed U.S.-Soviet jurisdiction also received bids, but the Secretary of the Interior subsequently concluded that it was not in the interest of the United States to retain the bids, and the bid deposits were refunded with interest in December 1988. Only two leases remain active, and they are due to expire in 1994; the remainder have been relinquished. A second lease sale, OCS Sale 107, was scheduled to be held in 1991, but has been postponed indefinitely because of low interest by industry.

One DST well was drilled in 1983 and eight exploratory wells in 1985 in the Navarin Basin. All of these wells have been permanently plugged and abandoned.

North Aleutian Basin planning area (Bristol Bay).—OCS Sale 92 was initially scheduled in the

North Aleutian Basin planning area in January 1986. However, a preliminary injunction prohibited opening of bids at that time, and completion of the sale was postponed until October 1988. The 23 leases awarded were placed under a one-year moratorium and concurrent one-year suspension of operations from October 1, 1989, to September 30, 1990, to allow time to study information gathered from the *Exxon Valdez* oil spill and to evaluate environmental consequences of oil development on Bristol Bay fisheries. Two subsequent moratoriums have resulted in suspension of operations in the North Aleutian Basin through September 30, 1992. Pending completion of the moratoriums and suspensions, the expiration date of the leases will be extended to the year 2002.

One DST well was completed in the North Aleutian Basin by ARCO in 1983.

No exploratory wells have been drilled to date because of the pending moratoriums.

Norton Basin planning area.—Fifty-nine leases were awarded in the Norton Basin planning area in 1983 in OCS Sale 57; all of the leases have subsequently been relinquished. Two additional lease sales, OCS Sales 100 and 120, were scheduled for 1986 and 1992, respectively, but were canceled or indefinitely postponed due to low industry interest. Two DST wells were drilled by ARCO in Norton Basin prior to OCS Sale 57. Six exploratory wells were drilled in 1984 and 1985 on leases acquired by Exxon and ARCO; all of these wells have been permanently plugged and abandoned.

St. George Basin planning area.—In the St. George Basin planning area, 96 leases were awarded in OCS Sale 70 held in 1983. Sixteen leases remain active and are due to expire in 1994. Two additional scheduled lease sales, OCS Sales 89 and 101, were canceled or postponed indefinitely in 1986 and 1990, respectively, due to low industry interest. Ten exploratory wells and two DST wells, all now permanently plugged and abandoned, were drilled in the St. George Basin prior to 1986.

Future Sales

The OCS Lands Act requires that the Department of the Interior prepare a 5-year program that specifies the size, timing, and location of areas to be assessed for Federal offshore natural gas and oil leasing. In accordance with the OCS Lands Act, the MMS has prepared a draft Comprehensive Program for the management and leasing of natural gas and oil on the Alaskan OCS, 1992–1997. The draft proposal limits the amount of acreage offered by excluding from lease offerings areas where resource potential and industry interest are low, thus reducing uncertainty about potential effects on natural resources. Compared to previous 5-year programs, fewer sales will be considered in fewer areas.

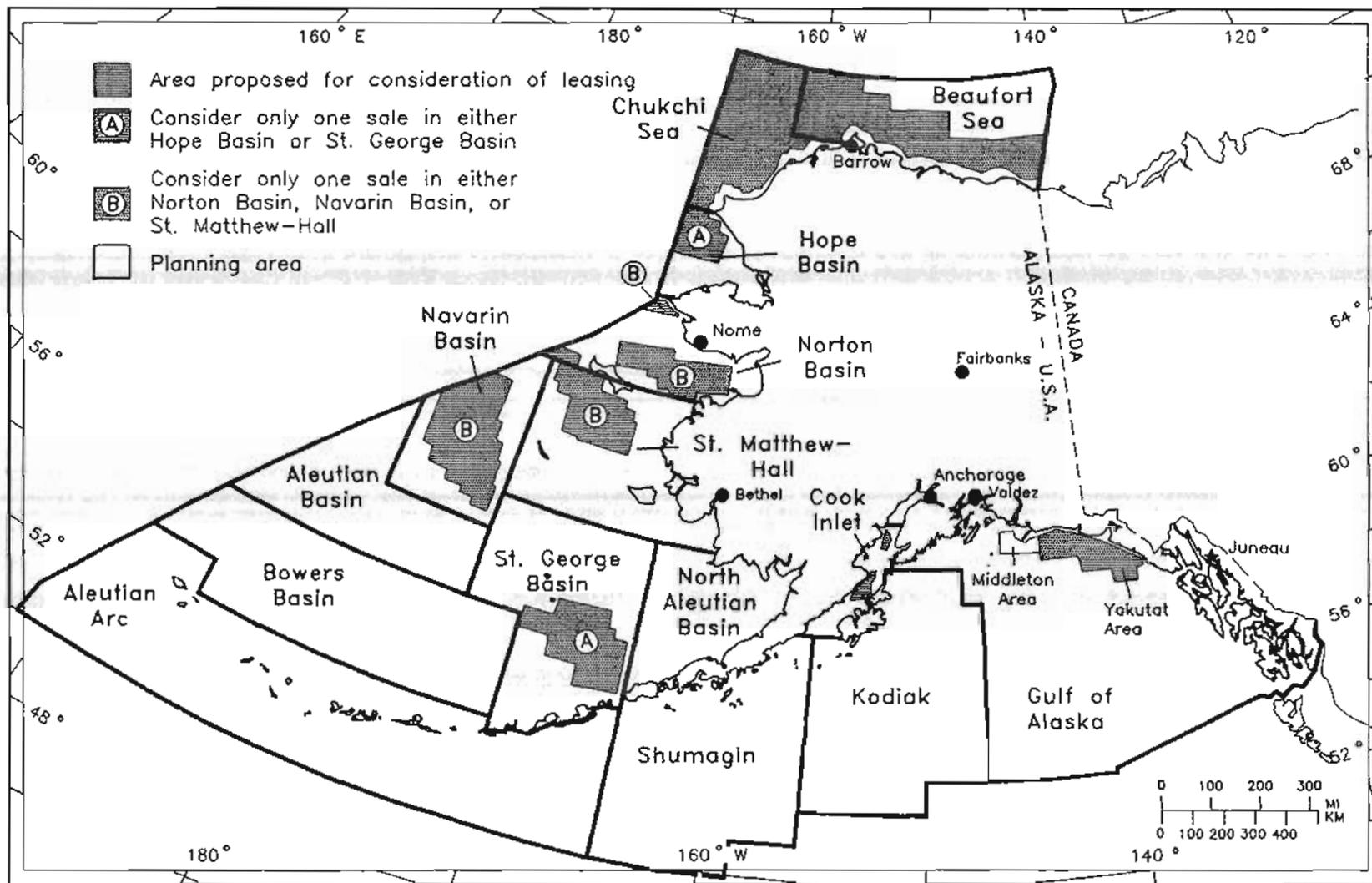


Figure 7. Areas proposed by the MMS for future lease sales or geological and environmental studies, 1992-1997. Information current to January 1, 1992.

Table 9. Proposed activity, current as of January 1, 1992, by Alaska Outer Continental Shelf region and planning area, 1992–1997

Region and planning area	Studies planned	Consider leasing ⁽¹⁾
Gulf of Alaska:		
Yakutat area -----	Yes	1995
Middleton area -----	Yes	-----
Kodiak -----	Yes	-----
Cook Inlet -----	Yes	1994
Shumagin -----	Yes	-----
Aleutian Arc -----	-----	-----
North Aleutian -----	Yes	-----
Bowers Basin -----	-----	-----
Aleutian Basin -----	-----	-----
Norton Basin <i>or</i> -----	Yes	1996
Navarin Basin <i>or</i> St. Matthew-Hall	-----	-----
Hope Basin <i>or</i> -----	Yes	1995
St. George Basin	-----	-----
Chukchi Sea -----	Yes	1994, 1997
Beaufort Sea -----	Yes	1993, 1996

⁽¹⁾Actual dates will depend upon the outcome of the Area Evaluation and Decision Process.

Leasing will be considered in 9 of the 15 Alaskan OCS planning areas during 1992–1997 (fig. 7, table 9). Two sales will be considered for the Beaufort Sea (1993 and 1996) and two for the Chukchi Sea (1994 and 1997). Consideration will be given to one sale in the Lower Cook Inlet planning area (1994) and one in the Yakutat area of the Gulf of Alaska (1995). In five lower-potential areas, consideration for lease sales will be evaluated based on future industry interest, environmental considerations, and apparent hydrocarbon potential. A maximum of two lease sales are proposed for the lower-potential areas: one sale in 1995 for either Hope Basin or St. George Basin, and one sale in 1996 in Norton Basin, Navarin Basin, or St. Matthew-Hall planning area.

No leasing will be considered for the remaining planning areas, but studies are planned for four of them: Shumagin, Kodiak, Gulf of Alaska (Middleton Island area), and North Aleutian Basin. The studies are intended to focus on the hydrocarbon potential and environmental characteristics of these areas.

Oil and Gas Resource Assessment

The MMS prepared estimates of the undiscovered, economically recoverable oil and gas resources on the OCS in 1987 as part of the Federal National Oil and Gas Resource Assessment. The results of this assessment were released in Mast and others (1989). In late 1989, the MMS initiated a review of OCS undiscovered re-

source estimates to determine whether they were still valid or if newly available geological and geophysical information would warrant an update. Subsequently, three of the Alaskan OCS planning areas were determined to have new information which would significantly change the National Assessment resource estimates. The revised estimates for these planning areas, based on geological and geophysical information available as of January 1990, were released in OCS Report MMS 91-0051 (Cooke, 1991).

The three OCS planning areas with revised oil and gas resource estimates are the Chukchi Sea, Beaufort Sea, and Hope Basin (table 10). In the Chukchi Sea planning area, which contains the largest amount of potentially productive acreage of all Alaskan OCS planning areas, the revised undiscovered economically recoverable resource estimates more than doubled compared to the 1987 assessment figures. The most significant factor contributing to this increase in estimated resources was the identification and assessment of over 70 additional plays in the Chukchi Sea planning area. The identification of these additional plays was facilitated by a 120-percent increase in line miles of seismic-reflection data acquired for the Chukchi Sea planning area between 1987 and 1990.

Undiscovered petroleum resource estimates in the Beaufort Sea planning area increased by about 80 percent from the 1987 assessment. Changes to the Beaufort Sea resource estimate cannot be attributed to any single variable, but instead were the result of the refinement of geological parameters primarily at the play level. When viewed on a conditional basis (which assumes that commercially recoverable oil and gas resources exist in the area), the change to resource estimates in the Beaufort Sea between 1987 and 1990 is relatively minor, about 15 percent.

Hope Basin does not contribute significantly to the overall OCS undiscovered petroleum resources (table 10). Although the number of identified prospects more than doubled for the 1990 assessment, the marginal probability of a commercial accumulation of oil or gas remains less than 1 percent.

Data Acquisition on the Alaskan OCS

Data acquisition activity on the Alaskan OCS reached a 28-year low in 1991, with industry acquiring a scant 30 miles of common-depth-point (CDP) seismic-reflection data in Federal waters. Seismic activity was limited to the inner-central Beaufort shelf, where exploration focused on areas adjacent to or extending shoreward into State waters. No permits for regional gravity or magnetic surveys were issued by MMS for the Alaskan OCS in 1991. Several reasons are proposed for the decline in data acquisition activity: (1) exploration on

Table 10. 1990 assessment of undiscovered economically recoverable oil and gas resources, Beaufort Sea, Chukchi Sea, and Hope Basin planning areas

[Results are calculated using the primary case economic scenario described in Max and others (1989). Under the primary case scenario, Alaskan natural gas is not estimated to be economically recoverable. BOE, barrels of oil equivalent; BBOE, billion barrels of oil equivalent]

Planning area	Conditional oil (BBO)			MPhc ¹	Risked oil (BBO)			Risked mean BOE ² (BBOE)
	95% case	5% case	Mean case		95% case	5% case	Mean case	
Beaufort Sea -----	0.58	4.69	1.66	0.23	0	2.63	0.38	0.38
Chukchi Sea -----	1.19	13.10	5.96	.23	0	8.76	1.36	1.36
Hope Basin -----	.20	1.44	.50	< .01	0	0	< .01	< .01

(1)MPhc, marginal probability of hydrocarbons.

(2)Conditional and risked gas values at 95%, 5%, and mean case for all three basins are zero; therefore, Risked oil (mean case) = Risked mean BOE.

Alaskan OCS waters has reached a mature stage, especially with respect to an understanding of the geological framework and petroleum potential of individual sedimentary basins, (2) no hydrocarbon discoveries have been announced to date on the Alaskan OCS, and (3) the relatively high cost of exploration and production in the offshore Alaska environment is prohibitive under the present oil and gas economic conditions.

Joint Federal-State Studies

In 1975, the Minerals Management Service, then the Conservation Division of the USGS, and the State of Alaska initiated joint geologic studies along certain coastal areas of Alaska where geological data were of mutual interest and where such data promised insights into the petroleum potential of adjacent onshore and offshore areas. Subsequent collaborations have investigated areas including the Gulf of Alaska, Cook Inlet, Kodiak Islands (Kodiak shelf), Seward Peninsula-Kuskokwim drainage (Norton Basin), Pribilof Islands (St. George Basin), Alaska Peninsula (North Aleutian Basin) (fig. 8), Waring Mountains (Hope/ Selawik Basins), and the northeast Brooks Range (Kaktovik Basin). Since 1984, the cooperative work has been funded by grants from the Studies Related to Continental Margins Program (SRCM program), sponsored by the MMS. Studies funded under the SRCM program are administered by the Bureau of Economic Geology, University of Texas at Austin, and performed by the ADGGS. In recent years, studies carried out under the SRCM program have focused on the geology of the Arctic Slope and the Arctic NWR. Detailed geologic mapping and fission-track studies of this area have provided insight into the thermal evolution of the Beaufort continental margin, particularly as it bears on the maturation history of key source rock sequences

(O'Sullivan, 1988; O'Sullivan and others, 1989; Clough and others, 1990). Phase II of this regional study, initiated in 1991, focuses in particular on glauconite radiometric dating of the Lower Cretaceous unconformity surface and bounding strata in the Prudhoe Bay area, in the Arctic NWR adjacent to the coastal plain, and to the west along the northern range front of the Brooks Range.

Environmental Studies Program

The Alaska Environmental Studies Program (ESP) was created by the DOI in 1974 in response to the Federal Government's decision to lease areas of Alaska's OCS for gas and oil development. The purpose of the ESP is to determine information needs and implement studies to assist in predicting, assessing, and managing potential effects of oil and gas exploration and development on the human, marine, and coastal environments of Alaska and the Alaskan OCS. Although the ESP is administered by the MMS, additional assessment information is provided to the Alaskan ESP by the National Oceanic and Atmospheric Administration (NOAA) and through direct MMS contracting with private enterprises.

Initially, the focus of the ESP was on obtaining baseline information on the biological resources and physical characteristics of the Alaskan environment. These studies included biological surveys of marine species, basic oceanography and meteorology, and investigations of geologic and sea-ice phenomena. As the OCS leasing program was accelerated in the late 1970's and early 1980's, the emphasis of ESP studies shifted to the potential effects of oil contamination on biological resources and to the probable transport and dispersion of oil that might be spilled in the marine environment.

Recently, with the Alaskan OCS leasing program approaching maturity and significant exploration activity un-

able and applicable for similar uses by all BLM field offices. The Division has also initiated a sophisticated well-log analysis computer program and has cooperated with the State of Alaska in reviewing and assessing the condition of various plugged and abandoned wells drilled on Federal lands throughout Alaska.

The Branch of Pipeline Monitoring is part of the BLM Division of Mineral Resources. The Branch's principal function is to ensure compliance with the terms and conditions of the Right-of-Way Grant issued to the Alyeska Pipeline Service Company for TAPS. The pipe on the main TAPS line at Atigun Pass was successfully replaced in September 1991. The new requirements of the oil spill contingency plan have been implemented, and a heightened awareness of oil spill effects and remedies is evident throughout TAPS. Work continues on wetlands mapping and processing of the Federal Energy Regulatory Commission application for the Anderson Bay liquid-natural-gas facility near Valdez. Activities regarding the Trans-Alaska Gas System (TAGS) project were scaled back when the startup date was postponed several years into the future. For a copy of the Annual Report of the Branch of Pipeline Monitoring, contact the BLM Public Affairs Office in the Federal Building in Anchorage (222 W. 7th Street, Box 13, Anchorage, AK 99513).

In establishing and implementing an oil and gas leasing program as required by Section 1008 of ANILCA, the BLM has made land available for noncompetitive oil and gas leasing in four areas south of latitude 68° N. Both the Minchumina and the Denali-Tickel-Slana areas were opened in 1982, and the Seward Peninsula in 1983 (fig. 9). As of September 30, 1990, the BLM had 4,021 leases on 735,028 acres in these areas. On the Seward Peninsula, 5 leases on 12,640 acres were issued during 1990. In July 1990, 1,636,528 acres in the Iditarod Gorge area was opened to oil and gas leasing. Except for NPRA and potentially the Arctic NWR, all BLM-administered oil and gas estates in Alaska are now handled under the leasing system established by the Federal Onshore Oil and Gas Leasing Reform Act of 1987. Drilling and production operations on BLM leases are administered through the BLM's Branch of Lease Operations.

Fish and Wildlife Service

Kenai National Wildlife Refuge

The Kenai National Wildlife Refuge is the only refuge in Alaska where commercial oil and gas production currently is permitted. Surface operations here are regulated by the FWS, and subsurface activities by the BLM. Data for 1991 production from the refuge's Swanson River and Beaver Creek Oil Fields were previously discussed in the section "Production Activity: Cook Inlet."

At the Swanson River field, operated by ARCO Alaska, soils contaminated by polychlorinated biphenyls

(PCB's) were discovered in 1985. Excavation and stockpiling of the contaminated soils were completed in early 1992, and by February 1992, approximately 97,000 tons of contaminated soils has been neutralized by a Circulating Bed Combustor (CBC). Destruction of the PCB's and removal of the CBC unit should be completed by October 1992. Also at Swanson River, an aromatic hydrocarbon spill was discovered at the field's pipe and supply yard in 1990. Initial experiments to remove the hydrocarbons with an airstripping unit have been successful, and site remediation is expected to require two more years. A second, diesel fuel spill was discovered in the Beaver Creek Oil Field, which is operated by Marathon Oil; remediation of the spill (fig. 10) is expected to be completed in 1992.

In 1991, ARCO Alaska completed an environmental audit of chronic crude oil spills and leaks at tank settings and flare pits throughout the Swanson River Oil Field. The remediation plan will be developed in 1992.

Activities under Section 1008 of ANILCA

Section 1008 of the ANILCA provides for oil and gas studies on refuges in Alaska to gather information for use in future land-management decisions. In 1991, special-use permits were issued for surface geologic work in the following national wildlife refuges (number of permits in parentheses): Alaska Maritime (one), Alaska Peninsula/Becharof (one), Arctic (nine), and Izembek (one). Other special-use permits issued by Alaska refuges in 1991 include the following: Alaska Peninsula/Becharof—reclamation activities (one); Arctic—reclamation activities (one); Kenai—geophysical survey (one), exploration well (one), development wells (31). All special-use permits include specific stipulations to ensure that the permitted activities remain compatible with the purposes of the refuges and to protect refuge resources and refuge users. Commercial permittees must post bonds. Copies of all data gathered from refuge activities must be submitted to the FWS. After review by the FWS, the data are provided to the BLM for confidential storage.

Resource Activity Impact Assessment

Permitting.—In 1991, the FWS commented on 53 Section 404 Clean Water Act permits dealing with oil and gas activities off refuges. These included 13 individual permits, modifications to 35 existing permits, 4 nationwide permits, and 1 general permit. Activities covered by these permits ranged across the Prudhoe Bay, Kuparuk, Endicott, Lisburne, Milne Point, and Pt. McIntyre fields and included the Trans-Alaska Pipeline. The FWS also reviewed 35 North Slope Borough oil and gas permit applications. One permit on the Kenai NWR

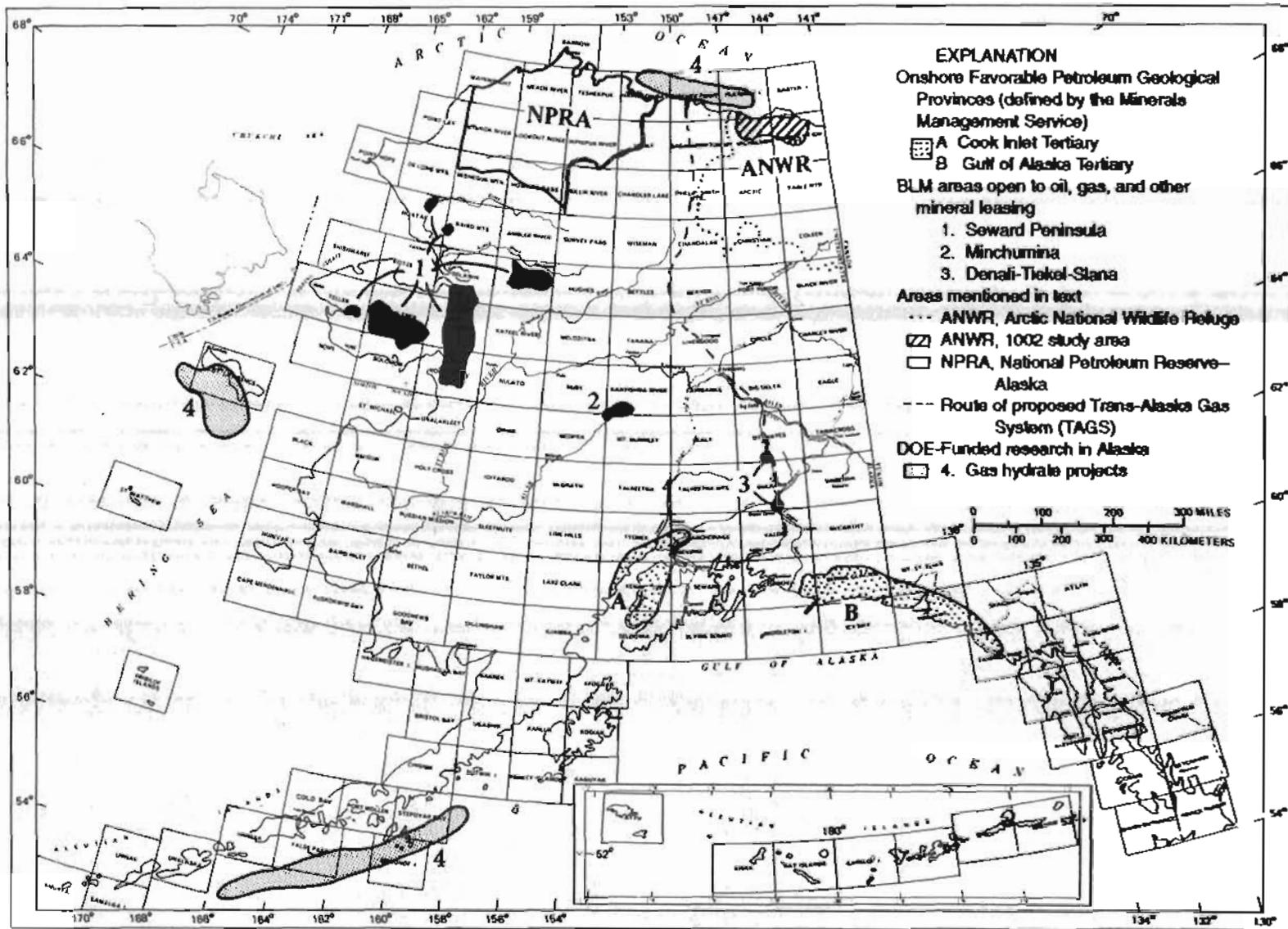


Figure 9. Onshore favorable petroleum provinces, land units referred to in text, and locations of DOE-funded research in 1991.

calculated in their 1987 report. Estimated economic recoverable resources improved from 3.2 billion barrels to 3.6 billion barrels. Engineering studies indicate that no additional development facilities would be required by this slight increase in estimated recoverable resources.

Exxon Valdez Oil Spill

The oil tanker T/V *Exxon Valdez* ran aground on Bligh Reef on March 24, 1989, spilling more than 11 million gallons (262,000 barrels) of Prudhoe Bay crude oil into eastern Prince William Sound. Containment efforts failed, and oil from the tanker eventually impacted large areas of coastline in Prince William Sound, the Gulf of Alaska, the Kodiak Archipelago, and the Alaska Peninsula. Exxon spent over \$2 billion on cleanup operations in three years. Most of the oil spilled has now either sunk to the bottom, been consumed by bacteria, washed ashore, or floated out to sea, but the long-term effects of the oil spill will continue to be a topic of study and controversy. The Coast Guard, as the Federal on-scene coordinator, and the State of Alaska on-scene coordinator officially announced on June 14, 1992, that the response phase of the *Exxon Valdez* oil spill cleanup was completed satisfactorily.

Interagency monitoring and assessment crews were composed of personnel from the ADEC, FWS, NPS, USCG, and USFS, and included oil spill specialists, marine biologists, and geologists. These crews surveyed coastlines, observed oil spill impacts, selected sites for cleanup, and monitored cleanup operations. The *Exxon Valdez* oil spill Trustee Council was formed of State and regional Federal agency heads to conduct damage assessment and restoration planning activities.

A final settlement to the criminal proceedings and civil lawsuit was approved by the court in October 1991. As a result, the Exxon Corporation and Exxon Shipping Company will pay a record \$1.25 billion in fines, restitution, and civil damages to the Federal and State governments. The Trustee Council, which will manage the restoration funds under the terms of the settlement, appointed an interagency Restoration Team to develop a restoration strategy for Prince William Sound and the Gulf of Alaska. Following the October 1991 settlement of the criminal and civil cases against Exxon, the FWS has supported the Department of the Interior's effort with other Federal and State agencies in planning for the restoration of injured trustee resources.

Activity by Federal Agencies

Fish and Wildlife Service

During the third year following the *Exxon Valdez* oil spill, the FWS remained actively involved with the

USCG Federal On-scene Coordinator in assessing the status of national wildlife refuge shorelines and in monitoring cleanup activities. Other programs were undertaken to protect DOI trust resources. Additionally, the FWS continued natural resource damage assessment and restoration planning. Investigations by FWS personnel focused on migratory birds and sea otters, the two trust resource groups most affected by the oil spill.

The FWS worked closely with the USCG and Exxon to protect nesting bald eagles from disturbance caused by cleanup activities. Surveys were conducted to map the locations and status of eagle nests, and protective measures were implemented to minimize disturbance. Buffer zones were established around active nests to exclude human activity, including aircraft movement. When conflicts developed between the need to protect active nests and the need to decontaminate ecologically sensitive areas (for example, anadromous fish streams), a monitoring system was implemented to allow cleanup while providing a mechanism to pull out the workers if eagles displayed disturbance behavior.

The FWS continued to represent the DOI in assessing injuries to natural resources resulting from the oil spill. The FWS continued studies on sea otters and migratory birds and cooperated with the other trustee agencies in providing important hydrocarbon analysis and mapping services. Following the October 1991 settlement of the criminal and civil case against Exxon, the FWS joined with Federal and State agencies in planning the restoration of injured trustee resources.

Minerals Management Service

While the MMS had no direct responsibility for response or damage assessment, the agency provided staff to assist the cleanup and monitoring efforts; an additional \$300,000 was directed to fund studies to assess the effects of the spill. MMS staff helped develop damage assessment programs, assisted in surveys and rehabilitation of seabirds and marine mammals, participated as members of a Resource Advisory Team, and provided technical expertise and assistance to the FWS and the Alaska Department of Fish and Game. Funding also was provided for a study on weathering of crude oil in sea water, for studies on the effects of oil on different species of fish and crustaceans, for surveys of sea otters and seabirds, and for collection of sediment samples for chemical analysis. In addition, support was provided for monitoring the performance of satellite-tracked surface oil drifters, for overflights of the spill, and for studies to determine the social impact of the spill on communities adjacent to the spill's path. The MMS/NOAA research vessel #1273 was provided for use as a field sampling station. Funding from the MMS National Studies Program enabled the USGS to deploy the Gloria Project survey ship

M/V *Farnella* in 1989 and the smaller USGS-owned R/V *Karluk* in 1990 to collect bottom-sediment samples.

The Social and Economic Studies Unit (SESU) of the Environmental Studies Section of the Alaska MMS OCS Region is presently involved in collecting information on the long-term social, economic, and cultural consequences of the *Exxon Valdez* oil spill for a number of communities in the Gulf of Alaska region. The SESU modified an existing contract, the Social Indicators Study, to allow the collection of information during calendar years 1989 through 1991. Results of this research should be available in the fourth quarter of 1992. In addition, the SESU signed a cooperative agreement in 1991 with the Subsistence Division of the Alaska Department of Fish and Game to investigate the long-term subsistence and social consequences of the spill. Research on this agreement is just underway, and preliminary results are not expected for several months.

National Park Service

The *Exxon Valdez* oil spill impacted three National Park Service units: Kenai Fjords National Park, Katmai National Park and Preserve, and Aniakchak National Monument and Preserve. In these park units, several hundreds of miles of shoreline and the resources supported thereon were affected by the oil and cleanup operations.

As the pace of response activities slowed in 1991, major oil spill activities for the NPS shifted away from beach cleanup and focused more on damage assessment and restoration. Beach segments with persistent oil were resurveyed by the interagency assessment team, and five cleanup operations were recommended and completed: four in Katmai National Park and Preserve, and one in Kenai Fjords National Park. Although contingencies exist for future cleanup if the need arises, cleanup activities on park lands essentially ended in June 1991. In the legal arena, the NPS responded to several major document subpoenas filed on it by Exxon and by private plaintiffs with actions pending against Exxon.

The Natural Resources Damage Assessment program moved forward in 1991 as study findings began to develop a more complete picture of injury from the oil and its secondary effects. The NPS participated in these major assessment studies and provided the DOI representative to the Restoration Planning Work Group (RPWG). The RPWG began the preparation of an overall framework plan and conducted public meetings on restoration strategies at various locations around the spill zone.

A comprehensive coastal resources program was initiated in 1991 that eventually will be implemented in all Alaskan national park units with marine coastlines. This program, developed as a result of the *Exxon Valdez* incident, is focusing initially on the park units that were impacted by the spill. In 1991, the NPS began an evaluation

of the data from monitoring stations established on the shorelines of the parks after the oil spill in order to determine the site's suitability and applications to a long-term ecological monitoring program for the national parks.

U.S. Geological Survey

The USGS has conducted two cruises to Prince William Sound to investigate the geologic fate of oil from the March 24, 1989, *Exxon Valdez* oil spill. The research cruises, undertaken in May 1989 and August 1990, were funded by the MMS and the USGS. During the first cruise, 50 days after the spill, sampling along the spill trajectory showed no conclusive evidence of oil in the sediment of the deep basins of the sound (Carlson and Reimnitz, 1990). During the second cruise, 17 months after the spill, samples were taken from beaches and deeper-water sediment off islands that had been impacted (fig. 11); oil or tar was present and sampled at all six beaches visited. In the sediment offshore of the impacted islands, scientists measured traces of the spilled oil and found preliminary geochemical evidence of oil in the deep sediment-sink basins sampled in 1989. The oiled sediment obtained from the island beaches matched the geochemical signature of oil impounded from the tanker *Exxon Valdez*, but, surprisingly, tar samples from two beaches have chemical parameters that indicate a different source (Carlson, 1991).

Samples from the two cruises were analyzed for hydrocarbons, microfossils, and sediment characteristics. These analyses will permit comparisons of samples collected 50 days after the oil spill to deep-water samples collected 430 days after the spill and beach and shallow-water samples collected 505 days after the spill. Results show that, although no oil had entered the sediment substrate within 50 days after the spill (Rapp and others, 1990), spilled oil is contained in sediment samples collected 1½ year later. The amount and consequence of this oil are not yet known. Further results of these cruises will be reported as they become available.

In the summer of 1992, a third cruise on the NOAA ship *MacArthur* is proposed. Earlier sampled sites will be re-occupied to determine whether increased quantities of spilled oil have accumulated in the sediment. Additional island beaches reported to have tar or asphaltic pavement will be investigated in order to compare the chemical signatures of those hydrocarbons with the chemistry of the spilled *Exxon Valdez* oil. Such studies are needed to understand the extent of oil contamination in this complex high-latitude fjord system.

U.S. Forest Service

The Chugach National Forest encircles Prince William Sound and includes Bligh Reef, where the T/V

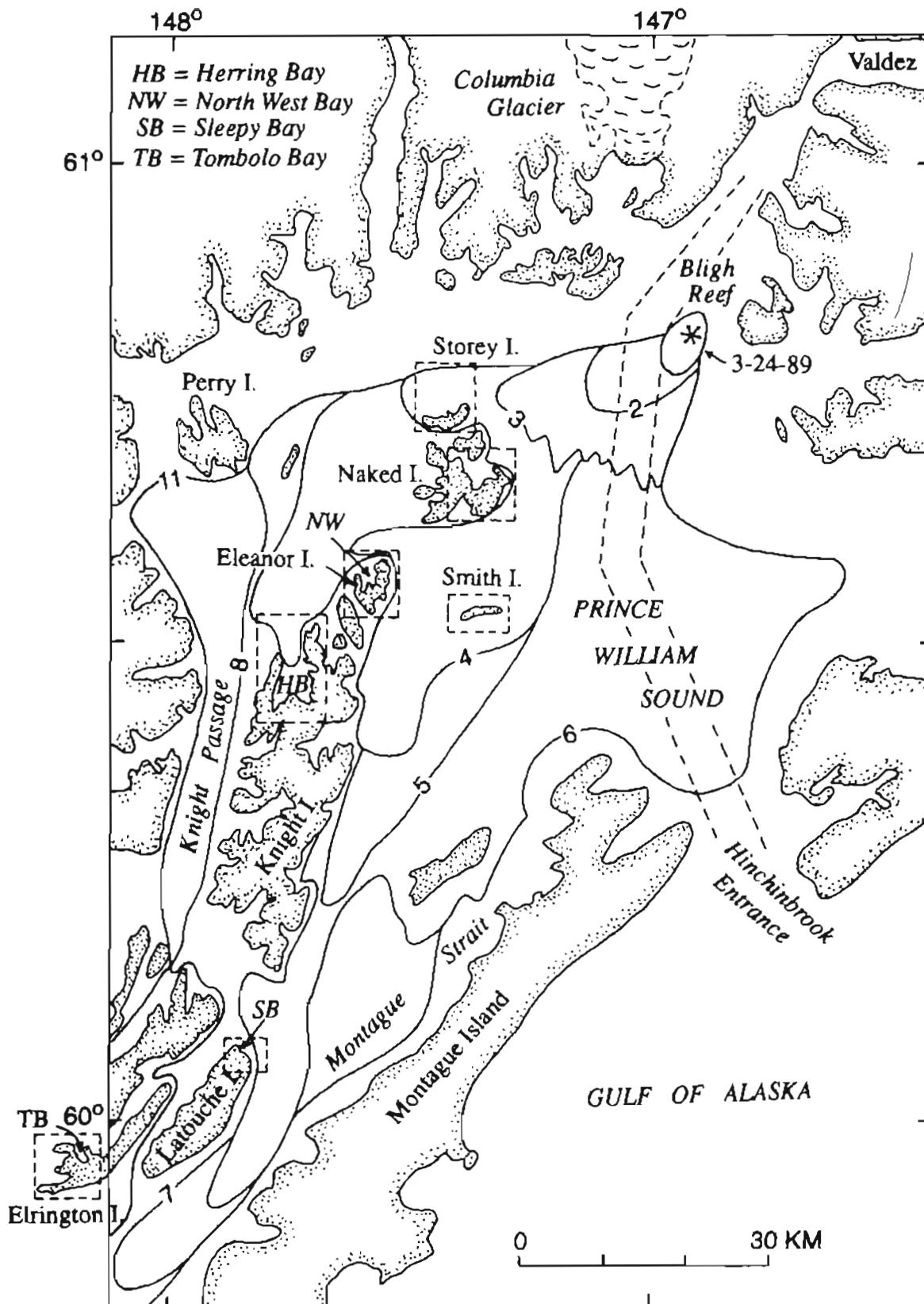


Figure 11. Sample areas (indicated by rectangles) in Prince William Sound in 1990. Location of oil spill on March 24, 1989, is shown by star. Dashed lines indicate oil tanker's travel route. Front of oil plume on consecutive days 2-8 and day 11 after the oil spill are portrayed by numbered lines.

Exxon Valdez ran aground. During the spring and summer of 1991, the Chugach National Forest continued its response to the oil spill by assigning personnel to three interagency monitoring teams in Prince William Sound. The USFS coordinated with the State to include land owner representatives on the survey teams. The teams comprise land owner representatives, Exxon facilitators, USCG and ADEC staffs, and oil spill specialists, marine biologists, and geologists. Their role was to observe National Forest lands, identify areas still covered with oil, observe primary and secondary impacts of the oil on the environment, and recommend actions to be taken during the summer of 1991.

Four USFS employees surveyed about 400 segments along approximately 100 miles of beach in 1991. Acting on team recommendations, approximately 30 miles of beach was subsequently treated. Treatment consisted primarily of manual pickup of tarmats, and bioremediation for more heavily oiled segments. From 10 to 15 sites will be monitored, and if conditions warrant, may require additional treatment. However, no cleanup is anticipated in 1992.

Coal and Peat Resources

Reflecting the national decline in coal production for 1991 (Coal News, January 20, 1992), coal production in Alaska was also down, dropping to 1.52 million short tons (Bundtzen and others, 1992), a 4-percent decline from the record level of 1.58 million short tons in 1990. The coal is valued at \$45 million (Bundtzen and others, 1992). All production comes from the Usibelli Coal Mine at Healy in central Alaska (fig. 12), the only active coal mine in the State. Additional coal projects are under development, but production from the new mines will most likely be delayed until there has been a substantial growth in the energy needs of Alaska or the Pacific Rim countries. When the time comes, the Alaskan coal industry will be ready to meet these increased demands.

Construction at the Wishbone Hill Coal Mine in the Matanuska Valley (fig. 12) may start in early 1994, with production beginning in mid-1995 (Alaska Journal of Commerce, September 16, 1991). Employing approximately 200 people, the mine could produce one million short tons of clean coal per year for export to Asia. The mine operator, Idemitsu Alaska, was issued a mining permit in early September 1991, but further permits have been delayed because a small portion of the 1,351-acre property has been included in the contentious issues of the State's mental health lands allotment.

Other coal projects in south-central Alaska include the Castle Mountain, Evan Jones, and Diamond Chuitna Mines. In the Matanuska Valley, Hobbs Industries has development at the Castle Mountain property when the coal-fired, radar power plant at Glenallen was scrapped.

Hobbs then turned its attention to the nearby Evan Jones Mine; a new portal and 79-foot tunnel had been completed by year's end (Bundtzen and others, 1992). Diamond Chuitna continued both permit fulfillment and mine development for the 330-million-short-ton Beluga Coal Field on the west side of Cook Inlet.

The "clean coal" 50-megawatt power plant at Healy has been approved to move into the full design and engineering phase (Alaska Journal of Commerce, July 29, 1991). Applications for land use and environmental permits have been filed, and a construction schedule is being determined. Burning a 50-50 blend of the Usibelli Mine's clean and waste coals, the plant will produce much fewer atmospheric pollutants than any current technology available. The project is jointly funded by the DOE and the State of Alaska.

The abundant coals of the North Slope continue to be attractive to the Arctic Slope Regional Corporation, which owns substantial portions of the coal fields in the region. The Arctic Slope Consulting Group conducted a drilling program to delineate coal resources in the Deadfall Syncline area north of Kotzebue (Bundtzen and others, 1992). The proposed Aluaq Coal Mine, located 90 miles north of the Red Dog Zinc Mine, could begin commercial mining as early as 1995 (Anchorage Times, August 7, 1991). However, the lack of a transportation infrastructure continues to be the main obstacle to development of the Aluaq Mine, and any other mine on the North Slope. If the State were to sponsor the construction of a road from Aluaq to Red Dog, coal could be mined year round and stockpiled, then exported during the summer via the Red Dog haul road to the Chukchi Sea (Alaska Journal of Commerce, May 13, 1991). Conversion of the diesel-fired generators in Nome and Kotzebue to power plants burning North Slope coals would save the State \$3 million a year in rural oil subsidies.

On July 9, 1990, the Alaska Superior Court put on hold all State land conveyances, permits, and leases on Alaska Mental Health lands (AMHL), including the coal developments at Wishbone Hill, Healy, and Diamond Chuitna. The AMHL land bank was established in trust form by Congress in 1956 to provide funding for Alaska's mental health programs; the AMHL's one million acres were scattered across Alaska and contained some of the most valuable lands in the State. The State dissolved the trust in 1978, and some of the land was leased or sold to State parks, municipalities, Native corporations, and private parties. In the late-1980's, mental-health advocates sued the State for its dissolution of the trust, which resulted in the 1990 Superior Court decision.

In 1991, the Governor signed into law the Mental Health Trust Lands Settlement Act, an attempt to recreate the original AMHL land bank as closely as possible. Although the act has become law, it is not yet in effect (Alaska Journal of Commerce, September 30,

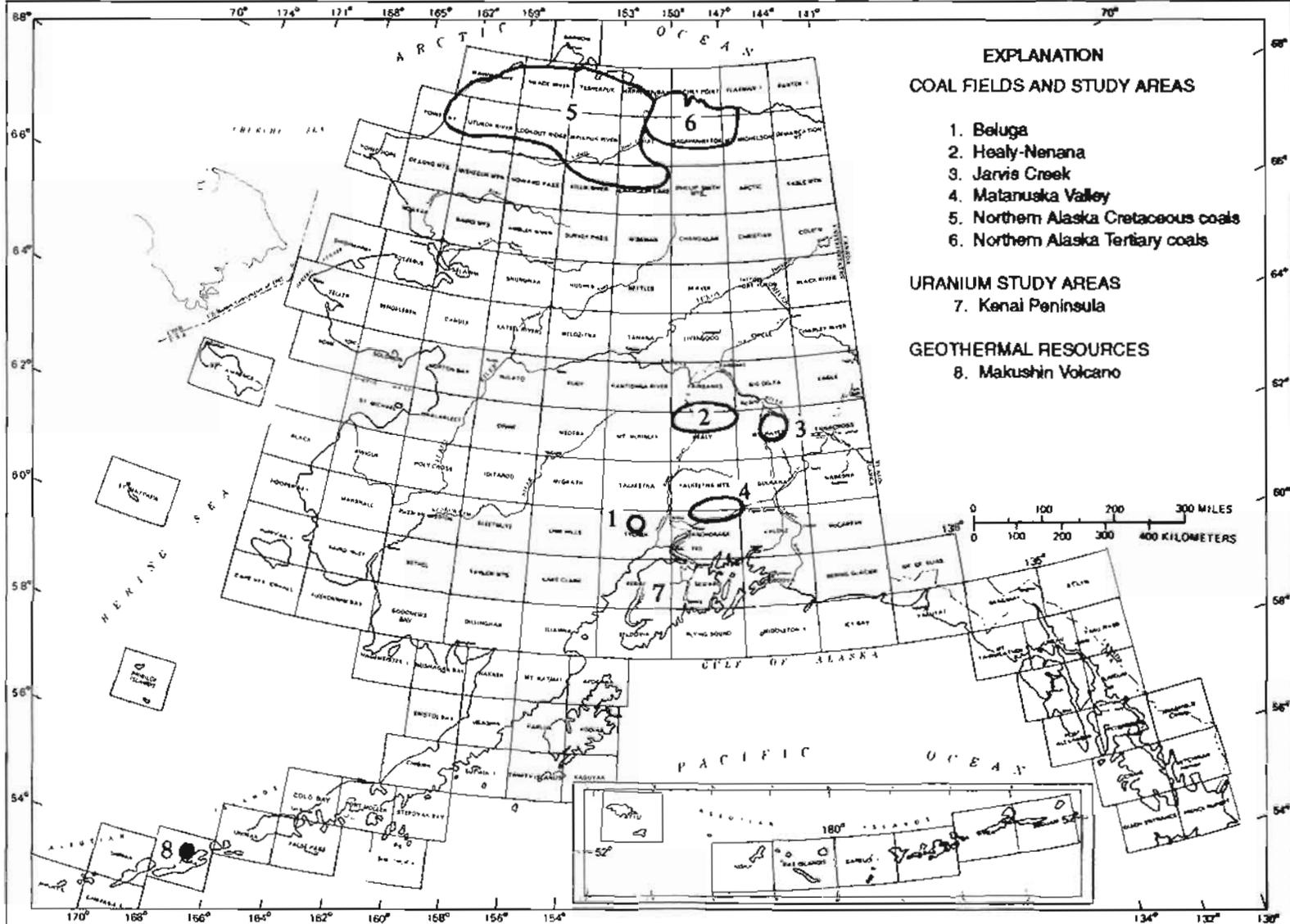


Figure 12. Areas of potential coal, uranium, and geothermal resources mentioned in text. 1:250,000-scale quadrangles are outlined and labeled.

1991). In the interim, the State has been working with the plaintiffs of the mental health lawsuit to allow some projects to move forward, such as the Wishbone Hill Coal Mine in the Matanuska Valley.

The Alaska Department of Natural Resources plans to drill a shallow test hole in 1992 in the Matanuska-Susitna region (fig. 12) in order to evaluate the methane potential of the underlying coalbeds (Alaska Journal of Commerce, November 4, 1991). Although Alaska has abundant natural gas supplies of 27.8 trillion cubic feet on the North Slope and 3.4 trillion cubic feet in the Cook Inlet basin, coalbed methane could be an energy source for areas in the State which do not have access to conventional fuels. Results from the test hole will also help the State to complete its inventory of natural resources.

Peat mined in Alaska is used primarily in agriculture and greenhouses as a soil conditioner; minor amounts are burned locally in villages for heat. Peat production increased in 1991 for the third consecutive year to 75,000 cubic yards, up 15 percent from 1990, valued at \$450,000 (Bundtzen and others, 1992). Alaska has one of the world's largest peat resources, estimated to be five times the energy potential of Prudhoe Bay.

Activity by Federal Agencies

U.S. Geological Survey

During the summer of 1991, Branch of Coal Geology personnel investigated coal-bearing formations in south-central Alaska. On the Kenai Peninsula, studies were conducted at 35 measured sections near McNeil Canyon, along Kachemak Bay, and north of Ninilchik. This study on the depositional environments of the Beluga and Sterling Formations of the Kenai Group suggests that thicker and more laterally persistent peats are more likely to be preserved in the deposits of vertically aggrading anastomosing streams than in deposits of laterally aggrading meandering streams (Flores and Stricker, 1992).

Branch of Coal Geology personnel also continue to investigate the vertical and horizontal major-, minor-, and trace-element distribution in the Usibelli Coal Mine near Healy. In 1991, 50 samples were collected for chemical analysis from a face channel transecting the No. 3, Moose, and Caribou coal seams. Previous work at the mine indicates that many trace elements vary vertically and horizontally within the three mined coal beds (Affolter and Stricker, 1987). Gold analysis was performed on 12 samples from the No. 3 and No. 4 coal seams, along with 3 fly ash samples from the mine-mouth power plant. Gold content in the ash for the 12 coal samples ranges from 0.001 to 0.018 parts per million (ppm) and, for the three fly ash samples, from 0.076 to 0.87 ppm (Stricker and others, 1992). The subbituminous coals mined at Healy have some of the lowest reported sulfur values for

any coal being mined in the United States; these coals have a mean of 0.24 percent and a range of 0.1 to 1.5 percent total sulfur (Stricker, 1991).

U.S. Bureau of Mines

The USBM inventoried all lands in Alaska to determine the availability of land for coal leasing and looked at the regulatory policies concerning such activity (Maas, 1991). The USBM also digitized onshore acreage and land ownership data and concluded that coal basins underlie nearly 51 million acres of Alaska. Of this land, 26.4 million acres is under Federal jurisdiction, the State manages 17.3 million acres, and nearly 7.3 million acres of these favorable coal lands is managed by Native corporations.

Bureau of Land Management

The BLM continued its management of a lease in the Jarvis Creek Coal Field south of Delta Junction (fig. 12) and awarded a permit to Hobbs Industries to conduct exploration activities on the lease. Coal from this field is a potential feedstock for gas production, which would be used to generate electrical power for the U.S. Army base at Fort Greeley. Interest in additional coal leasing on Federal land currently is growing.

The BLM is assessing the coal potential of NPRA in cooperation with the USBM and USGS as part of the USBM Colville Mining District study.

Department of Energy

The construction of a state-of-the-art mine-mouth power plant at the Usibelli Coal Mine in Healy has moved into the design and engineering phase. The plant is being financed by a \$93.9-million Clean Coal Technology cooperative agreement monitored by the DOE's Pittsburgh Energy Technology Center; the agreement was awarded on April 11, 1991. A consortium headed by the Alaska Industrial Development and Export Authority will provide the remaining \$99.5 million for the project's completion. Preparation continues on permit applications from the Alaska Department of Natural Resources for land use and from the U.S. Environmental Protection Agency, National Pollutant Discharge Elimination System. Project design and construction activities are also underway. The power plant is intended to provide electricity to railbelt communities in central Alaska.

The DOE grant for this 50-megawatt power plant is part of a national program to demonstrate the new and clean methods of burning coal without emitting the pollutants commonly cited as the causes of acid rain. Using Alaska's low-sulfur coal, the plant will produce virtually no smokestack emissions by scrubbing out particulate matter, nitrogen-oxide compounds, and sulfur dioxide.

At TRW, Inc.'s Cleveland facility, the Advanced Slagging Combustor has already been successfully tested using Healy project fuel.

Uranium Resources

The United States uranium mining industry experienced a poor year in 1991. By March 1992, no conventional open-pit uranium mines will remain in operation in the United States (Odell, 1992). A few in situ leach plants and by-product plants remain in operation, but domestic production in 1991 was only 8 million pounds U_3O_8 . Forty million pounds U_3O_8 was used by nuclear power plants in 1991 to produce 21 percent of the total electrical energy supply in the United States (Pool, 1991). The abundance of low-priced foreign uranium keeps the price of uranium low, and the supply of low-priced foreign uranium has increased due to recent export of uranium from countries of the former Soviet Union. Inventory liquidations during 1990 also helped keep the current U_3O_8 price low (Chenowith, 1991). For the seventh straight year, the Secretary of Energy declared the domestic uranium industry to be nonviable.

No money was spent on uranium exploration in Alaska, and little was spent in the lower 48 States during 1991. The outlook for uranium production in the lower 48 States is bleak, and for Alaska it is even worse, due to high exploration costs, remote beneficiation plants, and distant markets.

Activity by Federal Agencies

U.S. Geological Survey

A core program in uranium research continues to be carried out by the USGS in the Branch of Sedimentary Processes. This program is designed to keep the United States abreast of uranium geology research and maintain the capability to carry out such work. Some uranium research based on previously collected data in Alaskan resources is being continued.

A report describing uranium distribution and its relation to sediment sources in the Kenai Group on the Kenai Peninsula (fig. 12) was released during 1992 (Dickinson and Skipp, 1992).

Geothermal Resources

Hot springs occur throughout Alaska and historically have been used on a small, highly localized scale for recreation, space heating, and agriculture. However, widespread young volcanic activity on the Aleutian Islands, the Alaska Peninsula, the Wrangell Mountains,

and elsewhere in the State has created the potential for commercial geothermal energy production to serve selected population centers.

Makushin Volcano (fig. 12) has long been considered a potential source of power for the neighboring communities of Dutch Harbor and Unalaska, centers of the fishing industry in the northwestern Pacific Ocean. In 1991, the Alaska Energy Authority (AEA) signed a letter of agreement with OESI Power Corporation to construct and operate a 12-megawatt geothermal power plant on Unalaska Island (Anchorage Times, October 10, 1991); OESI will also develop and provide geothermal fluid from its resource leasehold. The AEA, which will retain ownership of the plant facilities, has authorized \$60 million in tax-exempt bonds to finance the project.

No Federal research was funded for geothermal studies in Alaska in 1991.

NONFUEL-MINERAL RESOURCES

Metallic Minerals

Industry Activity

The locations of mineral deposits, mines, and areas discussed in the following review of 1991 industry activity are shown on figure 13.

Economic and Regulatory Overview

The value of Alaska's 1991 mineral production, \$554 million, increased 4 percent over the 1990 value of \$533 million (table 11), in spite of the decline in mineral prices brought on by an international economic recession. Expenditures for mineral development increased 72 percent; from \$14.3 million in 1990 to \$24.6 million in 1991. Expenditures for mineral exploration, however, decreased by 40 percent. In 1991, \$37.9 million was spent in exploration, compared to \$63.3 million in 1990. The total value of Alaska's mineral industry, defined as the sum of exploration, development, and production expenditures, was \$617 million, nearly the same as the 1990 value of \$610 million (Bundtzen and others, 1992).

In 1991, Alaska's mines produced nearly 65 percent of the United States zinc output; Alaska also supplied 20 percent of the total silver and 10 percent of the total lead (Bundtzen and others, 1992).

As in 1990, the leading ore metal by value in 1991 was zinc (table 11), most of which was produced by the Red Dog Mine in its second year of operation. The value for silver fell in 1991, reflecting low metal prices due to the recession.

Mine reclamation continues to be an important issue to the mineral industry. A 1989 State law requiring submission

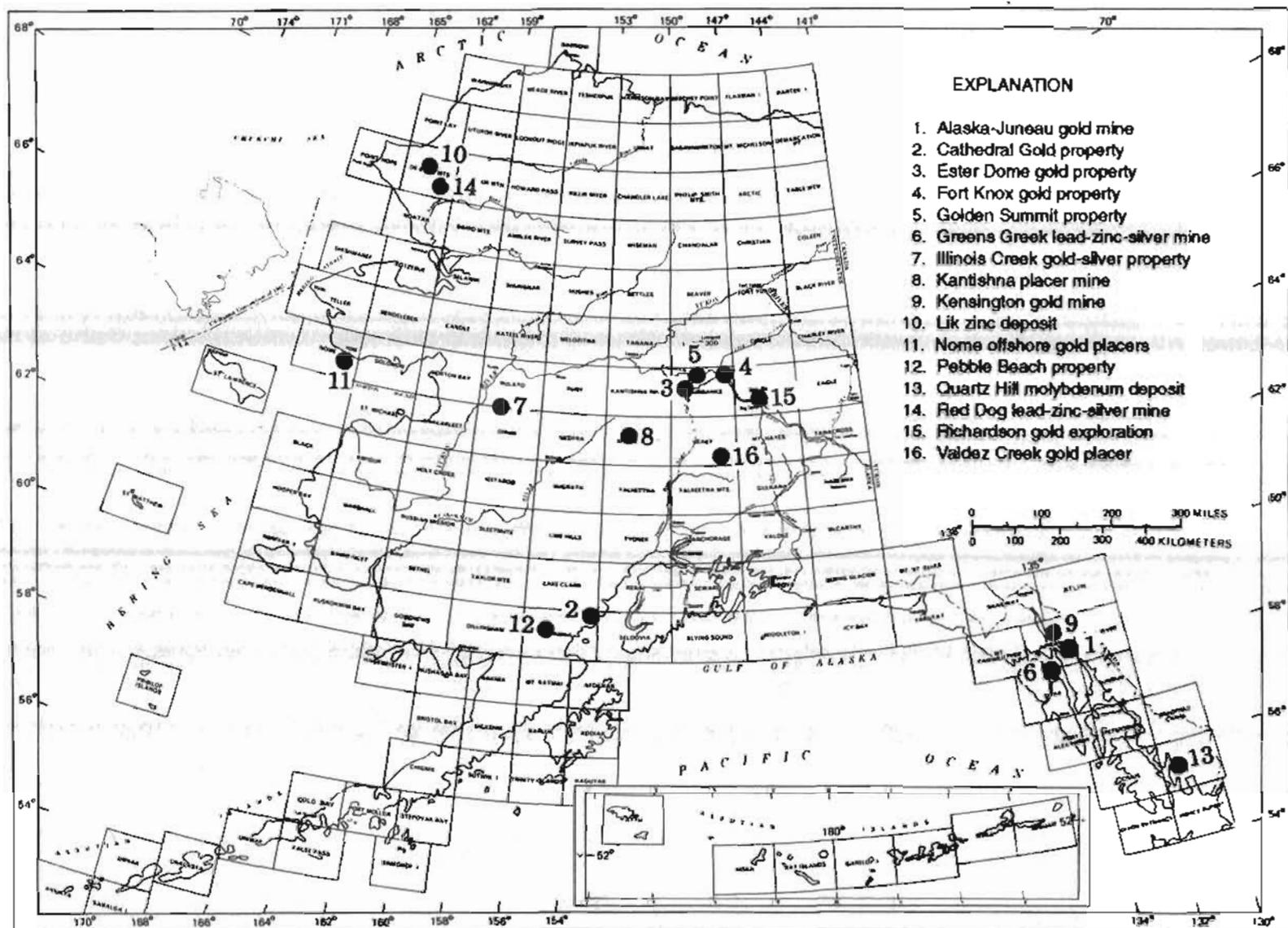


Figure 13. Areas of significant industry activity involving metallic minerals (excluding uranium) in 1991, and mine and deposit locations referred to in text. 1:250,000-scale quadrangles are outlined and labeled.

Table 11. Mining production in Alaska, 1988-1991

[Values calculated from 1991 annual price averages of gold, silver, platinum, zinc, and lead; other values directly supplied by mine operators. Data from Bundtzen and others (1992). NR, no report; W, information withheld by mine operators]

	Volume				Value (x \$1,000)			
	1988	1989	1990	1991	1988	1989	1990	1991
Zinc (tons)-----	NR	19,843	181,200	278,221	NR	29,383	253,680	278,221
Gold (troy oz)-----	265,500	284,617	231,700	243,900	112,837	108,724	89,204	88,292
Sand and gravel (million tons) -----	17.2	14.4	15.0	14.4	48,750	39,875	40,821	45,449
Coal (tons) -----	1,551,162	1,452,353	1,576,000	1,520,000	44,300	41,465	44,990	45,000
Silver (troy oz) -----	47,790	5,211,591	10,135,000	10,176,854	282	27,361	50,675	41,115
Lead (tons) -----	NR	9,585	44,220	69,591	NR	7,672	30,954	33,404
Building stone (million tons) -----	3.6	2.9	3.2	3.0	24,650	20,340	22,100	22,500
Peat (yd ³) -----	55,000	51,000	65,000	75,000	375	352	400	450
Tin (lb. metal) -----	300,000	194,000	57,000	6,800	950	672	200	22.1
Jade and soapstone (tons)-----	W	57.0	W	16.0	W	1,140	W	12
Platinum (oz) -----	.25	W	NR	15	14	W	NR	5.3
Tungsten (short tons) -	240	NR	NR	NR	14	NR	NR	NR
Mercury (lb) -----	W	W	NR	NR	W	W	NR	NR
Totals-----					232,172	277,084	533,024	554,470

of reclamation plans and bonding for all mining operations including sand and gravel on private, State, municipal, and Federal lands went into effect October 15, 1991 (Alaska Journal of Commerce, Oct. 21, 1991). The law states that all miners working claims larger than 5 acres must have an approved reclamation plan and must post bond of up to \$750/acre to guarantee that work. The reclamation plan and bonding requirements are waived for miners who mine less than 5 acres or less than 50,000 cubic yards of material at one site in one year. The details of the law as they apply to private land have not been worked out in detail, and miners are unsure how to comply with the law in these localities.

The Mining Act of 1872 has been the subject of much debate during the past year. The Mining Act was signed into law by President Grant to help promote westward expansion. It allows miners to stake claims on public land, pay no royalties on extracted minerals, and obtain title to the claims. The fees for patent, \$2.50 to \$5.00 per acre, are applicable to lone prospectors and major mining companies alike, and have come under heavy criticism from Congress in the past few years (Anchorage Times, Sept. 24, 1991). A bill recently submitted to Congress would change the 120-year-old mining law by requiring royalties to be paid to the Federal government on extracted hard rock minerals, as is currently paid by producers of coal, oil, and natural gas. Most miners consider that the 1872 law has worked well and

resist changes to it (Anchorage Times, Sept. 21, 1991). A four-member Congressional subcommittee heard spirited testimony concerning the 1872 mining law from miners and others at the University of Alaska, Fairbanks, on May 25, 1991. The outcome of this issue is uncertain.

In 1991, natural waters used for mining continue to be monitored. The Environmental Protection Agency issued fines against 15 miners for not submitting wastewater reports and also fined several miners for violating terms of EPA wastewater discharge permits or discharging waste without a permit to do so (Fairbanks News-Miner, March 3, 1991). Fines against miners on the Fortymile River and North Fork of Harrison Creek in the Circle District were dropped (Anchorage Daily News, August 5, 1991).

A cooperative exploration project between a California company and the leading mineral research agency of the former Soviet Union has been termed a tentative success. Although approval from the U.S. Government for a low-altitude geophysical survey by the Soviets came too late for implementation in 1991, important cooperative geologic work was carried out on a 64-square-mile trivalley claim block in the Richardson Mining District 70 miles southeast of Fairbanks (Fairbanks News-Miner, Sept. 9, 1991).

The Alaska Miners Association meeting held in the spring of 1991 in Juneau focused on the long dormant mining economy in southeast Alaska as well as Governor

Walter Hickel's new strategic plan aimed at "positioning Alaska for the 21st century." The plan contains measures to promote development carried out in an environmentally sound manner, including large-scale mining projects. Mining companies in Alaska in recent years have found resource development difficult. Land use has been a particularly critical issue. Federal lands total 215 million acres, with only 49.6 million acres left open to mining. State lands total 104.4 million acres, with 95.9 million acres open to mining. Private lands, including those held by native corporations, total 46.1 million acres, with 45.6 million acres open for mining (Native lands are open to mining if leased from Native corporations) (Northern Miner, April 29, 1991). Alaska is considered to be underexplored and has a high potential for new grassroots discoveries such as Cominco's sizable Pebble Beach copper-gold deposit, located 320 km southwest of Anchorage. Five years ago, Alaska had no major operating lode mines. The state currently has two new sizable lode mines—the Red Dog deposit north of the Arctic Circle and the Greens Creek Mine near Juneau. A number of advanced projects are in the development and permitting phase throughout the State, including several gold projects in the mineral-rich Juneau Gold Belt. The Alaska Miners Association is increasingly directing its attention to issues that will enable the mining industry in Alaska to flourish (Northern Miner, April 29, 1991).

A 4-day conference on mineral resources, the seventh annual McKelvey Forum, was held in Reno, Nevada, in February 1991. Two papers and nine poster sessions dealing with Alaska mineral resources were presented (Good and others, 1991). Poster sessions were presented on the mineral-resource assessment of all or parts of the Sitka, Goodnews, Hagemeister Island, Nushagak Bay, Mount Katmai, Naknek, and Afognak 1:250,000-scale quadrangles.

Precious Metals

Perhaps the most important news story regarding mining for the year was Amax Gold signing agreements that may lead to the investment of as much as \$200 million to acquire controlling interest in the Fort Knox Gold Mine. The deposit is located about 24 km northeast of Fairbanks and is expected to have the potential to become a "major world class mine" (Anchorage Times, Sept. 18, 1991). Fairbanks Gold, the previous owners, spent \$16 million exploring and developing the Fort Knox gold deposit since late 1987. If brought into operation, the mine will rival the Red Dog Zinc Mine near Kotzebue and the Greens Creek Silver Mine near Juneau, as the largest mine in production in Alaska. It would also rank among the top five gold-producing mines in North America (Anchorage Times, Sept. 14, 1991). When developed, the mine could create 300 to 500 new jobs and produce

350,000 ounces of gold per year, an amount in excess of the current gold production of the entire State of Alaska. Mineable reserves are estimated at 230 million tons of ore with 0.024 ounces of gold per ton; production is projected as 4.1 million ounces of gold per year for 16 years (Anchorage Daily News, Oct. 20, 1991). The Fort Knox deposit is relatively low grade; it probably would be developed as an open pit mine with the gold extracted by a leaching process. The gold occurs in narrow quartz veinlets, fractures, and shears in a quartz monzonite to granodiorite prophyry intrusive. Other low-grade ore deposits like Fort Knox may also exist in the Fairbanks area; gold mineralization similar to the Fort Knox occurrence has been identified in volcanic rocks at Ester Dome (Alaska Journal Commerce, Sept. 16, 1991).

The Golden Summit property, a gold prospect 33 km from Fairbanks, was acquired by Freegold Recovery during 1991. Preliminary reserve estimates are 5.2 million tons of ore with 0.062 ounces of gold per ton. Exploration activities during the year included trenching and reverse circulation drilling (Northern Miner, Sept. 23, 1991).

The Ryan Lode property, owned by La Teko Resources Ltd., also near Fairbanks, has been mined for gold on a seasonal basis. The company has identified 2.7 million tons of ore averaging 0.074 troy oz/ton gold to a depth of 76 m. Another 544,000 tons of ore grading 0.11 troy oz/ton gold are present at depth (Mining Journal, June 6, 1991).

One of the largest gold producers in Alaska, the huge bucket-line *Bima* dredge operating in Norton Sound, was unprofitable and shut down in 1990 (Alaska Daily News, June 26, 1991). The mining industry subsequently indicated interest in mining gold offshore in adjacent areas of the Bering Sea, and the MMS scheduled a mineral lease sale of more than 147,000 acres of the Outer Continental Shelf 5 to 22 km off the coast of Nome. The sale was cancelled as no bids were received, suggesting that the economic and geologic risks were too high for potential bidders (Anchorage Times, July 24, 1991). The MMS had estimated the lease area could contain 530,000 to 1,060,000 ounces of placer gold (Alaska Journal Commerce, March 25, 1991). The *Bima* had produced 126,924 ounces of gold from nearshore areas adjacent to the proposed lease sale.

The Valdez Creek Mine, also referred to as the Denali Mine, is Alaska's largest open-pit placer mine. The mine is located about 340 km north of Anchorage on the western flank of the Clearwater Mountains and produced more than 200,000 ounces of gold from 1984 to 1989. In October 1989, the mine was closed for almost one year because of low gold prices and the need to redirect Valdez Creek to allow mining upstream. Cambio Alaska, Inc., the operator of the mine in the fall of 1990, has been using a more efficient washing plant than had previously been in use. The gold mine is unique in

Alaska because it operates on a year-round basis. The mine is expected to produce approximately 65,000 ounces of gold in 1991. Resources total at least 5 million cubic yards of gravel grading 0.1 oz gold per cubic yard (Northern Miner, Dec. 9, 1991).

In southern Alaska, an ambitious exploration program conducted by Cathedral Gold and Pacific Sentinel Gold was undertaken to test mineralization on 300,000 acres near Anchorage, Alaska. This is the first intensive exploration program to cover the Jurassic volcanic belt in the Cook Inlet area. Exploration includes geochemical sampling, geological mapping, geophysical surveys, and prospecting for gold and base metal deposits (Northern Miner, July 25, 1991, and Mining Journal, July 26, 1991).

In southeast Alaska, the intense interest in the Juneau Gold Belt continues. The EIS on the reopening of the Alaska-Juneau (A-J) Gold Mine just east of Juneau is nearly complete, and completion of permitting is expected in early 1992 (Northern Miner, Dec. 9, 1991). The developer of the Alaska-Juneau project, Echo Bay Alaska Mines Inc., needs about two dozen Federal, State, and city permits to reopen the mine (Fairbanks News-Miner, Sept. 17, 1991). Many Juneau citizens oppose reopening the A-J Mine because of environmental concerns. Echo Bay Alaska also has interests in the Kensington Gold Mine project located approximately 70 km north of Juneau. The environmental impacts resulting from the development of this property are under study; however, permitting procedures are anticipated to be complete by early 1992, and construction can begin (Northern Miner, Dec. 9, 1991). The A-J Mine is proposed as a 13-year project that would produce 4.7 million ounces of gold, while the Kensington proposal would be an all-year operation that would produce 2.4 million ounces of gold (Fairbanks News-Miner, June 10, 1991).

Other Metals

The Red Dog Mine in the Delong Mountains of the western Brooks Range is one of the largest, lowest cost zinc-producing mines in the world, even though it has been producing only since 1990. In 1991, 60 percent of the United States mine output of zinc came from the Red Dog Mine (Bundtzen and others, 1992). The low production cost is due mainly to the mine's high-grade ore and low stripping ratios. The mine life is projected at 50 years (Mining Magazine, Dec., 1990). During mid-summer and fall of 1991, 521,404 tons of zinc, lead, and Imperial Smelting Furnace (ISF) composite-metal concentrates were exported from the Red Dog Mine (Bundtzen and others, 1992).

The Red Dog Mine operators, Cominco Alaska, Inc., currently are concerned about the declining price of zinc, which has fallen from a 6-month average of 82 cents per pound in the first half of 1988 to 47 cents per pound in

late 1991 (Anchorage Times, Nov. 18, 1991). Cominco spent \$11 million recently on stream relocation work in an attempt to eliminate seepage from mining activities that has caused toxic levels of heavy metals downstream. The relocation work successfully reduced stream pollution, and native Arctic Char are moving back into the creek drainage (Anchorage Daily News, Aug. 22, 1991).

The Anchorage-based Alaska Native regional corporation, CIRI, set up North Pacific Mining Corporation as a subsidiary to manage and develop the corporation's extensive mineral holdings. Illinois Creek, one of the properties receiving current attention, is a gold-silver prospect located 60 miles southeast of Galena on the Yukon River. If the results of drilling, metallurgical tests and environmental work are favorable, production could start in 1992 or 1993. If successful, this will be the first example of an Alaskan Native corporation developing and operating a mining property instead of working through an established mining company (Alaska Journal of Commerce, March 25, 1991). In addition to Illinois Creek, projects in an advanced stage of exploration include the Johnson River gold-copper-zinc deposit near Mt. Piamna, southwest of Anchorage; the chrome resource at Red Mountain near Seldovia; and a large area of base and precious metal mineralization near Tok, known as the Delta district (Alaska Journal of Commerce, April 8, 1991).

The Lik zinc deposit, located about 20 km northwest of Red Dog in northwestern Alaska, could become one of the top 20 zinc mines in the world, according to Charlie Gryba, president of Moneta Porcupine Mines. Moneta acquired 80-percent ownership of the property in 1991. Drilling in 1990 confirmed 18.2 million tons of ore grading 10.2 percent zinc, 3.3 percent lead and 1.5 ounces silver per ton. Two-thirds of the deposit is mineable by open-pit methods. The deposit appears to be capable of supporting a 15-year, 1.2-million-ton-per-year mine (Northern Miner, March 25, 1991).

Cominco Inc. is considering the development of a large porphyry copper-gold deposit on its Pebble Beach property located 320 km southwest of Anchorage. A preliminary resource estimate based on drilling indicates about 180 million tons of ore averaging 0.4 percent copper and 0.013 troy oz/ton gold (Mining Journal, March 1, 1991). Work on the deposit is still in the exploration phase, but, if developed, the mine could be the largest hardrock mine in Alaska. Company officials have said it could be years before a decision is made to develop the mine (Alaska Daily News, Oct. 3, 1991).

In southeast Alaska, the Quartz Hill Molybdenum Mine is still in the planning stage. Cominco, Inc. purchased the mine from U.S. Borax in September of 1991 but has no immediate plans for development. However, Cominco, Inc. has stated that some development may take place in 3 to 5 years (Alaska Journal of Commerce, Sept. 30, 1991). Development stopped last year after the EPA reversed its 1988 decision allowing tailings to be disposed

in Smeaton Bay. The mine is in the Misty Fiords National Monument, 72 km east of Ketchikan.

Depressed silver prices resulted in another unprofitable year at the Greens Creek Mine, about 30 km south of Juneau; however, the mine continues to operate. New discoveries have increased the reserves to 14 million tons of ore; this is likely to extend the life of the mine from the current estimate of 17 years to 30 or 40 years (Alaska Journal of Commerce, Sept. 2, 1991). Greens Creek is primarily a silver mine, but also produces substantial gold, lead, and zinc.

Activity by Federal Agencies

U.S. Geological Survey

Locations of USGS studies carried out during 1991 are shown on figures 14 and 15.

Alaska Mineral Resource Assessment Program (AMRAP)

AMRAP studies are conducted at four progressively more detailed levels to produce comprehensive assessments of the mineral and energy resources of Alaska. Level I studies are statewide in scope, and published maps are generally at a scale of 1:2,500,000. No level I studies are being pursued at this time.

Level II studies address large parts of the State, and resultant maps are generally published at a scale of 1:1,000,000. Level II studies of geology and mineral resource potential are ongoing on the Alaska Peninsula and in the eastern Alaska Range.

Level III studies consist of multidisciplinary evaluations involving team studies of selected 1:250,000-scale quadrangles; these continue to be the primary focus of AMRAP. Geologic, geochemical, and geophysical data are gathered to produce an inventory of areas defined to have mineral resource potential. Although numerous projects have been recessed or scaled down due to the lack of funding, level III studies are in progress in 30 quadrangles. Field work is complete, and reports are in preparation or in press for the Baird Mountains, Bendeleben, Bethel, Chandler Lake, Goodnews/Hagemeister Island, Iditarod, Killik River, Livengood, Mount Katmai/Naknek, Port Moller/Stepovak Bay, Simeonof Islands, Solomon, and Survey Pass quadrangles. Field work continues in the Atlin, Howard Pass, Juneau, Lime Hills, Seldovia, Sitka, Sleetmute, and Taku River quadrangles. Pre-assessments have been completed for the Bethel, Lime Hills, Seldovia, Sitka, Sleetmute, and Table Mountain quadrangles. To date, level III AMRAP assessments have been published for 25 quadrangles (fig. 14). The AMRAP project has now cumulatively published approximately 630 reports.

Level IV studies consist of detailed mapping (1:63,360 or larger scale) and sampling of individual

mineral deposits or mining districts, and related research. Ongoing level IV activities in Alaska include geochemical studies of massive sulfide deposits in mafic volcanic rocks of the Chugach and Prince William terranes, a study of turbidite-hosted lode gold in the Seldovia quadrangle, and metamorphic and structural studies in the central and western Brooks Range (fig. 15; table 12).

Major reports published recently as a result of AMRAP and related mineral resource projects include a comprehensive study of the gold placers of the Circle District (Yeend, 1991); lithologic and tectonic controls on mercury mineralization in the Bethel quadrangle (Frost and Box, 1991a); and undiscovered mineral resources of the Tongass National Forest, southeast Alaska (Brew and others, 1991; Brew and Drinkwater, 1991). The parts of the Tongass National Forest now open to mineral entry contain about 83 percent of the undiscovered metallic mineral resource endowment of the entire forest, which, in turn, contains about 69 percent of the undiscovered mineral endowment of all of southeast Alaska. Brew and Drinkwater (1991) report a revised figure of \$23.5 billion for the gross-in-place value of undiscovered metallic mineral resources in those parts of the Tongass National Forest that are open to mineral entry. The impact of mineral resource studies on the Tongass National Forest land-use planning process is shown by a new land-use designation for a "minerals prescription," never before used by the USFS. The "prescription" encourages mineral exploration and development in areas designated with the highest potential for undiscovered mineral resources.

The results of field and laboratory studies during 1990 on mineral and energy resources and the geology of Alaska have been published (Bradley and Ford, 1992). Mineral resource studies in this publication include a report on gold placers of the Fortymile River area, which identifies unmined terrace gravels that contain mineable gold; a report which records the occurrence of platinum-group elements in the native gold of nine Alaskan gold districts; and a geochemical study that reports new small base- and precious-metal vein systems in the Goodnews Bay quadrangle.

Precious Metals

USGS geologists are involved in several studies of precious-metal occurrences in Alaska. Present research (fig. 15) focuses on placer gold deposits in the Fortymile District (fig. 16), guidelines for lode gold exploration in central Alaska, and turbidite-hosted lode gold in the Seldovia quadrangle. Many level III AMRAP studies also involve research related to precious-metal deposits. Reports published in 1991 include depth controls on magmatism-related gold and mercury mineralization in the Bethel quadrangle (Frost and Box, 1991b).

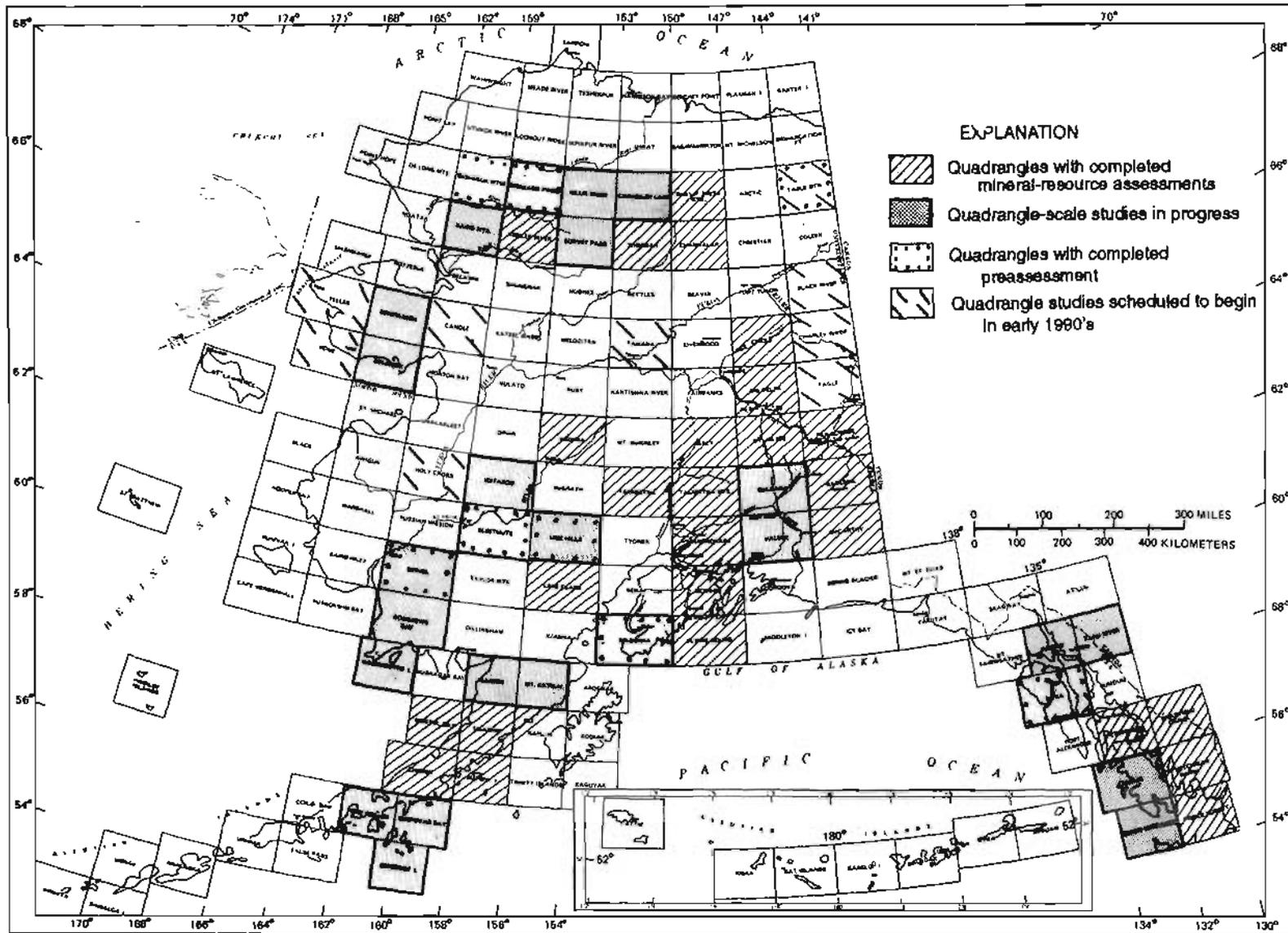


Figure 14. Status of USGS level III AMRAP quadrangle studies as of January 1992. 1:250,000-scale quadrangles are outlined and labeled.

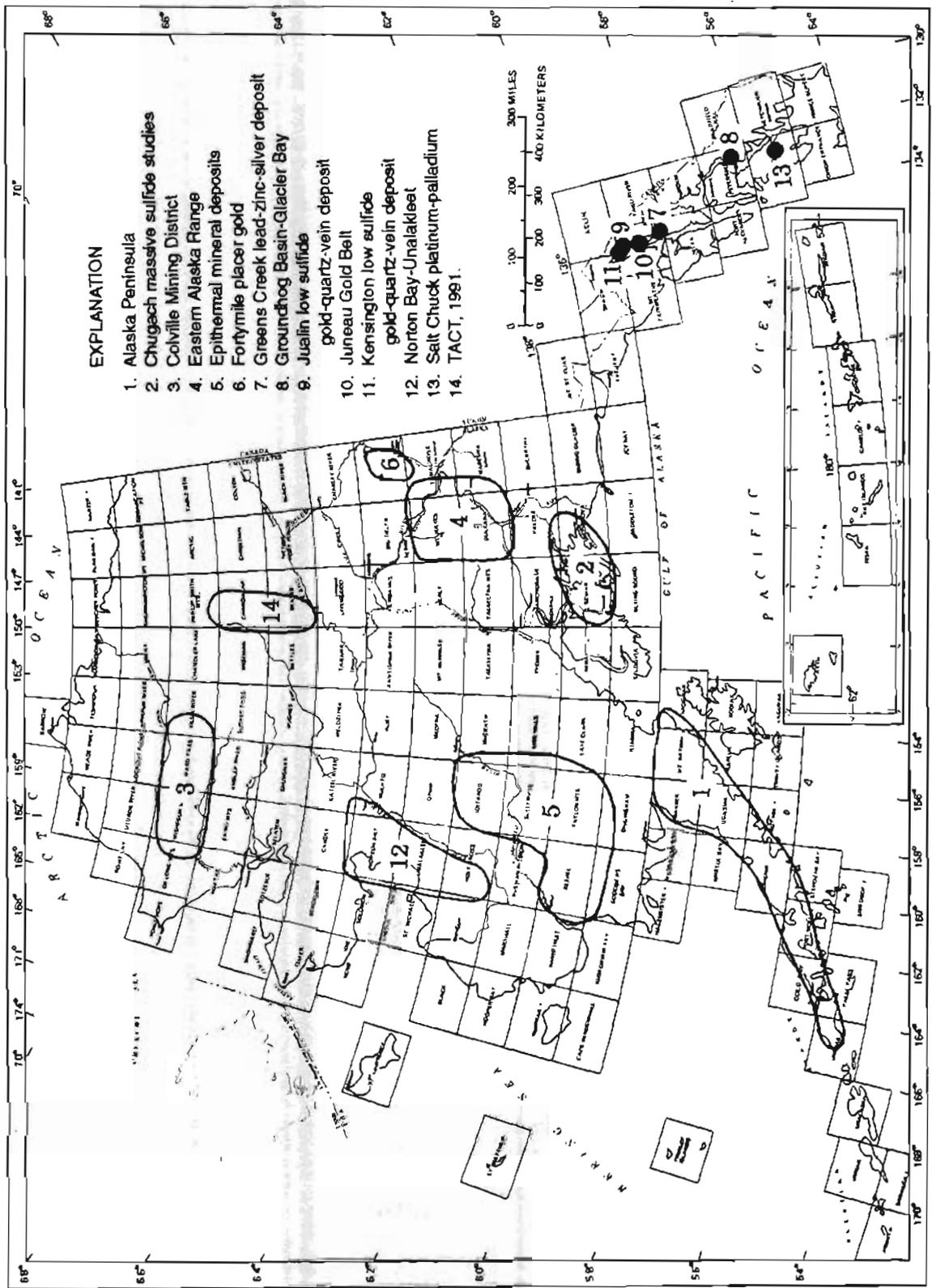


Figure 15. Locations of USGS level IV AMRAP metallic-mineral (table 12) and TACT studies in 1991. 1:250,000-scale quadrangles are outlined and labeled.

Table 12. Level IV studies of the U.S. Geological Survey Alaska Mineral Resource Assessment Program and related projects active in 1991

(Project chiefs are listed in parentheses. Projects marked by asterisk are of statewide scope)

Areal mineral-resource assessments
Alaska Peninsula, geology and mineral resources (F.H. Wilson)
Colville Mining District, geology and mineral resources (J.H. Dover, USGS; S. Fechner, USBM)
Eastern Alaska Range, metallogenesis (W.J. Nokleberg)
Fortymile District, placer gold deposits (Warren Yeend)
Juneau Gold Belt, lode gold deposits (R.J. Goldfarb)
Norton Bay-Ugalalet area, geology and mineral resources (W.W. Patton, Jr.)
* Placer gold deposits studies (Warren Yeend)
* Tin commodity studies (B.L. Reed)
Western Brooks Range, mineral deposits (J.M. Schmidt)
Framework or process studies
* Alaska mafic and ultramafic rocks (R.A. Loney)
* Alaska metamorphic-facies map (C. Dusel-Bacon)
Alaska Peninsula, upper Mesozoic stratigraphy (F.H. Wilson)
Apollo and Shumagin Mines, gold mineralization (W.H. White)
Central Alaska metamorphic studies (J.H. Dover)
Chugach massive sulfide deposits, geochemistry (S.W. Nelson)
Greens Creek silver-zinc-gold VMS deposit (R.S. Newberry and D.A. Brew)
Groundhog Basin-Glacier Basin silver-tin-lead-zinc deposits (R.J. Newberry and D.A. Brew)
Interior metamorphic terranes, structural analysis (J.H. Dover)
Jualin low sulfide gold-quartz-vein deposit (R.S. Newberry and D.A. Brew)
Kensington low sulfide gold-quartz-vein deposit (R.S. Newberry and D.A. Brew)
Northwestern Alaska crustal study (A.B. Till)
* Paleomagnetism of accreted terranes (C.S. Gromme)
Salt Chuck platinum-palladium deposits (R.A. Loney)
Yukon-Koyukuk crustal transect study (W.W. Patton Jr.)
Exploration geochemical studies
Western Brooks Range, stratabound base-metal deposits (K.D. Kelley)
Southwestern Alaska, epithermal mineral deposits (J.E. Gray)
Admiralty Island geochemistry (C.D. Taylor)

Strategic and Critical Minerals

Current research on the occurrence of strategic and critical minerals in Alaska includes studies of mafic and ultramafic rocks and their associated deposits of platinum-group metals (PGM), chrome, nickel, and cobalt. Tin commodity studies are also ongoing.

Other Metals

Research during 1991 on other metals and geologic background investigations includes a northwestern

Alaska crustal study; a mineral resource assessment of the eastern Alaska Range; a geologic and mineral resource study of the eastern Norton Bay area; geochemical sampling in the Howard Pass quadrangle, in an area having potential for stratabound massive sulfide type Zn-Ag-Pb mineralization; a soil geochemical survey around the Lik deposit northwest of Red Dog; the Yukon-Koyukuk geologic transect, a geophysical study of the Yukon-Koyukuk basin; a mining geophysics study of central Alaska; and metamorphic-facies mapping of Alaska. Site-specific studies are being done at both the Jualin and Greens Creek Mines to improve the understanding of the structure, mineralogy, alteration, and general geochemistry of these deposits. Ongoing general studies of undiscovered metallic mineral resources are designed to produce an undiscovered-mineral-resource assessment of all of southeastern Alaska, including the Tongass National Forest. Topical publications during 1991 detailed the results of studies on mercury mineralization in southwestern Alaska (Frost and Box, 1991a), described undiscovered locatable mineral resources of the Tongass National Forest, southeastern Alaska (Brew and others, 1991; Brew and Drinkwater, 1991), and reported on stratabound sulfide deposits of uncertain origins in metamorphic rocks (Newberry and Brew, 1991).

Cooperative Programs with Soviet Scientific Agencies

In 1987, joint studies were proposed to the USSR Academy of Sciences during a visit to the Soviet Far East by the Chief Geologist of the USGS and the USGS Branch Chief of Alaskan Geology. In 1988, two study proposals were exchanged, and memoranda of understanding were signed in 1989 between the National Science Foundation and the USSR Academy of Sciences.

The first proposal involves the comparative metallogenesis of lode mineral deposits in the Russian Far East and Alaska. As one of its goals, the study proposes to relate trends in the geology and lode mineral deposits from western Alaska across the Bering Strait to the Russian Far East. In 1989, a team of USGS geologists visited the Far East for five weeks. In 1990, the USGS and State of Alaska sponsored visits by two teams of Soviet geologists to Alaska. The geologists visited several mineral deposits near Nome, Fairbanks, and in south-central Alaska in conjunction with private industry.

The second proposal encompasses a joint comparative study of the geologic setting and age of ophiolites and their host terranes in Alaska and the former USSR Far East. Ophiolites typically mark fossil boundaries of crustal plates, and the study of ophiolites can lead to insights into the mechanisms of plate subduction and terrane accretion. Moreover, ophiolites commonly are associated with copper, chromium, nickel, and cobalt deposits. Soviet geologists toured several Alaskan ophiolite deposits in 1989,

and in 1990, U.S. geologists reciprocated with a study of important ophiolite localities in the Far East.

In 1991, the project, now sponsored by the USGS, the ADGGS, and the Canadian Geological Survey, continued to concentrate on metallogensis and tectonics of the former Soviet Far East, Alaska, and the Canadian Cordillera. A group of 11 former Soviet scientific managers was hosted at the 1991 McKelvey Forum on mineral resources in Reno, Nevada. A poster outlining the comparative metallogeny of the former Soviet Far East and Alaska was presented at the forum, and a summary article on the project was published in the 1990 USGS Yearbook (Nokleberg and others, 1991). Progress was also made compiling metallogenic and tectonic maps of the former Soviet Far East, Alaska, and the Canadian Cordillera, at a scale of 1:5,000,000. The North American metallogensis team traveled to the former Soviet Far East to work with Russian Far East collaborators on metallogenic and tectonic maps, explanations, and interpretative articles. Plans for 1992 are to (1) host the Russian metallogensis team from Vladivostok and Magadan for a working visit in Anchorage and Vancouver, Canada, to complete the project maps, (2) submit the metallogenic and tectonic maps of the region for technical review, and (3) display the Circum-North Pacific tectonic map at the International Geological Congress meeting in Japan in September.

Trans-Alaska Crustal Transect Program

The Trans-Alaska Crustal Transect (TACT) program is an integrated, multidisciplinary study of the crust along a

transect across Alaska and extending offshore to the north and south. The program combines data from geologic and geophysical surveys to decipher the deep-crustal structure of Alaska, using geologic mapping and specialized structural, isotopic, geochemical, and paleontologic studies; seismic refraction, seismic reflection, and passive seismic studies; magnetotelluric studies, and gravity and magnetic surveys. Although mainly a deep-crustal structure program, the results of the TACT program are used for (1) mineral resource assessment studies, (2) formulation of tectonic models of mineralization that are used in research and by private industry, and (3) minerals exploration by private industry.

Compilation of field and laboratory data and publication of interpretative articles continued in 1991 for the TACT geologic studies project. Field studies were conducted in the southern Brooks Range. Preparation continued for interpretative articles on the bedrock geology of southern, south-central, and northern Alaska that will be published in the Alaskan Volume for the Decade of North American Geology by the Geological Society of America.

National Petroleum Reserve—Alaska

A cooperative 4-year study of nonfuel mineral resources of the Colville Mining District in the southern portion of the NPRA was initiated by the USGS and the USBM in 1990. The overall objective of the study is to evaluate the mineral potential of the Colville Mining District to aid the BLM in land planning. The evaluation will include a USBM compilation of data on known de-



Figure 16. Placer mine operation to recover gold in Chicken Creek of Fortymile District, an area being assessed for mineral resources by USGS geologists. Photograph by W. Yeend.

posits and a USGS estimate of the undiscovered mineral resources. Field work continued in 1991 and included detailed geologic mapping, structural analyses, paleontologic sampling, detailed stratigraphy investigations, a joint USBM-USGS geophysical investigation of the Drenchwater Creek deposit, and an integrated geologic and geophysical study of the Abby barite deposit.

U.S. Bureau of Mines

The USBM's AFOC is responsible for conducting four programs under the USBM's Directorate of Information and Analysis and for coordinating work with other USBM field and research centers throughout the United States. The USBM's Research Directorate is responsible for several ongoing projects in Alaska, through both the Mineral Institute program and the nine USBM-research centers.

Minerals Availability Program

The USBM studied submarine tailings disposal, examined the potential for acid mine drainage from mines in northwestern British Columbia, developed costs for solvent extraction plants, and contributed to the USBM world gold and tin availability studies. The USBM MILS data base was revised with new data and received widespread use from the public sector.

Submarine tailings disposal.—In many coastal mining locations, submarine tailings may be the preferred method of disposal from both an environmental and economic standpoint. The USBM initiated studies assessing the technology, environmental impacts, current regulations, and potential effects on the availability of minerals from U.S. sources resulting from the use of this method of tailings disposal. The USBM also signed a cooperative agreement with the University of British Columbia to develop case studies of operating and historical submarine tailings disposal sites worldwide. A bibliography on the subject was completed and will be published in 1992. Tailings samples from several mines in southeastern Alaska and from one mine near Prince William Sound were collected and sent to the USBM Spokane Research Center for analysis.

Acid mine drainage from northwestern British Columbia.—The USBM looked at mineral development in northwestern British Columbia that has the potential to create acid mine drainage which could impact waters in southeastern Alaska. Eleven mines and prospects were investigated: the Johnny Mountain, Silbak Premier, and Snip Mines, and prospects at Eskay Creek, Golden Bear, Kerr, Polaris Taku, Silver Butte, Sulphurets, Tulsequah Chief, and Windy Craggy; the completed report will be published in 1992.

Solvent extraction.—Solvent extraction is the process where a metal is dissolved from ore; it can be used to recover copper, nickel, uranium, and beryllium. In 1991, the USBM compiled costs of building solvent extraction plants to be used in updating the USBM Cost Estimating Handbook.

Gold and tin availability.—The USBM is updating the world gold and tin availability studies. Data from gold and tin properties in Alaska were compiled and sent to USBM specialists for inclusion in upcoming publications.

Public information.—The MILS data base continued to be updated with data from previous field projects. Data on Russian mineral deposits was also collected for inclusion in the data base. The MILS also received widespread use by government agencies, industry, and the public sector. Map overlays that show mineral deposit locations were provided to the Alaska Department of Natural Resources in order to assist the State in making final land selections under the ANILCA.

Policy Analysis

All 16 quadrangles in southeast Alaska were digitized, and the land status updated to June 1988; 27 quadrangles in south-central and north-central Alaska were also digitized. Land status to June 1989 was updated in a draft form in 16 of these quadrangles.

Initial compilation of the Mineral Claim Information System (MCIS) was completed (Sherman, 1990). There are approximately 73,100 active claims (30,700 Federal and 42,400 State) on the 1990 MCIS data base, a drop of 7.5 percent from the 79,100 claims (33,900 Federal and 45,200 State) active in 1989.

State Mineral Activities

The State Mineral Officer wrote the annual preliminary "Mineral Industry Survey of Alaska in 1990," summarizing significant nonfuel mineral activity. Legislative and executive actions of interest to the mineral industry were monitored and reported monthly. News items were prepared for the weekly "Mineral Alerts" and for the bimonthly survey "Minerals and Materials." Mineral briefing profiles were prepared for DOI and USBM officials as required. Mineral news of interest to USBM staff and its commodity specialists were forwarded to them weekly.

Minerals information and analysis are provided through a series of scheduled and unscheduled publications and reports, and through other responses to inquiries from State and Federal agencies, industry, and the public. One priority is the identification and evaluation of issues, problems, and trends in order to provide the USBM additional opportunities for constructive action in the minerals field.

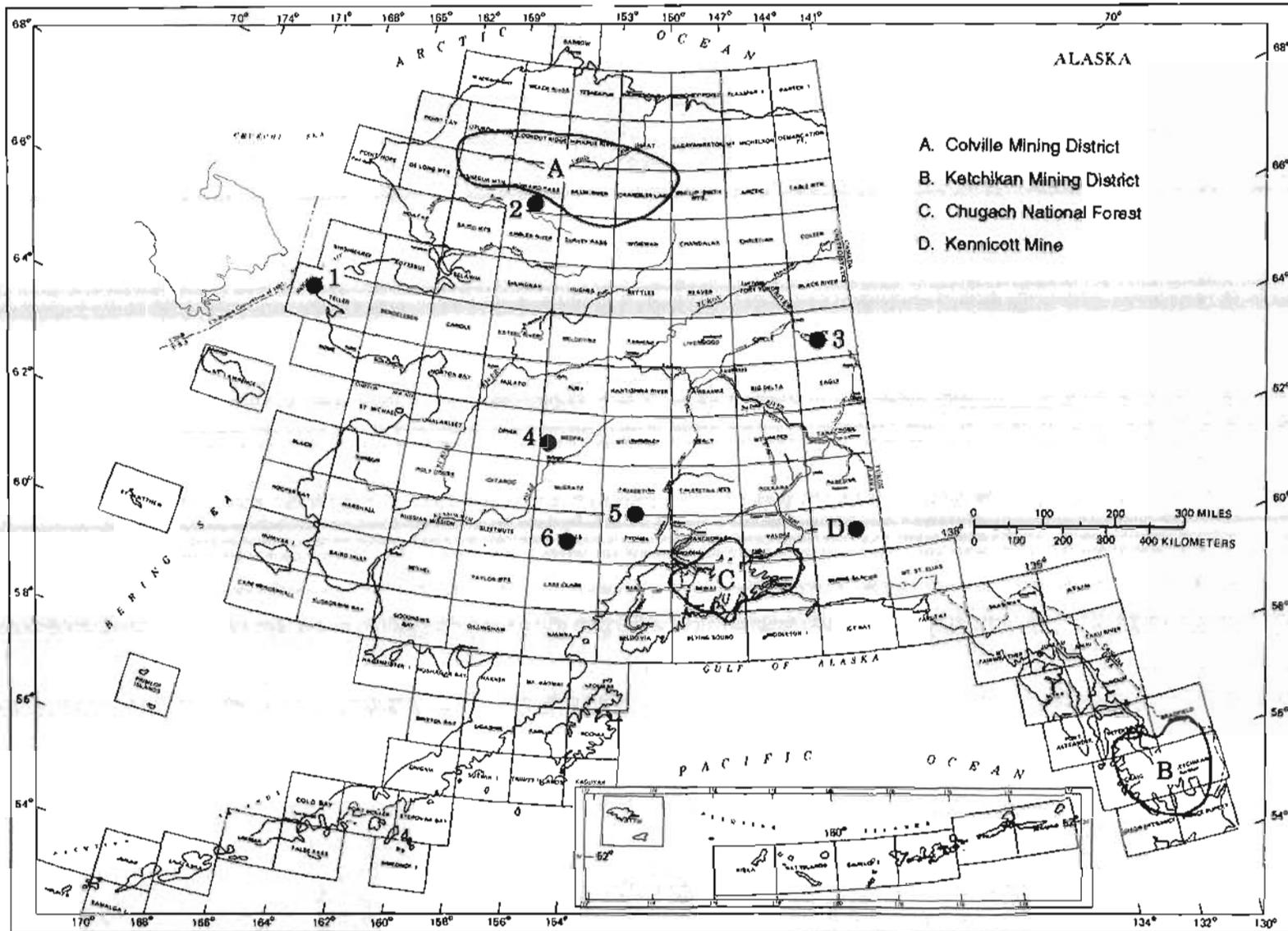


Figure 17. Locations of 1991 USBM mining district studies (A, B, C, D) and studies of strategic and critical minerals (1-6) listed in table 13. 1:250,000-scale quadrangles are outlined and labeled.

Table 13. U.S. Bureau of Mines activity in mining districts and at strategic and critical mineral localities in 1991

Study area	Deposit or element of major interest
Mining districts	
A. Colville Mining District	Lead, zinc, barite, phosphate, coal
B. Ketchikan Mining District	Placer and lode gold, massive sulfide, chromium, PGM
Site Specific Mineral Investigations	
1. Tin City	Sn, In
2. Sinaktanneyak Mt.	Cr, PGM, Au
3. Yukon River	Ag, V
4. Win Prospect	Sn, Nb, Ag
5. Alaska Range	PGM
6. Tired Pup	REE
Abandoned Mine Land Hazard	
Chugach National Forest	
Kennicott Mine	

Mineral Land Assessment

During 1991, the USBM conducted mining district studies, site-specific mineral investigations, and abandoned mine land activities in Alaska (fig. 17, table 13).

Mining district studies.—Each mining district study is designed to determine the mineral development potential of the district by identifying mineral resources and reserves, evaluating the probability that more resources exist, and determining the feasibility of mining certain deposit types. The studies include site-specific evaluations when the presence of significant minerals is noted. The mining district studies are done in cooperation with Federal and State agencies. In 1991, the USBM investigated the Colville and Ketchikan Mining Districts.

The Colville Mining District is located in northern Alaska and includes the southern part of the NPRA. A minerals study of the area was requested by the BLM for use in a Land Management Plan for the Arctic District. Access is currently restricted for much of the public land in the district, but this could change with legislative action. An original inventory in 1977 and 1978 by the USBM (site-specific) and USGS (regional) had already identified coal resources and areas of zinc-lead-silver mineralization, as well as rocks with high fluorine, phosphate, rare-earth elements (REE), barium, vanadium, and chromium contents. In 1991, the area between Drenchwater Creek in NPRA and the Chandler River in Gates of the Arctic National Park and Preserve was examined. Approximately 97 percent of the identified USGS geochemical anomalies in the area were investi-

gated, and approximately 750 samples collected. Thirteen mineral occurrences and 12 mineralized areas were identified, examined, and sampled on a reconnaissance level. Detailed site-specific examinations of the Drenchwater, Kady, Kivliktort West, Koiyaktot East, Koiyaktot West, and Story Creek occurrences were completed. Activities at these sites included detailed mapping, soil and bulk rock sampling, and a geophysical survey at Drenchwater Creek (fig. 18).

Field work in the Ketchikan Mining District continued during 1991. More than 70 new properties were investigated on Prince of Wales Island. At these sites, more than 1,300 rock, stream sediment, and placer samples were taken; six metallurgical test samples were collected; and approximately 4,000 feet of underground workings was mapped.

Site-specific mineral investigations.—Through field studies, deposit modeling, and beneficiation and metallurgical testing, the USBM is conducting site-specific investigations to locate, characterize, and quantify deposits that contain strategic and critical minerals and advanced materials. The USBM has investigated occurrences of chromium, cobalt, gallium, germanium, indium, manganese, niobium, PGM, REE, tantalum, tin, vanadium, yttrium, and zirconium at nearly 300 sites in Alaska.

In 1991, work was done at six localities. Three areas of mineralization in southwestern Alaska were examined. In the western Alaska Range, several composite plutons were evaluated, in cooperation with the USGS. It was found that these plutons are mineralogically similar to composite plutons mapped in the eastern Alaska Range. Also in the western Alaska Range, the major creeks that drain the Tired Pup pluton were evaluated for their tin and REE potential. Tin- and REE-bearing minerals in alluvium were collected from creeks that drain the southwestern portion of the pluton. The USBM identified arsenopyrite, cassiterite, wolframite, scheelite, loellingite, and uraninite in pan concentrate samples. Field investigations at the Win prospect yielded rock samples which averaged 7 percent tin and 19 oz/ton silver over 8 feet; a few samples contained up to 57 percent tin and 334 oz/ton silver.

In northwestern Alaska, the USBM, in cooperation with the USGS, evaluated the ultramafic complex at Sinaktanneyak Mountain. The USBM identified up to 2.5 million short tons of chromic oxide and anomalous concentrations of gold and platinum-group metals in bedrock. The potential exists for the area to contain platinum and gold placer deposits. On the Seward Peninsula, previous reports of high indium values in the taconite deposits around Tin City were investigated; rock samples with up to 750 ppm indium were collected.

In the northeastern portion of the State, outcrops of the Calico Bluff Formation, Ford Lake Shale, and lower part of the Glenn Shale near the Yukon River were sampled. These units may contain anomalous amounts of vanadium and silver.

Abandoned mine land.—In 1989, the USFS requested the USBM to locate and assess hazards associated with abandoned mine sites in the Chugach National Forest. A cursory evaluation of the mine sites determined that 100 properties contain potentially high risk hazards. In 1991, 12 sites were visited; the hazards identified during the evaluation included underground workings, buildings, scrap lumber and metal, machinery, abandoned explosives, and petroleum product spills.

The NPS is negotiating to acquire the historic Kennicott Copper Mine and Mill. In 1990, the NPS requested the USBM to provide technical support and consultation on the environmental site assessment of the mine, in response to DOI regulations requiring assessment of all potential environmental hazards on a site prior to acquisition by the Federal government. Through planning meetings and on-site visits, the USBM provided guidance to the NPS on appropriate methodologies for a characterization of the site. The USBM is also reviewing the results of the assessment and will evaluate any proposed remediative actions.

Research Activities

Mine closure in Arctic environments.—The goal of this project is to identify possible environmental impacts from various types of mining activities and to develop methods for closing mines so as to mitigate any undesirable impacts. Methods include revegetation, wetlands preservation, improvement of surface drainage, and consideration of visual aesthetics. Work was performed in

cooperation with the U.S. Department of Agriculture's Soil Conservation Service on mined lands near Nome.

Subaqueous disposal of mining wastes.—This project will determine the environmental and economic feasibility of disposing mine wastes in marine or lacustrine environments. In 1991, a bibliography of 2,000 references was compiled. A reconnaissance of Alaskan and Canadian mines that used or would like to use marine disposal of tailings was conducted; samples were collected from the Island Copper Mine in British Columbia, and from the A-J, Kensington, and Greens Creek Mines in Alaska.

Analysis of underground mining.—This is a cooperative project between the Kennecott-Greens Creek Company and the USBM at the Greens Creek Mine in southeastern Alaska. Investigations at the mine will be used to analyze the behaviors of soil, rock, and the mining infrastructure in Arctic environments. The USBM performed a rock mechanics study of the present mine, and stress analysis confirmed that the present mine layout would not create any surface disturbance. Underground sensors have been installed to monitor sulfur-dioxide levels and the amount of stress in the wall rocks. After the USBM's evaluation of the backfill method used in the mine, Cominco has switched from backfilling using "slinger" trucks to backfilling with slurries pumped into the underground openings.

Underground mining methods for Alaskan deep placers.—This project will develop economic, safe, and environmentally sound techniques for recovering metals from deep

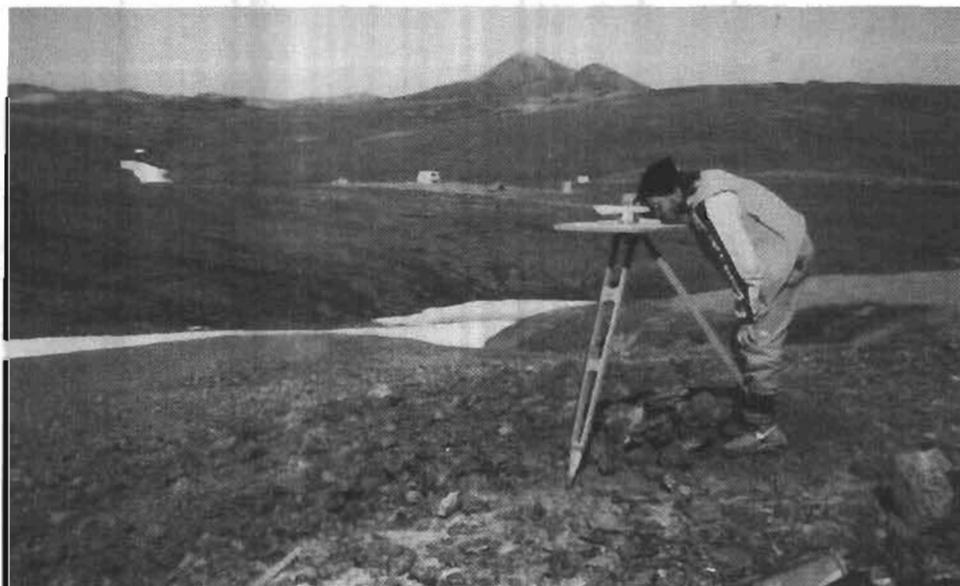


Figure 18. USBM geologist mapping location of mineral deposit at Drenchwater Creek by plane-table survey. This site is being evaluated for mineral occurrences using geologic field and laboratory investigations and geophysical surveys. USBM and USGS are conducting a joint study of the mineral potential of this region for use by the BLM in preparing a Land Management Plan for the Arctic District. Photograph by J. Kurtak.

placer deposits in Alaska. In 1991, underground placer mining operations in the Fairbanks area were examined. Samples were collected to characterize the physical properties of materials under different conditions. Initial computer modeling has indicated that the creep material codes characteristic of permafrost must be considered in order to predict the behavior of permafrost accurately. Pertinent data have been compiled from the Cold Regions Research and Engineering Laboratory's tunnel research to quantify the behavior of materials in the Fairbanks region.

Borehole slurry mining.—Borehole slurry mining is a method by which large cavities can be eroded in an ore body using a high-pressure water jet and slurry pump operating in a vertical borehole. This technique has been successful in the mining of uranium sandstones, coals, phosphate, and foundry sand, and the USBM is trying to adapt the method for deep Alaskan placer deposits. Researchers have developed a borehole mining jet that cuts both frozen and unfrozen gravel. New research is concentrating on lateral pumping between boreholes and on mechanical means of breaking cobbles in the borehole to improve pumping capabilities.

Frozen tailings as backfill material.—This project will evaluate the disposal of frozen tailings as backfill material in Arctic and alpine environments. A literature search was conducted for references of current underground mining techniques, placer deposits, and proposed underground mining methods. The chemical stability of the frozen material will be evaluated to determine its long-term durability.

Other.—The USBM research centers in Albany, Oregon, and Salt Lake City, Utah, continue to characterize and conduct beneficiation tests on bulk samples from mineral deposits in Alaska that contain strategic and critical commodities; a sample of oolitic phosphorite taken from the Ivotuk Hills in NPRA contained 36.6 percent phosphoric oxide and 0.11 percent vanadium. The research centers also conduct tests on domestic resources; a bulk sample from the Story Creek prospect in NPRA contained 2.1 percent lead and 5.4 percent zinc.

Bureau of Land Management

In 1991, there were filings/recordings of a total of 29,267 Federal mining claims in Alaska. The total number of active mining operations on BLM-administered lands included 122 Notices, which cover 5 acres or less total surface disturbance, and 72 Plans of Operations, which cover more than 5 acres of total surface disturbance. Decisions were issued that resulted in the closure of 2,019 claims. Seven mineral patents were adjudicated to completion, and 92 claims were rejected.

Geologists, support personnel, and field personnel from the BLM Arctic District Office accompanied and cooperated with the USBM's field work for the Colville Min-

ing District study of metallic minerals in southern NPRA. In addition, the BLM Division of Mineral Resources published three reports on the hard rock mineral potential of northwestern Alaska (Mowatt, 1991; Mowatt and others, 1991a, b). These references are listed in appendix 1, BLM section.

Fish and Wildlife Service

Valid mining claims on lands established as national wildlife refuges by the ANILCA in 1980 remain valid if they are kept active. In 1991, there were 135 claims which may be valid on 8 of the 16 refuges in Alaska, including 1 in the Alaska Maritime refuge, 70 in the Alaska Peninsula refuge, 9 claims and 1 mill site in the Arctic refuge, 1 in the Becharof refuge, 2 in the Innoko refuge, 4 in the Tetlin refuge, 35 in the Togiak refuge, and 13 in the Yukon Delta refuge.

The FWS conducted contaminant monitoring on the Koyukuk, Nowitna, and Yukon Flats Refuges where placer mining occurs upstream from the refuges, on rivers which flow into the refuges. The FWS also reviewed 61 ACE permits or permit modifications for mining-related activities. The FWS reviewed and commented on a mineral assessment for northwestern Alaska and commented extensively on EIS's for two sites in southeastern Alaska: (1) harbor facilities and a dam on Sheep Creek for tailings disposal from the A-J Gold Mine in Juneau, and (2) harbor facilities and a disposal pit for the Kensington Mine at Berners Bay.

Minerals Management Service

OCS Mining Program, Norton Sound Lease Sale

The MMS had scheduled a July 1991 competitive OCS mineral lease sale in Norton Sound for areas south and southeast of Nome. The focus of this proposed sale was gold-bearing placer deposits at or near the sea floor in Federal waters at depths ranging from 60 to 100 feet. The proposed sale area included 147,050 acres of the OCS and extended up to 10 miles seaward of the State of Alaska's 3-mile coastal water limit. Preliminary studies had indicated that the sale area could yield as much as 1,060,000 ounces of gold. The Final EIS for the mineral sale was released in March 1991 and the Final Leasing Notice was issued the following June. Lease sale bids were to be opened on July 24, 1991; however, no bids were received by close of business on July 23, so the lease sale was canceled.

Industry responses to a Request for Comments and Nominations in March 1988 had indicated that sufficient industry interest existed to justify proceeding with a gold sale in the Federal OCS waters of Norton Sound. On-shore mining of stream and beach placers near Nome has occurred intermittently since the first gold discoveries in

1899. Since that time, miners have recovered over 6 million troy ounces of gold from the Seward Peninsula, of which over 4.5 million troy ounces came from the Nome Mining District. From 1986 to 1990, the Western Gold Exploration and Mining Company (WestGold) used the floating dredge *Bima* to mine 21,750 acres of mineral leases in State of Alaska waters landward of the proposed sale area, extracting approximately 130,000 ounces of gold. However, at the end of the 1990 season WestGold ceased production, citing high operating costs, and put the *Bima* up for sale.

National Park Service

Within the NPS organization in Alaska, minerals-related programs are managed at both the regional and park unit levels. In the NPS Alaska Regional Office, the Minerals Management Division manages a comprehensive program for a wide range of minerals-related activities, such as mining claim management, claim acquisition, transportation corridors, access, hazardous waste, reclamation, and oil and gas exploration. The Division is organized in two branches: Resource Assessment, and Mining and Minerals. Within the mining claim management program, personnel from both branches review mining plans of operations and evaluate available natural, physical resource, and engineering information on areas proposed for placer or lode mining. NPS personnel also conduct claim validity examinations and develop and implement site-specific long-term reclamation programs. In addition to the Minerals Management Division, the Regional Office maintains a Mining Compliance Branch within the Cultural Resources Division which reviews cultural resource aspects of mineral-related programs. Complementing the Regional Office staff in Anchorage, Denali and Wrangell-St. Elias National Parks and Preserves maintain professional minerals management staffs consisting of environmental specialists and geologists who implement park-specific aspects of the minerals management programs. In park units with smaller minerals-related programs, resource staff specialists manage mineral programs as collateral duties, often assisted by Regional Office staff. Major NPS accomplishments during 1991 are as follows:

1. The 9th Circuit Court reaffirmed the U.S. District Court's decision approving the EIS's prepared by the NPS evaluating the cumulative effects of mining in Denali, Wrangell-St. Elias, Yukon-Charley, and Gates of the Arctic National Parks and Preserves. This freed the NPS to pursue the EIS's identified proposed action of acquiring all patented and valid unpatented mining claims in the named Park units on a "willing seller" basis. Pending acquisition, the NPS will continue to process complete plans of operations for mining activities under existing regulations.

2. The NPS expended \$ 2.65 million for the acquisition of 17 mining claims in Denali National Park and Preserve. As of 1991, Congress had appropriated approximately \$9.1 million for mining claim acquisition in Denali. Two claim groups in the Kantishna area of Denali are identified for purchase in 1992. In preparation for future acquisitions, the NPS completed hazardous waste inventories and appraisals on additional Kantishna properties during the 1991 field season.

3. Under provisions of Section 1010(b) of ANILCA, regulations were promulgated under which eligible Federal agencies could conduct AMRAP activities in units of the National Park System. Final regulations at 36 CFR Part 9, Subpart D, were published in May. For the 1991 summer field season, nine AMRAP activity permits were issued: three for USGS work in Kenai Fjords National Park, Lake Clark National Park and Preserve, and Wrangell-St. Elias National Park and Preserve; three for USBM work in Gates of the Arctic National Park and Preserve, Noatak National Preserve, and Yukon-Charley Rivers National Preserve; and three for MMS work in Aniakchak National Monument and Preserve, Katmai National Park and Preserve, and Lake Clark National Park and Preserve. These permits supported USGS AMRAP mapping activities, the USBM's strategic and critical minerals program, and the MMS's OCS leasing program.

4. Mineral examinations for claim validity determinations were made on 26 placer and 147 lode claims in Denali National Park and Preserve, and on one placer claim in Wrangell-St. Elias National Park and Preserve. Nine validity reports were completed which covered 194 claims in three park units.

5. Large- and medium-scale aerial color infrared photographs were acquired for the Kantishna area of Denali National Park and Preserve for reclamation planning and claim survey work.

6. To define the location of unpatented mining claims, claim boundary locations were surveyed for 55 mining claims in Denali National Park and Preserve. Two-foot-contour-interval topographic maps were computer-generated from the field survey data to support mining claim management and reclamation planning.

7. The NPS received three new plans of operations for proposed mining activities, two in Denali National Park and Preserve and one in Wrangell-St. Elias National Park and Preserve. One previously received plan in Denali was denied following the preparation of an environmental assessment which identified unacceptable cumulative and site-specific environmental impacts from the proposed operation. Three mines operated in park units under previously approved plans, one each in Bering Land Bridge National Preserve, Kenai Fjords National Park, and Wrangell-St. Elias National Park and Preserve. Two permits for access to mining claims in

Wrangell-St. Elias National Park and Preserve were issued.

8. Reclamation research continued in the Kantishna area of Denali National Park and Preserve. Revegetation studies of alder and willow plantings are being conducted on a 27-acre site reclaimed by the NPS in 1988 near the confluence of Glen and Moose Creeks. The abandoned placer mine reclamation area is a prototype project designed to study the process of ecosystem recovery within the Kantishna Hills region. In 1991, 2,400 feet of flood plain was recontoured to an engineer-designed 100-year flood plain; new willow plantings and man-made vegetation berms were installed to protect and stabilize the new flood plain surface. Research results will be used to guide reclamation planning for plan-of-operations submissions and reclamation/stabilization work on mining claims acquired by the NPS.

9. The Abandoned Mineral Lands (AML) Program is designed to manage sites of former mining operations; its objectives are to eliminate and (or) mitigate safety hazards and to preserve any significant natural or cultural resource values located on the former mining properties. In 1991, one AML site inventory was completed in Wrangell-St. Elias National Park and Preserve, and 15 site inventories were completed in Kenai Fjords National Park.

10. The Cultural Resources Division continued to insure that all mineral-related activities were accomplished under the mandates of the National Historic Pres-

ervation Act. Multidisciplinary cultural resource field crews conducted intensive surveys within five park units; no prehistoric sites were recorded, but 21 historic mining sites were documented (fig. 19). Inventories included a unique brush shelter associated with the 1913 Chisana Gold Rush in Wrangell-St. Elias National Park and Preserve and a group of large historic lode-mining sites in Kenai Fjords National Park. Under the auspices of the Region's AML program, structures and engineering features of the historic Fairhaven Ditch in Bering Land Bridge National Preserve were also documented.

U.S. Forest Service

The USFS has received eight mineral patent applications on the Tongass and Chugach National Forests in 1991 and 1992. Most of these mineral patent applications were filed in response to congressional proposals to revise the 1872 General Mining Law. During August 1991, mineral validity examinations were performed on mining claims located on State-selected land in the Girdwood area of the Chugach National Forest.

Tongass National Forest

Management Plan.—A supplement was prepared to the Draft EIS for the Tongass Land Management Plan in August 1991 to incorporate new policies set forth in the Tongass Timber Reform Act of October 1990. The



Figure 19. Miner's tool shed and wagon, circa 1930, along Caribou Creek in Denali National Park and Preserve. This historic site was inventoried by NPS Cultural Resource staff members under the mandates of the National Historic Preservation Act. Photograph by NPS staff, Cultural Resource Mining Inventory and Monitoring Program.

Tongass Timber Reform Act, PL 101-626, added an additional 296,080 acres of wilderness to the Tongass National Forest in six new wilderness areas, for a total of 5,693,246 acres of wilderness in a 16,737,492-acre National Forest.

The revised Land Management Plan includes a "prescription" for minerals management; this is the first time such a designation has been used in the USFS planning process. The minerals management prescription designation is designed to encourage and facilitate development of the mineral resources. In the supplement to the Tongass Land Management Plan, 12 areas that have a high potential for minerals development are identified for a minerals management prescription. Controversy over the prescription has erupted between the mining industry, which, while generally supportive of the prescription, believes that it was too narrowly applied, and environmental groups, which contend that it amounted to a land "give-away" to the mining industry. The mining industry would like to see some provision made for minerals development in areas not specifically designated with a minerals management prescription.

The supplement to the Draft EIS of the Tongass Land Management Plan increases the number of minerals management prescription areas from 6 to 12, adjusts some of the prescription boundaries to reflect recreational concerns in the Juneau area, and modifies wording in the mineral prescription to better address the need to consider other resources.

Greens Creek.—The Greens Creek Mine, the largest producing silver mine in the United States, is located in the Admiralty Island National Monument, administered by the Tongass National Forest. The deposit was discovered and staked in 1974, and first drilled in 1975. The ANILCA of 1980 authorized development and production of the mine in Section 503(f)(2)(A). In 1983, the USFS completed a Mine Development EIS for the project. In 1988, under the provisions of Section 503(e)(1) of ANILCA, USFS mineral examiners evaluated nine new mining claims and notified the Greens Creek Mining Company that the claims were valid, thus increasing the viable ore reserves of the mine. The mine was aggressively developed, and production began in January 1989. In late March 1990, the Kennecott, Greens Creek Mining Co. claimed extralateral rights under the provisions of the 1872 General Mining Law, based on the projected geometry of the deposit. Extralateral rights allow the company to pursue development of the downward extent of the ore body beyond the vertical boundaries of the valid mining claims. The USFS evaluated the company's assertion and recognized the company's case for extralateral rights in May 1990. In order to accommodate the expanded mining operation, the USFS is preparing an environmental analysis for a new waste rock disposal site.

Quartz Hill.—U.S. Borax and Chemical Corporation's Quartz Hill molybdenum deposit is located in the Misty Fjords National Monument, on a 152,000-acre tract that is

excluded from designation as wilderness. Evaluation and development of the deposit is authorized under ANILCA Section 503(f)(2)(A). The USFS completed the Mine Development Final Environmental Impact Statement (FEIS) for Quartz Hill in October 1988. The two sites considered in the FEIS for marine tailings disposal were the Boca de Quadra fjord and the Wilson Arm/Smeaton Bay fjord. In his Record of Decision, the Alaska Regional Forester concluded that, environmental impacts being almost equal, tailings disposal in the Wilson Arm offered distinct economic advantages. The EPA, a cooperater in the preparation of the FEIS, issued a draft discharge permit for Wilson Arm in November 1988.

The Sierra Club Legal Defense Fund (SCLDF) appealed the USFS decision on behalf of several environmental and commercial fishing organizations, contending that economics should not have been an element of the Regional Forester's decision due to the environmental sensitivity of Misty Fjords National Monument. On January 11, 1990, the Regional Forester reaffirmed his decision, noting that Congress specifically directed the USFS to consider the effect of mitigation measures on the economic viability of the project. However, in May 1990, citing SCLDF information and other reasons, the EPA reversed itself and announced plans to deny the disposal permit. In September 1990, the EPA, with the concurrence of the State of Alaska, issued a final decision to deny the discharge permit for Wilson Arm. Because of this action and because the price for molybdenum is depressed, U.S. Borax and Chemical Corporation suspended further permitting activities on the Quartz Hill project. In mid-1991, Cominco, Inc. purchased the Quartz Hill deposit. No development plans have been announced at this time.

Kensington Project.—The Kensington Project (fig. 20), located in Berners Bay 50 miles north of Juneau, is a joint venture between Coeur d'Alene Mines and Echo Bay Mines. The Juneau Ranger District of the Tongass National Forest is presently evaluating public comments on the Draft EIS for the project and is beginning to prepare the FEIS. Controversial issues raised in public comment include mountain goat disturbance and the effect of tailings effluent on the water quality of Lynn Canal.

Jualin Project.—The Jualin Project is located adjacent to the Kensington Project, 50 miles north of Juneau, along the same geological structure (the Jualin shear zone). Gold was first discovered here in 1895. Recent exploration and claim location have been in progress since 1980. The deposit extends through USFS, private, and State lands. Placer Dome and Curator American, Inc. continued exploration drilling on the Jualin deposit during the summer of 1991.

Other.—Exploration and development activity continued during 1991 in the Juneau Gold Belt. Controversy surrounds further development of the Alaska-Juneau Gold Mine, due to its close proximity to the city of Ju-

neau and the large size of the project. The USFS and BLM are cooperators in the Alaska-Juneau project. The BLM prepared a Draft EIS for the project that identifies Sheep Creek as the preferred alternative for tailings disposal from the mine. The other three alternative disposal sites are located on USFS land. If one of these other alternatives is selected, the USFS must approve the selection through a plan of operation or a special-use permit before any tailings disposal can occur.

Chugach National Forest

Mining areas in the Chugach National Forest are being inventoried by the USBM for environmental and safety hazards that may have resulted from past mining activities. The USBM is providing field and technical assistance for this investigation through a partnership agreement with the Chugach National Forest. An inventory of mining areas on the Kenai Peninsula was completed in 1990 and in the Prince William Sound area in 1991. The USBM prepared a report from the inventories on the type and severity of identified hazards as well as

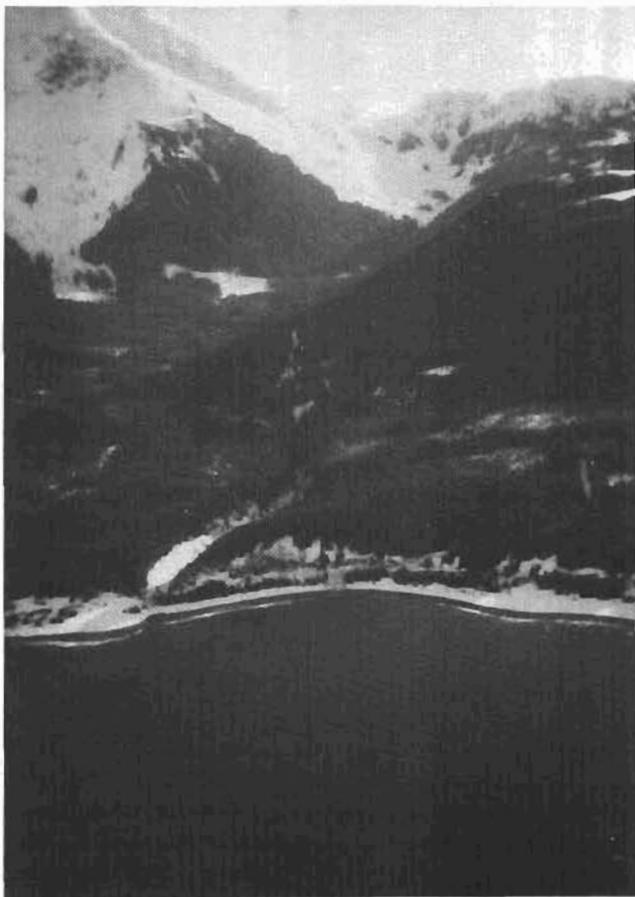


Figure 20. South-looking view of Kensington Project, showing mine (center of photograph), mining camp (in center of beach), and Lions Head Mountain (upper left). Photograph courtesy of Juneau Ranger District, Tongass National Forest.

recommended mitigation measures. The Chugach National Forest is presently considering mitigation measures for the physical and environmental hazards that were identified. Abandoned and improperly stored dynamite is the first priority hazard to be corrected because of the great potential for immediate harm to the public. Mitigation measures will be initiated and additional field investigations performed in 1992.

The USGS and the USBM will be conducting minerals field work on Chugach National Forest land in 1992, in the upper regions of Unakwik Inlet and Collee Fjord, and in the Copper River Additions between the Copper River delta and the Tasnuna River. The information collected will be used to (1) identify and quantify suspected mineral deposits in the Chugach National Forest, (2) update the Chugach National Forest minerals data base for known mineral occurrences, (3) identify potential opportunities for mineral development, and (4) protect access and predict the extent of mineral development to be considered for the revision of the Forest Plan which will begin in 1994.

Industrial Minerals

In 1991, the industrial mineral industry, comprised of sand and gravel and building stone, remained at the same level of production as for the last 5 years. About 14.4 million short tons of sand and gravel, valued at \$45.6 million, were mined during 1991, and 3 million short tons of building stone were mined (Bundtzen and others, 1992).

The Anchorage Assembly voted against the development of a gravel mine in Sand Lake, within the Municipality of Anchorage. Developers sought a permit to remove 1.6 million cubic yards of gravel and then reclaim the 60-acre gravel pit by turning it into a residential subdivision. Local residents claimed that trucking an estimated 80,000 loads of gravel from the pit would cause a traffic hazard and produce objectionable dust. The developers plan to appeal the decision in State court (Alaska Daily News, Jan. 9, 1991).

Ice is one of Alaska's most abundant resources. The ice industry in Alaska began in 1852, when the State was part of Russian America. Lake ice was obtained from Lesnoi Island (Woody Island near Kodiak) and New Archangel (present-day Sitka). In 1852, 325 tons were shipped to California and sold for \$75 per ton (Smith and Barnett, 1990). Now, in 1991, Ice Alaska, a Fairbanks non-profit group, is working to send 150,000 pounds of the bluish ice found on Fairbanks ponds to France, where it will be used for a sculpture in one of Paris' busiest areas (Fairbanks News-Miner, Dec. 13, 1991).

The possibility of collecting, transporting, and selling huge amounts of Alaska's natural fresh water has been a popular topic of discussion as the multi-year

drought in California continues. The original idea has been a favorite megaproject of Walter J. Hickel, the current Governor of Alaska, for more than 20 years (Fairbanks News-Miner, March, 19, 1991). Termed a 2,000-mile-long North American Water Transfer Engineering Facility, the project would involve the transfer of a trillion gallons of water a year in a pipeline or several pipelines underwater along the Continental Shelf from Alaska to somewhere in California (Fairbanks News-Miner, June 4, 1991). At least one study concluded that the pipeline was unfeasible. Another study concluded the project would be "a unique civil engineering undertaking" costing approximately \$110 billion (Alaska Daily News, August 15, 1991). A University of Alaska oceanographer, however, cautions that a much more thorough study is needed of the giant project's environmental consequences. The proposed pipeline could divert enough of the Alaska coastal current to have adverse effects on marine life (Anchorage Times, June 9, 1991). Also under consideration is a project that would use ocean-going tankers to transport water to California. The Alaska Department of Natural Resources is considering bids from a Santa Barbara, California, company to export millions of gallons of water per year from a river and lake in the south-east part of Alaska (Anchorage Times, Nov. 27, 1991).

Activity by Federal Agencies

U.S. Bureau of Mines

A USBM report summarized 1990 industrial minerals activity in the Ketchikan Mining District (Maas and others, 1991). This report is listed in appendix 1, USBM section.

Bureau of Land Management

The disposal of salable mineral materials, namely sand and gravel, continued to be a minor activity for the BLM in Alaska.

Fish and Wildlife Service

When compatible with refuge purposes, the FWS issues special-use permits for the sale and extraction of sand and gravel to support development activities in rural communities. In 1991, the Selawik NWR issued one gravel-removal permit; the gravel was to be used for topping surfaces at the reconstructed Selawik Airport. The excavation site was cleared for archeological resources by an FWS archeologist, but, due to low water, mining did not occur in 1991.

U.S. Forest Service

Annually, the USFS permits the removal of many thousands of tons of sand, gravel, and stone. Much of

this material is used in the construction of timber-sale roads. Lesser amounts are used by State and local governments for the construction and maintenance of breakwaters, airports, and roads.

Large reserves of generally high quality sand and gravel occur in the Portage Valley, within the Glacier Ranger District of the Chugach National Forest, 50 miles south of Anchorage. Gravel extraction sites on USFS land in the Portage Valley are the primary source for aggregate in the Girdwood area. Extraction sites are reclaimed mainly for fish enhancement.

REFERENCES CITED

- Affolter, R.H., and Stricker, G.D., 1987, Variations in element distribution of coal from the Usibelli Mine, Healy, Alaska, in Rao, P.D., ed., Focus on Alaska's Coal '86, Conference proceedings: University of Alaska at Fairbanks, Mineral Industry Research Laboratory Report 72, p. 91-99.
- Alaska Department of Natural Resources, 1986, Oil and gas resources of Alaska: Alaska Division of Geological and Geophysical Surveys Information Circular 31, 9 p.
- Alaska Journal of Commerce [published weekly by OCA Publishing, 3710 Woodland Drive, Suite 2100, Anchorage, AK 99517].
- Alaska Oil and Gas Conservation Commission Bulletin [published monthly by the State of Alaska, Alaska Oil and Gas Conservation Commission, 3001 Porcupine Drive, Anchorage, AK 99501].
- Alaska Report [published weekly by Petroleum Information Corporation, P.O. Box 102278, Anchorage, AK 99510].
- Anchorage Daily News [published daily by Anchorage Daily News Incorporated, 1001 Northway Drive, Anchorage, AK 99508].
- Anchorage Times [published daily by Anchorage Times Publishing Company, 820 West Fourth Avenue, Anchorage, AK 99501].
- Beck, R.J., 1992, World oil flow slips in 1991 amid Mideast, USSR woes: Oil and Gas Journal, v. 90, no. 10, p. 23-27.
- Bradley, D.C., and Ford, A.B., eds., 1992, Geologic studies in Alaska by the U.S. Geological Survey, 1990: U.S. Geological Survey Bulletin 1999, 242 p.
- Brew, D.A., and Drinkwater, J.L., 1991, Tongass Timber Reform Act Wilderness Areas supplement to U.S. Geological Survey Open-File Report 91-10 (Undiscovered locatable mineral resources of the Tongass National Forest and adjacent lands, southeastern Alaska): U.S. Geological Survey Open-File Report 91-343, 35 p., 1 fig.
- Brew, D.A., Karl, S.M., Barnes, D.F., Jachens, R.C., Ford, A.B., and Horner, R., 1991, A northern Cordilleran ocean-continent transect: Sitka Sound to Atlin Lake, British Columbia: Canadian Journal of Earth Sciences, v. 28, no. 6, p. 840-853.
- Bundtzen, T.K., Swainbank, R.C., Wood, J.E., and Clough, Albert, 1992, Alaska's mineral industry—1991 summary: Alaska Division of Geological and Geophysical Surveys, Information Circular 35, 11 p.

- Callahan, J.E., Brougham, G.W., and Bascle, R.J., 1987, Economically recoverable oil resources, in Bird, K.J., and Magoon, L.B., eds., *Petroleum geology of the northern part of the Arctic National Wildlife Refuge, northeastern Alaska*: U.S. Geological Survey Bulletin 1778, p. 299-307.
- Carlson, P.R., ed., 1991, Sediment of Prince William Sound, beach to deep fjord floor, a year after the *Exxon Valdez* oil spill: U.S. Geological Survey Open-File Report 91-638, 4 chapters, 101 p.
- Carlson, P.R., and Reimnitz, Erk, eds., 1990, Bottom sediment along oil spill trajectory in Prince William Sound and along Kenai Peninsula, Alaska: U.S. Geological Survey Open-File Report 90-39, 102 p.
- Carter, L.M.H., 1992, USGS research on energy resources, 1992: U.S. Geological Survey Circular 1074, 89 p.
- Chenowith, W.L., 1991, State of the U.S. uranium industry in 1990 in Nuclear Minerals Committee Report: American Association of Petroleum Geologists, Energy Minerals Division News letter, v. 3, no. 1, p. 4-5.
- Clough, N.K., Patton, P.C., and Christiansen, A.C., eds., 1987, Arctic National Wildlife Refuge, Alaska, coastal plain resource assessment—Report and recommendation to the Congress of the United States and final legislative environmental impact statement: Washington, DC, U.S. Fish and Wildlife Service, U.S. Geological Survey, and Bureau of Land Management, 2 v., 208 p.
- Clough, J.G., Robinson, M.S., Decker, J., and O'Sullivan, P.B., 1990, Bedrock geology of the Sadlerochit and Shublik Mountains and apatite fission-track thermal history of Permian to Tertiary sedimentary rocks in the Arctic National Wildlife Refuge, northeastern Alaska, in Hunt, M.C., Doenges, S., and Stubbs, G.S. eds., *Second Symposium on Studies Related to Continental Margins—A summary of year-three and year-four activities*: Bureau of Economic Geology, University of Texas at Austin, May 21-23, 1989, sponsored by the Minerals Management Service and the Continental Margins Committee of the Association of American State Geologists, Proceedings, p. 18-24.
- Coal News [published weekly by National Coal Association, 1130 17th Street N.W., Washington, DC 20036].
- Cooke, L.W., 1991, Estimates of undiscovered, economically recoverable oil and gas resources for the Outer Continental Shelf, revised as of January 1990: Minerals Management Service OCS Report MMS 91-0051, 30 p.
- Dickinson, K.A., and Skipp, G.L., 1992, Clay mineral depositional facies and uranium resource potential in part of the Tertiary Kenai Group, Kenai Peninsula, Alaska, in Bradley, D.C. and Ford, A.B., eds., *Geologic studies in Alaska by the U.S. Geological Survey, 1990*: U.S. Geological Survey Bulletin 1999, p. 81-99.
- Fairbanks Daily News-Miner [published 6 days a week by the Fairbanks Publishing Company, 200 North Cushman, Fairbanks, AK 99701].
- Finley, P.D., and Krason, J., 1988, Basin analysis, formation, and stability of gas hydrates in the Beaufort Sea: v. 12 of *Geological evolution and analysis of confirmed or suspected gas hydrate localities*: Department of Energy/Morgantown Energy Technology Center, DOE/MC/21181-1950, 227 p.
- Finley, P.D., and Krason, J., 1989, Evaluation of geological relationships to gas hydrate formation and stability: Summary Report, v. 15 of *Geological evolution and analysis of confirmed or suspected gas hydrate localities*: Department of Energy/Morgantown Energy Technology Center, DOE/MC/21181-1950, 111 p.
- Flores, R.M., and Stricker, G.D., 1992, Some facies aspects of upper part of the Kenai Group, southern Kenai Peninsula, Alaska, in Bradley, D.C., and Dusel-Bacon, Cynthia, eds., *Geologic studies in Alaska by the U.S. Geological Survey, 1991*: U.S. Geological Survey Bulletin 2041 [in press].
- Frost, T.P., and Box, S.E., 1991a, Lithologic and tectonic controls on mercury mineralization in the Bethel 1°x3° quadrangle, southwestern Alaska, in Good, E.E., Slack, J.F., and Kotra, R.K., eds., *USGS research on mineral resources—1991: Program and abstracts*: U.S. Geological Survey Circular, 1062, p. 29-31.
- 1991b, Depth controls on magmatism-related gold and mercury mineralization, Bethel quadrangle, southwestern Alaska [abs.]: *Geological Society of America Abstracts with Programs*, v. 23, p. 27.
- Good, E.E., Slack, J.F., and Kotra, R.K., eds., 1991, *USGS research on mineral resources—1991: Program and abstracts*: U.S. Geological Survey Circular 1062, 99 p.
- Howell, D.G., Bird, K.J., Lu, H., and Johnsson, M.J., 1992a, Tectonics and petroleum potential of the Brooks Range fold and thrust belt—A progress report, in Bradley, D.C., and Ford, A.B., eds., *Geologic Studies in Alaska by the U.S. Geological Survey, 1990*: U.S. Geological Survey Bulletin 1999, p. 112-126.
- Howell, D.G., Fehri, N., and Bird, K.J., 1991a, Thin- versus thick-skinned thrusting in the central Brooks Range orogen, Alaska—Constraints based on surface geology [abs.]: *Eos, Transactions of the American Geophysical Union*, v. 72, no. 44, p. 295.
- Howell, D.G., Johnsson, M.J., and Bird, K.J., 1991b, Solid bitumen at Atigun Gorge, central Brooks Range front—Implications for oil exploration in the North Slope fold and thrust belt [abs.]: *American Association of Petroleum Geologists Bulletin*, v. 75, p. 598.
- Howell, D.G., Johnsson, M.J., Underwood, M.B., Lu, H., and Hillhouse, J.W., 1992b, Tectonic evolution of the Kandik region, east-central Alaska—Preliminary interpretations, in Bradley, D.C., and Ford, A.B., eds., *Geologic studies in Alaska by the U.S. Geological Survey, 1990*: U.S. Geological Survey Bulletin 1999, p. 127-140.
- Johnsson, M.J., Bird, K.J., Howell, D.G., Magoon, L.B., Stanley, R.G., Valin, Z.C., Harris, A.G., and Pawlewicz, M.J., 1991a, Preliminary map showing thermal maturity of sedimentary rocks in Alaska [abs.]: *American Association of Petroleum Geologists Bulletin*, v. 75, no. 3, p. 603.
- Johnsson, M.J., Howell, D.G., and Bird, K.J., 1991b, Use of vitrinite reflectance to constrain regional structural patterns—An example from the North Slope of Alaska [abs.]: *Eos, Transactions of the American Geophysical Union*, v. 72, no. 44, p. 549-550.
- Kirschner, C.E., 1988, Map showing sedimentary basins of onshore and continental shelf areas, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1873, 1 sheet, scale 1:2,500,000.
- Krason, J., and Ciesnik, M., 1987, Basin analysis, formation,

- and stability of gas hydrates of the Aleutian Trench and the Bering Sea, v. 10 of *Geological evolution and analysis of confirmed or suspected gas hydrate localities*: Department of Energy/Morgantown Energy Technology Center, DOE/MC/21181-1950, 152 p.
- Krason, J., and Finley, P., 1989, Basin analysis, formation, and stability of gas hydrates in the Beaufort Sea, v. 12 of *Geological evolution and analysis of confirmed or suspected gas hydrate localities*: Department of Energy/Morgantown Energy Technology Center, DOE/MC/21181-1950, 227 p.
- Leonard, K.R., and Huber, D.F., 1987, Status of Alaska Mineral Resources Data System, in Hamilton, T.D., and Galloway, J.P., eds., *Geologic studies in Alaska by the U.S. Geological Survey during 1986*: U.S. Geological Survey Circular 998, p. 15-18.
- Maas, K.M., 1991, Land ownership and the regulatory framework for oil, gas, and coal leasing in Alaska: U.S. Bureau of Mines Open-File Report 41-91, 22 p.
- Mast, R.F., Dolton, G.L., Crovelli, R.A., Root, D.H., and Attanasi, E.D., U.S. Geological Survey; Martin, P.E., Cooke, L.W., Carpenter, G.B., Pecora, W.C., and Rose, M.B., Minerals Management Service, 1989, Estimates of undiscovered conventional oil and gas resources in the United States—A part of the Nation's energy endowment: U.S. Department of the Interior, 44 p.
- Minerals Management Service, 1990, Alaska regional studies plan (Final, FY 1991-1992): U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska, 141 p.
- Mining Journal [published weekly by The Mining Journal Limited, P.O. Box 10, Edenbridge, Kent TN8 5NE, England].
- Mining Magazine [published monthly by The Mining Journal Limited, P.O. Box 10, Edenbridge, Kent TN8 5NE, England].
- Morgantown Energy Technology Center, 1987, Gas hydrates technology status report: DOE/METC-87/0246 (NTIS/DE87001027), 25 p.
- Newberry, R.J., and Brew, D.A., 1991, Stratabound sulfide deposits of uncertain origins in metamorphic rocks vs. black box data: 3 Alaskan examples [abs.]: Alaska Miners Association Conference Juneau 1991, Juneau, Alaska, April 17-19, 1991, Abstracts of Professional Papers, p. 10-11.
- Nokleberg, W.J., Patton, W.W., Jr., and Hearn, P.P., 1991, The Soviet Far East and Alaska: United States Geological Survey Yearbook Fiscal Year 1990, p. 72-73.
- Northern Miner [published weekly by Northern Miner Press Limited, 7 Labatt Avenue, Toronto, ON M5A 3P2, Canada].
- Odel, R.D., 1992, North American uranium activity: Rocky Mountain Scout, Casper, Wyoming, R.D. 24 p.
- Oil and Gas Journal, 1992, Newsletter: Oil and Gas Journal, v. 90, no. 1, p. 2-3.
- O'Sullivan, P.B., 1988, Apatite fission-track study of the thermal history of Permian to Tertiary sedimentary rocks in the Arctic National Wildlife Refuge, northeastern Alaska: Alaska Division of Geological and Geophysical Surveys Public-Data File 88-42, 184 p.
- O'Sullivan, P.B., Decker J.E., and Bergman, S.C., 1989, Apatite fission-track study of the thermal history of Permian to Tertiary sedimentary rocks in the Arctic National Wildlife Refuge, northeastern Alaska [abs.]: Geological Society of America Abstracts with Programs, v. 21, p. 126.
- Pool, T.C., 1991, Uranium: Engineering and Mining Journal, v. 192, no. 3, p.57-60.
- Rapp, J.B., Hostettler, F.D., and Kvenvolden, K.A., 1990, Comparison of Exxon Valdez oil with extractable material from deep-water bottom sediment in Prince William Sound and the Gulf of Alaska: U.S. Geological Survey Open-File Report 90-39-B, 26 p.
- Sherman, G.E., 1990, Mining Claims Information System—A database retrieval program for active mining claims in Alaska: U.S. Bureau of Mines Open-File Report 50-90, 7 p.
- Smith, B.S., and Barnett, R.J., eds., 1990, Russian America: The forgotten frontier. Washington D.C., Historical Society, 256 p.
- Snyder-Conn, Elaine, Densmore, D., Moitoret, C., and Stroebel, J., 1990, Persistence of trace metals in shallow Arctic marine sediments contaminated by drilling effluents: Oil & Chemical Pollution, v. 7, p. 225-247.
- Stricker, G.D., 1991, Economic Alaskan coal deposits, in Gluskoter, H.J., Rice, D.D., and Taylor, R.B., eds., *Economic geology—U.S.*: Geological Society of America, *Geology of North America*, p. 591-602.
- Stricker, G.D., McHugh, J.B., Tripp, R.B., Affolter, R.H., and Cathrall, J.B., 1992, Gold in the Usibelli Group coals, Nenana Coal Field, Alaska, in Bradley, D.C., and Dusel-Bacon, Cynthia, eds., *Geologic studies in Alaska by the U.S. Geological Survey, 1991*: U.S. Geological Survey Bulletin 2041 (in press).
- U.S. Bureau of Land Management, 1991, Overview of the 1991 Arctic National Wildlife Refuge recoverable petroleum resource update: Department of the Interior, Administrative Report.
- U.S. Fish and Wildlife Service, 1991, Marine mammals—Incidental take during specified activities: Federal Register, v. 56, no. 115, p. 27443-27465.
- White, E.R., 1992, Reports about Alaska in non-USGS publications released in 1990 that include USGS authors, in Bradley, D.C., and Ford, A.B., eds., *Geologic studies in Alaska by the U.S. Geological Survey, 1990*: U.S. Geological Survey Bulletin 1999, p. 236-242.
- 1992, U.S. Geological Survey reports on Alaska released in 1990, in Bradley, D.C., and Ford, A.B., eds., *Geologic studies in Alaska by the U.S. Geological Survey, 1990*: U.S. Geological Survey Bulletin 1999, p. 231-235.
- Yeend, Warren, 1991, Gold placers of the Circle District, Alaska: U.S. Geological Survey Bulletin 1943, 42 p.

APPENDIX I.—ALASKA MINERAL REPORTS RELEASED DURING 1991 AND EARLY 1992

The following selected publications contain pertinent information about energy resources and other minerals in Alaska released during 1991 or early 1992; these are in addition to the reports listed in the section entitled "References Cited." This listing is only a selection of relevant reports from the publications of any agency. Reports by Federal or State agencies can generally be obtained from the agency offices in Alaska, or are available at the Alaska Resources Library, Federal Building, 701 C Street, Anchorage, AK 99513-7599.

The USGS publishes a monthly listing of its own releases, "New Publications of the U.S. Geological Survey," available free from the U.S. Geological Survey, 582 National Center, Reston, VA 22092. These listings are also compiled into an annual volume, "Publications of the U.S. Geological Survey, 1991." Information about the prices and sources of listed reports is given in these two publications and is also available from the USGS Earth Science Information Centers.

The USBM's central distribution office is the Branch of Production and Distribution, 4800 Forbes Avenue, Pittsburgh, PA 15213. Many USBM reports are available from the U.S. Government Printing Office in Washington, D.C., or from the National Technical Information Service (NTIS) in Springfield, VA 22161. USBM reports listed here are available from the USBM library in Juneau; for further information, contact the Chief, Alaska Field Operations Center, 3301 C Street, Suite 525, Anchorage, AK 99503.

MMS publications may also be purchased from NTIS, which issues listings of all available MMS volumes. A limited number of complimentary reports are available at the MMS Library/Public Information Room, Alaska OCS Region, Minerals Management Service, 949 East 36th Avenue, Room 110, Anchorage, AK 99508-4302; phone (907) 271-6439.

Department of the Interior

U.S. Geological Survey

- Barnes, D.F., and Kelley, J.S., 1991, Applications of gravity data to studies of framework geology, evaluation of mineral deposits, and mineral prospecting in northwestern Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p.3-4.
- Barnes, D.F., Nokleberg, W.J., and Brocher, T.M., 1991, Gravitational and seismic evidence for Tertiary structural basins in the Alaska Range and Tanana Lowland [abs.]: Geological Society of America Abstracts with Programs, v. 23, p. 5.
- Beaudoin, B.C., Fuis, G.S., Mooney, W.D., Nokleberg, W.J., Lutter, W.J., and Christensen, N.I., 1991, Thin, low-velocity crust beneath the Yukon-Tanana terrane, east-central Alaska [abs.]: Geological Society of America Abstracts with Programs, v. 23, p. 5.
- Bird, K.J., 1991, Geology, play descriptions, and petroleum resources of the Alaskan North Slope (Petroleum Provinces 58-60): U.S. Geological Survey Open-File Report 88-450Y, 52 p.
- Bird, K.J., 1991, North Slope of Alaska, in Gluskoter, H.J., Rice, D.D., and Taylor, R.B., eds., Economic geology, U.S.: Geological Society of America, Geology of North America, v. P-2, p. 447-462.
- 1991, The Ellesmerian petroleum system—North Slope of Alaska [abs.]: American Association of Petroleum Geologists Bulletin, v. 75, no. 3, p. 542.
- Bird, K.J., and Molenaar, C.M., 1992, The North Slope foreland basin, Alaska, in MacQueen, R., and Leckie, D.A., eds., Foreland basins and foldbelts: American Association of Petroleum Geologists Memoir [in press].
- Brew, D.A., 1991, U.S. Geological Survey bedrock geologic studies in Glacier Bay National Park and Preserve, southeastern Alaska [abs.]: U.S. National Park Service—Glacier Bay National Park and Preserve Science Superintendents Annual Research Report for 1990, USNPS/GBNPP, Gustavus, Alaska, p. 27-28.
- Brew, D.A., 1991, Geology, tectonics, and metallogeny of southeastern Alaska and adjacent parts of the Pacific Ocean rim [abs.]: Geological Society of America Abstracts with Programs, v. 23, no. 5, p. A218.
- Brew, D.A., Drew, L.J., Schmidt, J.M., Root, D.H., and Huber, D.F., 1991, Assessment of undiscovered mineral resources, Tongass National Forest, southeastern Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p. 6.
- Brew, D.A., Drew, L.J., Schmidt, J.M., Root, D.H., and Huber, D.F., 1991, Undiscovered locatable mineral resources of the Tongass National Forest and adjacent areas, southeastern Alaska: U.S. Geological Survey Open-File Report 91-10, 73 p., 14 tables, 15 maps at 1:250,000, 1 map at 1:500,000, 11 figs.
- Brew, D.A., Drew, L.J., Schmidt, J.M., Root, D.H., and Huber, D.F., 1991, Undiscovered locatable mineral resources of the Tongass National Forest and adjacent areas, southeastern Alaska [abs.]: Alaska Miners Association Conference, Juneau, Alaska, April 17-19, 1991, Abstracts of Professional Papers, p. 45-46.
- Briggs, P.H., Motooka, J.M., Bailey, E.A., Cieutat, B.A., Burner, S.A., Kelley, K.D., and Ficklin, W.H., 1992, Analytical results of soil, stream sediment, panned concentrate, and water samples from the Lik deposit, northwestern Brooks Range, Alaska: U.S. Geological Survey Open-File Report 92-15-A, 53 p. (paper version); 92-15-B (diskette version).
- Brocher, T.M., Fisher, M.A., Luzitano, Robert, Fuis, G.S., and Nokleberg, W.J., 1991, Crustal structure and evolution of the Alaska Range, Alaska [abs.]: Geological Society of America Abstracts with Programs, v. 23, p.8.
- Brocher T.M., Nokleberg, W.J., Christensen, N.I., Fisher, M.A., and Geist, E.L., 1991, Seismic reflection/refraction mapping of the faulting and regional dips in the eastern Alaska Range: Journal of Geophysical Research, v. 96, p. 10,233-10,249.
- Cathral, J.B. and Antweiler, J.E., 1992, Occurrence of platinum-group elements in some gold-mining districts of Alaska, in Bradley, D.C., and Ford, A.B., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1990: U.S. Geological Survey Bulletin 1999, p. 33-43.

- Cathral, J.B., Carlson, R.R., A\$ntweiler, J.C., and Mosier, E.L. 1991, Platinum group elements in native gold, alluvium concentrates, and mineralized rock concentrates from some gold mining districts of Alaska: U.S. Geological Survey Open-File Report 91-348, 36 p., 1 sheet.
- Coel, R.J., Crock, J.G., and Kyle, J.R., 1991, Biogeochemical studies of gold in a placer deposit, Livengood, Alaska: U.S. Geological Survey Open-File Report 91-142, 51 p.
- Crowe, D.E., Shanks III, W.C., and Valley, J.W., 1991, Laser-microprobe studies of sulfur isotopes in stockwork and massive sulfide ores, Rua Cove mine, south-central Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p. 13-14.
- Dusel-Bacon, Cynthia, 1991, Metamorphic history of Alaska: U.S. Geological Survey Open-File Report 91-556, 48 p., 3 figs., 2 tables, 2 sheets (1:2,500,000-scale map).
- Dusel-Bacon, Cynthia, Brew, D.A., and Douglas, S.L., 1991, Metamorphic facies map of southeastern Alaska—Distribution, facies, and ages of regionally metamorphosed rocks: U.S. Geological Survey Open-File Report 91-29, 47 p., 4 figs., 2 tables, 2 sheets (including 1:1,000,000-scale map).
- Frost, G.M., and Stanley, R.G., 1991, Preliminary geologic and Bouguer gravity map of the Nenana basin area, central Alaska [abs.]: Geological Society of America Abstracts with Programs, v. 23, no. 2, p. 26.
- 1991, Compiled geologic and Bouguer gravity map of the Nenana basin area, central Alaska: U.S. Geological Survey Open-File Report 91-562, 30 p., 2 sheets, scale 1:250,000.
- Goldfarb, R.J., Bailey, E.A., Folger, P.F., and Schmidt, J.M., 1991, The use of heavy-mineral concentrate data to show geochemical favorability for zinc-lead-silver and copper-(cobalt) mineral occurrences in the Baird Mountains quadrangle, northwest Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-2151, scale 1:250,000, 1 sheet.
- Goldfarb, R.J., Newberry, R.J., Pickthorn, W.J., and Gent, C.A., 1991, Oxygen, hydrogen, and sulfur isotope studies in the Juneau Gold Belt, southeastern Alaska: Constraints on the origin of hydrothermal fluids: *Economic Geology*, v. 86, no. 1, p. 66-80.
- Goldfarb, R.J., and Pickthorn, W.J., 1991, Synorogenic auriferous fluids of the Juneau Gold Belt, southeast Alaska—Stable-isotope evidence for a deep crustal origin [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p. 32-33.
- Goldfarb, R.J., Snee, L.W., Miller, L.D., and Newberry, R.J., 1991, Timing of gold deposition within the Juneau Gold Belt [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 25-26.
- Grantz, A., and Moore, T.E., Crustal model of northern Alaska from the Brooks Range to the Arctic Ocean Basin [abs.]: Geological Society of America Abstracts with Programs, v. 23, no. 2, p. 30.
- Gray, J.E., Goldfarb, R.J., Detra, D.E., and Slaughter, K.E., 1991, Geochemistry and exploration criteria for epithermal cinnabar and stibnite vein deposits in the Kuskokwim River region, southwestern Alaska: *Journal of Geochemical Exploration*, v. 41, no. 3, p. 363-386.
- Grybeck, D.J., 1991, Tapping the potential mineral resources of Alaska, in United States Geological Survey Yearbook, Fiscal Year 1990, p. 45-47.
- Grybeck, D.J., Nokleberg, W.J., and Bundtzen, T.K., 1991, Comparative metallogeny of the Soviet Far East and Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p. 36.
- Hopkins, D.M., Gray, J.E., and Slaughter, K.E., 1991, Low-level gold determinations by use of flow injection analysis-atomic absorption spectrophotometry—An application to precious-metal-resource assessment in the Iditarod 1° X 3° quadrangle, southwestern Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U. S. Geological Survey Circular 1062, p. 39.
- Hopkins, D.M., Gray, J.E., Hageman, P.L., McDougal, C.M., and Slaughter, K.E., 1991, Gold, mercury, tellurium, and thallium data and sample locality map of stream-sediment samples from the Iditarod quadrangle, Alaska: U.S. Geological Survey Open-File Report 91-283-A, 37 p., 1 sheet, scale 1:250,000 (paper version); 91-283-B (diskette version).
- Horton, R.J., Karl, S.M., Griscom, Andrew, Taylor, C.D., and Bond, K.R., 1991, Annette Islands Reserve Mineral Assessment Project, southeast Alaska, in Manydeeds, S.A., and Smith, B.D., eds., Mineral frontiers on Indian lands, Annual Northwest Mining Convention, 97th, Spokane, Wash.: U.S. Bureau of Indian Affairs, Division of Energy and Mineral Resources, p. 22-31.
- Howell, D.G., and Bird, K.J., 1991, How continental collisions produce major hydrocarbon accumulations [abs.]: *Comunicaciones Departamento de Geologia Universidad de Chile, Santiago*, no. 42, p. 96-98.
- Karl, S.M., 1991, Regional geology of the Chichagof Mining District, southeastern Alaska [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 12-13.
- Karl, S.M., Goldfarb, R.J., Kelley, K.D., Sulphin, D.M., Finn, C.A., Ford, A.B., and Brew, D.A., 1991, Mineral resource potential of the Sitka 1°x3° quadrangle, southeastern Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p. 45-46.
- Kilburn, J.E., Box, S.E., Goldfarb, R.J., and Gray, J.E., 1992, Geochemically anomalous areas in the eastern Goodnews Bay 1° by 3° quadrangle, southwest Alaska, in Bradley, D.C., and Ford, A.B., eds., *Geologic studies in Alaska by the U.S. Geological Survey, 1990: U.S. Geological Survey Bulletin 1999*, p. 156-162.
- Kilburn, J.E., Box, S.E., Goldfarb, R.J., Gray, J.E., and Jones, J.L., 1991, Mineral-resource assessment of the Goodnews 1° x 3° quadrangle and parts of the Hagemester Island and Nushagak Bay quadrangles, southwestern Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS re-

- search on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p. 46.
- Lange, I.M., Nokleberg, W.J., and Newkirk, S.R., 1991, Primary and secondary textures in multiply deformed and metamorphosed Devonian age massive sulfide deposits, Yukon-Tanana terrane, Alaska [abs.]: Geological Society of America Abstracts with Programs, v. 23, p. 40.
- Light, T.D., Brew, D.A., and Ashley, R.P., 1989, The Alaska-Juneau and Treadwell lode gold systems, southeastern Alaska: U.S. Geological Survey Bulletin 1857, p. D27-D36.
- Light, T.D., Lee, G.K., and Moll, S.H., 1991, Reconnaissance guidelines for gold exploration in central Alaska [abs.]: 15th International Geochemical Exploration Symposium, Reno, Nevada, April 29–May 1, 1991, Abstracts with programs, p. 36.
- Madden-McGuire, D.J., and Winkler, G.R., 1991, Areas of mineral-resource favorability (with emphasis on gold and chromite) in the Anchorage 1° x 3° quadrangle, southern Alaska [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p. 50-51.
- McLean, Hugh, and Stanley, R.G., 1992, Reconnaissance sandstone petrology and provenance of the Cantwell Formation, central Alaska, in Bradley, D.C., and Ford, A.B., eds., Geologic Studies in Alaska by the U.S. Geological Survey, 1990: U.S. Geological Survey Bulletin 1999, p. 170-179.
- Moll, S.H., Light, T.E., and Bie, S.W., 1991, Digital methods for lode gold exploration in Central Alaska [abs.]: Geological Society of America Abstracts with programs, v. 23, no. 5, p. 414.
- Moore, T.E., Nokleberg, W.J., Jones, D.L., Till, A.B., and Wallace, W.K., 1991, Contrasting structural levels of the Brooks Range orogen along the Trans-Alaska Crustal Transect (TACT) [abs.]: Eos, Transactions of the American Geophysical Union, v. 72, p. 295.
- Nokleberg, W.J., Poster, H.L., Lanphere, M.A., Aleinikoff, J.N., and Pavlis, T.L., 1991a, Structure and tectonics of the Yukon-Tanana, Wickersham, Seventymile, and Stikinia terranes along the Trans-Alaska Crustal Transect (TACT), east-central Alaska [abs.]: Geological Society of America Abstracts with programs, v.23, p. 84.
- Nokleberg, W.J., Lange, I.M., Roback, R.C., Yeend, Warren, and Silva, S.R., 1991b, Metalliferous lode and placer mineral occurrences, mineral deposits, prospects, and mines, Mount Hayes quadrangle, eastern Alaska Range, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1996-C, 1 sheet, scale 1:250,000, 42 p.
- Riehle, J.R., Church, S.E., and Magoon, L.B., 1991, Resource assessment of the Mount Katmai 1° x 2° quadrangle and adjacent parts of the Naknek and Afognak quadrangles, Alaska Peninsula [abs.], in Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS research on mineral resources—1991: Program and abstracts: U.S. Geological Survey Circular 1062, p.65-66.
- Roberts, S.B., 1991, Subsurface cross-section showing coal beds in the Sagavanirktok Formation, vicinity of Prudhoe Bay, east-central North Slope, Alaska: U.S. Geological Survey Coal Investigations Map C-139-A, 1 sheet.
- Roberts, S.B., Stricker, G.D., and Affolter, R.H., 1991, Stratigraphy and chemical analysis of coal beds in the Upper Cretaceous and Tertiary Sagavanirktok Formation, east-central North Slope, Alaska: U.S. Geological Survey Coal Investigations Map C-139-B, 1 sheet.
- Stanley, R.G., Flores, R.M., and Wiley, T.J., 1992, Fluvial facies architecture in the Tertiary Usibelli Group of Suntrana, central Alaska, in Bradley, D.C., and Ford, A.B., eds., Geologic Studies in Alaska by the U.S. Geological Survey, 1990: U.S. Geological Survey Bulletin 1999, p. 204-211.
- Stanley, W.D., Nokleberg, W.J., and Labson, V.F., 1991, Flysch belts and collisional processes: East-central Alaska and Alpine-Carpathian regions [abs.]: Geological Society of America Abstracts with Programs v. 23, p. 100.
- Tripp, R.B., and Madden, D.J., 1991, Mineralogical maps showing distribution of ore-related minerals in the non-magnetic, heavy-mineral-concentrate fraction of stream sediment from the Anchorage 1° x 3° quadrangle, southern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1975, 1 sheet, scale 1:250,000.
- Valin, Z.C., Bader, J.W., Barnes, D.F., Fisher, M.A., and Stanley, R.G., 1991, Simple Bouguer gravity anomaly maps of the Nenana basin area, Alaska: U.S. Geological Survey Open-File Report 91-33, 4 sheets at 1:250,000 scale, 1 sheet at 1:500,000 scale.
- Yeend, Warren, 1992, Gold placer, gold source, and high terrace gravels in the Fortymile River area, Alaska, in Bradley, D.C., and Ford, A.B., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1990: U.S. Geological Survey Bulletin 1999, p. 228-230.

U.S. Bureau of Mines

- Balen, M.D., 1991, Executive summary of the Bureau of Mines investigations in Valdez Creek Mining District, Alaska: U.S. Bureau of Mines Special Publication, 43 p.
- Barker, J.C., 1991, Investigation of rare-earth and associated elements, Zane Hills pluton, northwestern Alaska: U.S. Bureau of Mines Open-File Report 36-91, 33 p.
- Burleigh, R.E., 1991, Evaluation of the tin-tungsten griesen mineralization and associated granite at Sleiat Mountain, southwestern Alaska: U.S. Bureau of Mines Open-File Report 35-91, 41 p.
- Johnson, J.L., and Parker, T., 1991, Tin and silver recovery from Coal Creek, Alaska: U.S. Bureau of Mines Report of Investigation 9356, 21 p.
- Maas, K.M., 1991, Bureau of Mines mineral investigations in the Ketchikan Mining District, Alaska 1990-91 [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 49-50.
- Maas, K.M., Still, J.C., Clough, A.H., and Oliver, L.K., 1991, Mineral investigations in the Ketchikan Mining District, Alaska, 1990—Southern Prince of Wales Island and vicinity: U.S. Bureau of Mines Open-File Report 33-91, 139 p.
- U.S. Bureau of Mines, 1991, State mineral summaries 1991: U.S. Bureau of Mines, 147 p.
- U.S. Bureau of Mines, 1991, Bureau of Mines mineral investigations in the Juneau Mining District, Alaska: 1984–1988, v. 1, Executive summary: U.S. Bureau of Mines Special Publication SP1-91, 49 p.

U.S. Bureau of Mines, 1991, U.S. Bureau of Mines Research '91—A summary of significant results and economics in mineral technology: U.S. Bureau of Mines, 160 p.

Minerals Management Service

OCS Reports and Maps are authored by the MMS professional staff. OCS Studies are generally contractually prepared environmental, socioeconomic, and technological studies.

- Meyer, B., 1991, Assessing the risk to Pacific Herring from offshore gas and oil development in the southeastern Bering Sea: Lowell Wakefield Fisheries Symposium, Proceedings of the International Herring Symposium, Anchorage, Alaska, October 23-25, 1990, Alaska Sea Grant Program Report No. 91-01.
- Miller, G.W., Davis, R.A., and Richardson, J.W., 1991, Behavior of bowhead whales of the Davis Strait and Bering/Beaufort stocks vs. regional differences in human activities: Minerals Management Service OCS Study MMS 91-0029.
- Monkeliën, K., and Conner-Hite, T., 1991, Regulatory processes for mining on the outer continental shelf [abs.], in SPE International Arctic Technology Conference, Anchorage, Alaska, May 29-31, 1991, Proceedings, p. 247.
- Moore, S.E., and Clarke, J.T., 1991, Aerial surveys of endangered whales in the Alaskan Chukchi and western Beaufort Seas, 1990: Minerals Management Service OCS Study MMS 91-0017.
- Risley, D.E., and Steffy, D.A., 1991, Structural geology and tectonics along the US-USSR border, Pt. I: Navarin Basin to the Bering Strait [abs.]: Geological Society of America Abstracts with programs, v. 23, no. 5, p. 93.
- Steffy, David, 1991, Abnormal formation pressures in the Navarin Basin, Bering Sea, Alaska: Minerals Management Service OCS Report MMS 91-0034.
- Steffy, D.A., and Risley, D.E., 1991, Sedimentary basins and petroleum potential along the US-USSR border, Part I: Navarin Basin to the Bering Strait [abs.], in 1991 SEPM First Annual Theme Meeting, Continental Margins, Portland, Oregon, August 15-18, 1991, Proceedings, p. 33.
- Thurston, D.K., and Lothamer, R.T., 1991, Seismic evidence of evaporite diapirs in the Chukchi Sea, Alaska: *Geology*, v. 19, p. 477-480.
- Thurston, D.K., and Theiss, L.A., 1991, Identification of wrench faults using subsurface structural data: Criteria and pitfalls, DISCUSSION: American Association of Petroleum Geologists Bulletin, v. 75, no. 11, 1991, p. 1770-1781.
- Thurston, D.K., and Zerwick, S.A., 1991, Sedimentary basins and petroleum potential along the US-USSR border, Part II: Bering Strait to the Chukchi Sea [abs.], in 1991 SEPM First Annual Theme Meeting, Continental Margins, Portland, Oregon, August 15-18, 1991, Proceedings, p. 34.
- Treacy, S.D., 1991, Aerial surveys of endangered whales in the Beaufort Sea, Fall 1990: Minerals Management Service OCS Study MMS 91-0055.
- U.S. Department of Commerce and U.S. Department of Interior, 1991, OCSEAP final reports of principal investigators, NOAA/OCSEAP, v. 73: Minerals Management Service OCS Study MMS 91-0035.

U.S. Department of the Interior, Minerals Management Service, 1991, Oil spill response capabilities for North Aleutian Basin Sale 92.

U.S. Fish and Wildlife Service, 1991, Monitoring of populations and productivity of seabirds at St. George Island, Cape Pierce, and Bluff, Alaska, 1989: Minerals Management Service OCS Study MMS 90-0049.

Zerwick, S.A., and Thurston, D.K., 1991, Structural geology and tectonics along the US-USSR border, Pt. II: Bering Strait to the Chukchi Sea [abs.]: Geological Society of America Abstracts with programs, v. 23, no. 5, p. 112.

Bureau of Land Management

- Banet, A.C., Jr., 1991, Oil and gas development on Alaska's North Slope—Past results and future prospects: U.S. Bureau of Land Management, Alaska Open-File Report 34, 42 p.
- 1991, Geochemistry of biological marker compounds extracted from sediments and oils of the Bulge, northern Alaska and Yukon Territory [abs.]: American Association of Petroleum Geologists Bulletin, v. 75, no. 3, p. 537.
- 1991, Possible hydrocarbon habitat of the Bulge, Alaska and Yukon Territory [abs.]: American Association of Petroleum Geologists Bulletin, v. 75, no. 3, p. 537-538.
- Diel, William, 1992, Leasable mineral resource assessment of the South Central Planning Area, Alaska: U.S. Bureau of Land Management, Alaska Open-File Report 35 [in press].
- Mowatt, T.C., 1991, Platinum and palladium in mafic-ultramafic igneous rocks, northwestern Alaska: U.S. Bureau of Land Management, Open-File Report 37, 21 p.
- Mowatt, T.C., and Banet, A., 1991, Reservoir quality studies, Arctic National Wildlife Refuge, Alaska [abs.]: American Association of Petroleum Geologists Bulletin, v. 75, no. 3, p. 641-642.
- Mowatt, T.C., and Dygas, J., 1991, Petrographic survey and appraisal of reservoir quality and potential, National Petroleum Reserve—Alaska: U.S. Bureau of Land Management, Alaska Open-File Report 36, 22 p.
- Mowatt, T.C., Dygas, J., and Gibson, C., 1991, The Red Dog deposit, northwestern Alaska—Discovery, delineation, and development implications: U.S. Bureau of Land Management, Open-File Report 38, 15 p.
- Mowatt, T.C., Dygas, J., Gibson, C., and Seidlitz, A., 1991, Mineral resources of western Arctic Alaska: U.S. Bureau of Land Management, Open-File Report 39, 27 p.
- Mowatt, T.C., Gibson, C., Seidlitz, A., Basche, R., and Dygas, J., 1991, Petrologic-petrophysical-engineering relationships, selected wells near the Arctic National Wildlife Refuge, Alaska [abs.]: American Association of Petroleum Geologists Bulletin, v. 75, no. 3, p. 642.
- Mowatt, T.C., and Mowatt, J.C., 1991, Diagenetic relationships and reservoir quality implications in Brookian clastic sequences, National Petroleum Reserve, Alaska: U.S. Bureau of Land Management, Open-File Report 40, 40 p.
- Mowatt, T.C., Ogbe, D.O., Kamath, V.A., and Sharma, G.D., 1991, Petrologic-petrophysical relationships, West Sak and Ugnu (Brookian), northern Alaska [abs.]: American Association of Petroleum Geologists Bulletin, v. 75, no. 3, p. 641.

Mowatt, T.C., Seidlitz, A., Gibson, C., Bascle, R., and Dygas, J., 1991, Reservoir quality and potential, National Petroleum Reserve in Alaska [abs.]: American Association of Petroleum Geologists Bulletin, v.75, no. 3, p. 641.

Fish and Wildlife Service

- Bayha, K., and Kormendy, J., eds., 1990, Evaluation of the response effort on behalf of sea otters after the T/V Exxon Valdez oil spill into Prince William Sound: Sea Otter Symposium, Anchorage, Alaska, April 17-19, 1990. Proceedings: U.S. Fish and Wildlife Service Biological Report 90(12), 485 p.
- Jackson, R., 1991, Becharof National Wildlife Refuge contaminants study—Report of findings: Anchorage, Alaska, U.S. Fish and Wildlife Service, Ecological Services, 27 p.
- Trawicki, J.M., Lyons, S.M., and Elliot, G.V., 1991, Distribution and quantification of water within the lakes of the 1002 Area, Arctic National Wildlife Refuge, Alaska: Anchorage, Alaska, U.S. Fish and Wildlife Service Technical Report Number 10, 24 p.
- U.S. Fish and Wildlife Service, 1991, Summary of effects of the Exxon Valdez oil spill on natural resources and archaeological resources: Anchorage, Alaska, U.S. Fish and Wildlife Service Special Report, 19 p.

Department of Energy

- Collett, T.C., 1991, Natural gas hydrates on the North Slope of Alaska: DOE/MC/20422 - 2968 (DE91002054), 32 p.
- Finley, P.D., and Krason, J., 1991, Geological evolution and analysis of confirmed or suspected gas hydrate localities—Evaluation of geological relationships to gas hydrate formation and stability: Summary report: DOE/MC/21181-1950, v. 15, (DE90000452), 11 p.
- Kamath, V.A., Sharma, G.D., and Patil, S.L., 1991, Development of Alaskan gas hydrate resources: Final report and addendum—Experimental study of hydrate decomposition during steam injection: University of Alaska, Fairbanks Alaska, DOE/FE/61114-3031, 473 p..
- Malone, R.O., 1990, Gas hydrates—Technology status report: U.S. Department of Energy DOE/METC - 90/0270 (DE 90015321), 52 p.

Non-Federal Reports

Alaska Division of Geological and Geophysical Surveys

List includes publications by the ADGGS and other publications with ADGGS authors:

- Bundtzen, T.K., and Laird, G.M., 1991, Geology and mineral resources of the Russian Mission C-1 quadrangle, southwest Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 109, 24 p., 2 sheets, scale 1:63,360.

Bundtzen, T.K., Swainbank, R.C., Wood, J.E., and Clough, Albert, 1992, Alaska's mineral industry—1991 summary: Alaska Division of Geological and Geophysical Surveys, Information Circular 35, 11 p.

Clautice, K.H., Bundtzen, T.K., and Liss, S.A., 1991, Preliminary rock geochemistry from the northeastern Craig A-1 quadrangle, Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 91-16, 13 p., 1 sheet, scale 1:40,000.

Fritts, C.E., Eakins, G.R., and Garland, R.E., 1991, Geology and geochemistry near Walker Lake, southern Survey Pass quadrangle, Arctic Alaska (1972): Alaska Division of Geological and Geophysical Surveys Public-Data File 91-7, 9 p.

Ray, S.R., 1991, Hydrologic and water quality investigations related to placer mining in interior Alaska—Summer 1990: Alaska Division of Geological and Geophysical Surveys Public-Data File 91-19, 61 p.

Robinson, M.S., and Decker, J., 1991, Turbidite hosted gold deposits—An exploration model based on facies relationships [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 5-6.

Solie, D.N., Kline, J.T., Gilbert, W.G., Robinson, M.S., Harris, E.E., and Liss, S.A., 1991, Analytical results from rock geochemical samples, Tyonek D-6 and parts of adjacent quadrangles, Alaska: Alaska Division of Geological and Geophysical Surveys Public-Data File 91-1, 14 p., 1 sheet, scale 1:63,360.

Solie, D.N., Reifentstahl, R.R., and Gilbert, W.G., 1991, Preliminary results of geologic and geochemical investigations in the Hyder area, southeast Alaska: Alaska Division of Geological and Geophysical Surveys Public-Data File 91-8, 11 p., 1 sheet, scale 1:40,000.

Swainbank, R.C., Bundtzen, T.K., and Wood, J.E., 1991, Alaska's mineral industry 1990: Alaska Division of Geological and Geophysical Surveys Special Report 45, 78 p.

———1991, Summary of Alaska's mineral industry for 1990: Alaska Division of Geological and Geophysical Surveys Public-Data File 91-6, 9 p.

Wiltse, M.A., 1991, National uranium resource evaluation (NURE) geochemical data for stream- and lake-sediment samples, Alaska (Anchorage, Beaver, Bettles, Big Delta, Candle, Charley River, Circle, Eagle, Gulkana, Healy, Kateel River, Lime Hills, Livengood, Medfra, Melozitna, Mount Hayes, Norton Bay, Nulato, Ruby, Selawik, Talkeetna Mountains, Tanacross, Tanana, Unalakleet, and Valdez Quadrangles): Alaska Division of Geological and Geophysical Surveys Public-Data File 91-22, 33 p. and one 5-1/4" diskette.

Wood, J.E., 1992, Preliminary results of heavy minerals concentrate analysis from selected interior and western Alaska placer mines: Alaska Division of Geological and Geophysical Surveys Public-Data File 92-2, 8 p.

Additional Non-Federal Publications

Bressler, J.R., and Fredericksen, R.S., 1991, Deep drilling at the Treadwell Mine [abs.]: Alaska Miners Association, Juneau

- Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 32-34.
- Brooks, L.D., 1991, ANWR issues revisited: Geophysics: The Leading Edge of Exploration, v. 10, no. 2, p. 35-39.
- California Mining Journal, 1991, Alaska mineral production for last year may top \$500 million: California Mining Journal, v. 60, no. 6, p. 3.
- Crowe, D.E., Milholland, M.A., and Brown, P.E., 1991, Precious and base metal mineralization associated with high-salinity fluids in the Mount Estelle pluton, south-central Alaska: *Economic Geology*, v. 86, no. 5, p. 1103-1109.
- Danielson, Vivian, 1991, Cominco discovers large copper-gold porphyry in Alaska: *Northern Miner*, v. 76, no. 47, p. 1 and 19.
- 1991, Echo Bay develops historic gold producer: *Northern Miner*, v. 77, no. 10, p. 1, 17.
- 1991, High fixed costs make volume key to Greens Creek success: *Northern Miner*, v. 77, no. 12, p. 1, 20.
- 1991, Past may be prologue if A-J Mine revives: *Northern Miner*, v. 77, no. 11, p. 1, 6.
- Fredericksen, R.S., and Miller, L.D., 1991, Update on the A-J project [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 35-36.
- Gehrels, George, and Miller, L.D., 1991, Regional geology of the Juneau Gold Belt [abs.]: Alaska Miners Association, Juneau, Alaska, Abstracts of Professional Papers, p. 23-24.
- Giegerich, H.M., 1991, Unique solutions to problems of arctic mining: *Northern Miner*, v. 77, no. 9, p. 4.
- Harvey, D.B., and Kirkham, R.A., 1991, The Kensington vein gold deposit [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 27-29.
- Hollister, V.F., 1991, Origin of placer gold in the Fairbanks, Alaska, area: A newly proposed lode source: *Economic Geology*, v. 86, no. 2, p. 402-405.
- Kilburn, John, 1991, Exploration in Alaska up by 19%: *Northern Miner*, v. 77, no. 3, p. B3.
- Mardock, C.L., and Barker, J.C., 1991, Theories on the transport and deposition of gold and PGM minerals in offshore placers near Goodnews Bay, Alaska: *Ore Geology Reviews*, v. 6, no. 2/3, p. 211-227.
- Northern Miner, 1991, Canalaska revises Rainbow Hill reserves: *Northern Miner*, v. 77, no. 6, p. 17.
- 1991, Lik zinc prospect in Alaska key part of Moneta's plans: *Northern Miner*, v. 77, no. 6, p. 17.
- 1991, Positive study for Fairbanks on Fort Knox: *Northern Miner*, v. 77, no. 11, p. 6.
- O'Conner, W.K., and Dahlin, D.C., 1991, Ore mineralogy and physical characteristics of the Sheep Creek prospect, north-central Alaska Range: *Ore Geology Reviews*, v. 6, no. 2/3, p. 153-169.
- Oil and Gas Journal, 1991, Chukchi Sea, western gulf lease sales set: *Oil and Gas Journal*, v. 89, no. 15, p. 97.
- Pacific Oil World, 1991, Conoco announces oil discovery on Alaska's North Slope: *Pacific Oil World*, v. 83, no. 9, p. 22.
- Petroleum Information Corporation, 1991, Arco completes Upper Cook Inlet oil discovery: *Alaska Report*, v. 37, no. 44, Sec. 1, Oct. 30, p. 1.
- 1991, Chevron to drill south-central Alaska wildcat: *Alaska Report*, v. 37, no. 21, May 22, Sec. 1, p. 1.
- 1991, Court decision gives state access to ANWR well data: *Alaska Report*, v. 37, no. 48, Sec. 1, Nov. 27, p. 3.
- 1991, Details reported on discovery of Niakuk Field: *Alaska Report*, v. 37, no. 41, Oct. 9, Sec. 1, p. 1-2.
- 1991, GMC receives samples from North Slope wells: *Alaska Report*, v. 37, no. 22, August 14, Sec. 1, p. 2.
- 1991, Production from Prudhoe Bay field reaching economic limit: *Alaska Report*, v. 35, no. 25, June 19, Sec. 1, p. 1.
- 1991, Special report: Annual review, Alaska—1990: *Alaska Report*, v. 37, no. 13, Sec. 1, p. 3-10.
- Piekenbrock, J.R., 1991, An overview of the Jualin project, Berners Bay, Alaska [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 30-31.
- Rogers, R.K., Bradley, L.M., and Bigelow, C.G., 1991, Geology of the Cliff Gold Mine, Valdez, Alaska [abs.]: Alaska Miners Association, Juneau Branch, Conference, Juneau, Alaska, Abstracts of Professional Papers, p. 7.
- Skok, Mark, 1991, Alaska's Red Dog Mine: *Geotimes*, v. 36, no. 11, p. 17-19.
- Walker, Simon, 1991, Greens Creek keeps it clean; operation demonstrates how mining can coexist with environmental care in a wilderness area: *Engineering and Mining Journal*, v. 192, no. 11, p. 20-23.
- Wicks, J.L., Buckingham, M.L., and Dupree, J.H., 1991, Endicott Field—U.S.A., North Slope basin, Alaska, in Foster, N.H., and Beaumont, E.A., compilers, *Structural traps V: American Association of Petroleum Geologists, Treatise of Petroleum Geology, Atlas of Oil and Gas Fields*, p. 1-25.
- Williams, Bob, 1991, Alaska dominates exploration and development activity on U.S. West Coast: *Oil and Gas Journal*, v. 89, no. 14, p. 50-52.

APPENDIX 2.—ROLES OF FEDERAL AGENCIES IN MINERAL PROGRAMS

Department of the Interior

U.S. Geological Survey

The mission of the USGS is to develop and interpret the geologic, topographic, and hydrologic data necessary for prudent management of the Nation's minerals, land, and water. The USGS carries out its mission through research that produces geographic, cartographic, and remotely sensed information; geologic, geochemical, and geophysical maps and studies; energy, mineral, and water resource assessments; geohazards research, including toxic waste studies; and participation in multidisciplinary projects, maintaining data bases, and publishing reports and maps.

In Alaska, the USGS is active in assessing minerals, including metalliferous and energy resources. Field and laboratory researchers also gather information about domestic petroleum, coal, uranium, and geothermal resources. At the request of land-managing agencies, the USGS provides mineral resource assessments for land planning, including wilderness studies. Within Alaska, the USGS maintains offices for its Geologic, National Mapping, and Water Resources Divisions. Within the Geologic Division, the Branch of Alaskan Geology is the primary USGS office studying mineral resources in Alaska; the Branch is headquartered in Anchorage with a field office in Fairbanks. Other Alaska Branch geologists are stationed in Menlo Park, California. During the summer field season, many USGS scientists from other branches within the Geologic Division conduct mineral-related research in Alaska.

U.S. Bureau of Mines

The mission of the USBM is to help ensure that the Nation's mineral supplies are adequate to maintain national security, economic growth, and employment. The USBM's Alaska Field Operations Center (AFOC) has headquarters in Anchorage and offices in Juneau and Fairbanks. The AFOC carries out its mission through five programs:

1. *Minerals availability program.*—This program is part of a worldwide USBM program responsible for developing the Minerals Availability System (MAS) computer data base and the Mineral Industry Location System (MILS), a subset of MAS. MILS contains basic information about the identification and location of known mineral deposits. MAS is more extensive, containing information about reserve estimates, mineral extraction and beneficiation methodologies, environmental constraints to mining, and cost analyses for selected major mineral deposits. A computer and communication system allow the information to be stored, manipulated, and retrieved as computer-plotted map overlays and printouts of MAS/MILS data, enabling rapid and uniform development of cost data for MAS mineral-deposit evaluations. MAS and MILS mineral-deposit data are cross-indexed to several other minerals-information data bases.

2. *Policy analysis.*—This program emphasizes the analysis of newly developed and existing mineral data to interpret their significance in the context of local and national mineral needs.

Assessment of technical, institutional, political, social, and economic factors that affect the supply of, and demand for, domestic and international minerals is the key to identifying mineral issues.

3. *State mineral activities.*—This program covers minerals-related activities in Alaska and assists in developing and releasing nonfuel-mineral-industry information. The program also provides the USBM with direct communication to the ADGGS, the Alaska Division of Mining, other minerals-oriented government agencies, industry, private firms, and individuals. The USBM's State Mineral Officer collects, analyzes, and reports mineral data and develops information regarding activities and trends in the mining industry. This program produces the annual USBM Minerals Yearbook chapters and Mineral Industry Surveys.

4. *Mineral land assessment.*—This is the USBM's major Alaskan program, conducted in cooperation with other Federal and State agencies. Mineral assessments are both areal and commodity-oriented. In support of the Secretary of the Interior's commitment to assess the mineral potential of public lands in Alaska, the AFOC initiated a program in 1985 to evaluate mineral resources of the mining districts in the State. The program seeks to identify the type, amount, and distribution of mineral deposits; related studies will determine their economic feasibility. Legislative effects on mineral development will also be addressed. The USBM has completed its study of the Juneau Mining District; studies of the Ketchikan and Valdez Creek Mining Districts are in progress.

A statewide program provides an inventory and specific technical evaluations of Alaska's strategic and critical mineral and advanced material deposits on Federal lands that are closed to mineral entry, and on lands that are open to entry but not of current interest to industry. In addition to locating, mapping, and estimating the size and grade of deposits, the USBM obtains bulk samples for metallurgic research to determine recovery and extraction methods and costs. These studies are undertaken in cooperation with the USBM Research Centers in Albany, Oregon, and Salt Lake City, Utah. These investigations provide reserve estimates of marginal and submarginal deposits in Alaska and its coastal waters.

5. *Minerals research.*—The USBM is attempting to provide solutions to mining, mineral recovery, and environmental problems in Alaska through a number of research efforts and technology transfer. Several research projects are currently being conducted in Alaska by USBM research centers or at universities sponsored by the USBM's Mineral Institute Program. USBM and university research centers cooperate with the AFOC to solve mineral utilization problems.

Minerals Management Service

The MMS was created in 1982 with a twofold mission: (1) to collect and disburse revenues generated from mineral leases on Federal and Indian lands, and (2) to oversee the orderly development of America's offshore energy and mineral resources while properly safeguarding the environment. The MMS supervises mineral leasing, exploration, development, and production on the OCS. It is responsible for oil rig safety, oil rig pollution control regulations, determination of the envi-

ronmental impact of resource development, and estimation of oil and gas resources. The MMS also has the authority to lease the OCS for ocean mining of hard minerals. At present, revenues from the Alaska OCS are primarily derived from competitive leasing activities; no development or production occurs there at this time. The responsibility of the MMS for onshore Alaskan minerals is limited to the collection of royalties, bonuses, and rents from Federal and certain Native lands.

The MMS holds Synthesis Meetings and Information Transfer Meetings, Regional Technical Working Group Meetings, Coordination Team Meetings, and public hearings on Environmental Impact Statements. To determine public concerns for consideration and inclusion in EIS's, scoping meetings related to specific planning or subject areas are held in the local villages. The public is invited to attend these meetings and can contact the MMS Regional Office for specific subjects, dates, and times.

In Alaska, the MMS is active in assessing the oil and gas potential of offshore basins through the analysis of geophysical and geologic data. This work is integrated into the National Resource Assessment and is a basis for evaluations of the potential monetary worth of individual OCS lease blocks, for appraisals of the resource potential of entire basins, and for the formulation of geologic models of basin development. The MMS conducts specialized studies of geological and geophysical data obtained from Deep Stratigraphic Test (DST) wells and exploratory wells drilled on OCS lands. The results of these studies are published through the MMS OCS Report series or in appropriate scientific journals. The MMS also sponsors resource-oriented geologic studies through the Program for Studies Related to Continental Margins, which funds research by State agencies and affiliated academic institutions.

Bureau of Land Management

The BLM manages Federal onshore mineral resources. The BLM also works cooperatively with the NPS, FWS, and USPS to provide technical evaluation of the mineral-related issues on lands under these agencies' jurisdiction.

Multiple-use resource management decisions concerning all minerals on the 92 million acres of land currently managed by the BLM in Alaska (fig. 1) are made through the Resource Management Planning process. The BLM first identifies the mineral potential of each planning unit. The effects of minerals exploration, development, and production, and land abandonment and rehabilitation are then analyzed in regard to the needs and sensitivities of the other resources present. Mitigation measures are developed and evaluated to reduce or avoid adverse impacts of the anticipated mineral activities. Field monitoring of all phases of mineral activity ensures that no unnecessary or undue degradation occurs. The BLM also provides resource management for retained Federal mineral estates on an additional 100 million acres.

Fish and Wildlife Service

The FWS provides Federal leadership to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of people. In Alaska, the FWS seeks to accomplish this mission through programs that implement provisions of the Endangered Species Act, Marine Mammal Protection Act, Fish and Wildlife Coordination Act, National Wildlife Refuge System Administration Act, ANILCA, Rivers and Harbors Act, Clean Water Act, various migratory-bird laws and treaties, and other statutes.

Under ANILCA, 16 refuges in Alaska (fig. 3) were created or enlarged to conserve fish and wildlife populations and their habitats, as well as other values. Except for valid rights existing at the time of establishment, these refuges are closed to entry and location under mining laws. The refuges are open to entry under leasing laws but are closed to the mining of coal by the Federal Coal Leasing Amendments Act of 1975 and are closed to geothermal resource leasing by the Geothermal Steam Act of 1970. Although many traditional activities have been deemed appropriate for these refuges, other uses, including oil and gas leasing, will be permitted only when such activities are compatible with the purposes for which a specific refuge was established.

National Park Service

In 1916, Congress established the National Park Service and stated that the fundamental purpose of the Nation's parks, monuments, and other reservations was "to conserve the scenery and natural and historical objects and the wildlife therein and to provide for the enjoyment of same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations" (39 Stat. 535). NPS management policies are based on the concept of conservation and preservation while providing for appropriate enjoyment of natural and cultural resources within the park system.

Congress enacted the "Mining in the Parks" Act in 1976, declaring that a continued application of the mining laws of the United States to park units conflicts with the purposes for which the parks were established and that all mining operations in park units "should be conducted so as to prevent or minimize damage to the environment and the other resource values" (90 Stat. 1342). The NPS manages mining activities on park lands through regulations found at Title 36 CFR, Part 9, Subpart A. These regulations apply to mining-related activities on patented or valid unpatented claims located under the Mining Law of 1872, and proposed plans of operations for such claims must conform to the statutes. Regulations at Title 36 CFR, Part 9, Subpart B govern non-Federal mineral development. Pursuant to the permitting and coordination requirements of Title 36 CFR, Part 9, Subpart D, eligible Federal agencies may conduct AMRAP activities in units of the National Park System.

Department of Agriculture

U.S. Forest Service

The mission of the USFS is to provide a continuing flow of natural-resource goods, including mineral and energy resources, to help meet national needs, and to contribute to meeting such needs worldwide. It is the responsibility of the USFS to encourage and support environmentally sound mineral enterprises on Federal lands under its administration. In managing the use of these resources, the USFS objective is to minimize unnecessary adverse environmental impacts to surface and cultural features and values that might result from lawful exploration and development operations. This objective is accomplished through the application of reasonable conditions that do not interfere with well-planned mineral operations. The USFS also provides research information and technology to help with post-mining reclamation. In implementing this policy, the USFS Chief directed that:

1. A key objective of the minerals program is to encourage and facilitate the orderly exploration, development, and production of mineral resources.
2. Minerals, like range, recreation, timber, water, wildlife, and wilderness, are one of the multiple uses the USFS manages.
3. USFS managers must develop a good understanding of the minerals industry, its practices, and the minerals laws and regulations.
4. Managers must develop a strong working relationship with the minerals industry.
5. Visibility and interaction with the minerals industry must be increased by attendance and participation of line officers and appropriate staff at industry and professional association activities and meetings.
6. Directories, organization charts, and receptionists direct the mineral industry to personnel who have minerals-administration responsibilities.

Department of Energy

The DOE's mission is to reduce the Nation's vulnerability to disruptions of energy supplies and to mitigate any adverse impacts on the Nation should a shortage occur. With regard to Alaska, the energy sources currently being addressed by the DOE are fossil fuels (petroleum and coal) and geothermal.

The strategy for responding to petroleum-supply interruptions is to rely on the free market, supplemented as necessary and appropriate with other measures, such as the Strategic Petroleum Reserve. The DOE's Fossil Energy Research and Development Programs are aimed at careful consideration of the alternatives available and the relative chances for success in fostering an adequate supply of energy at a reasonable cost through long-term, high-risk research and development. Alternatives for increasing domestic petroleum supplies include (1) DOE's Unconventional Gas Recovery Program, which emphasizes the development of advanced technologies for the extraction of natural gas from resources that are classified as unconventional because of unique geologic settings and production mechanisms that are not now well understood, and (2) DOE programs for developing tertiary oil recovery, tar sands, and heavy-oil deposits.

The purpose of the DOE's Geothermal Energy Program is to develop the technology needed by industry for the use of geothermal resources. DOE research is aimed toward improving methods used to locate, extract, and convert geothermal heat to usable forms of energy. Through DOE funding in Alaska, Federal and State agencies have researched and published several studies of specific geothermal systems.

A further purpose of DOE programs is to generate data essential to the private sector's decisionmaking process to facilitate the development of commercial projects.