WILDERNESS MINERAL POTENTIAL

Assessment of Mineral-Resource Potential in U.S. Forest Service Lands Studied 1964-1984

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FOREWORD

For nearly three decades our Nation has been debating how the national domain should be used. This has led to much study of the resources of the land, especially renewable resources such as timber and wildlife, and nonrenewable resources such as minerals and mineral fuels. This book contains information on the mineral resources of part of the public lands.

Provided here are summaries of the mineral resources of many present and potential wilderness areas primarily in the national forest lands. The summaries—which cover about 45 million acres distributed over nearly 800 areas—are distillations of longer, more technical reports prepared during the last 20 years by geologists and mining engineers of the U.S. Geological Survey and the U.S. Bureau of Mines. This work was required by the Wilderness Act of 1964 (Public Law 88-577) and a number of subsequent acts.

The mineral endowment of the Nation is the sum of the deposits that have been discovered and the deposits that have not been discovered. Earth science in its present state of development can deal more precisely with discovered deposits than with undiscovered deposits, although it is by no means powerless in dealing with the latter. Deposits that have already been discovered are generally discussed in terms of tons of reserves and resources and estimates of grades of specific commodities. Undiscovered deposits are generally considered from the point of view of favorable ground assessments—the demarkation of land areas favorable for the occurrence of minerals accompanied by a listing of the types of minerals that are expected to occur in them.

One point about our studies needs emphasis. Resource assessments are influenced by the eras in which they are prepared. They reflect the economic circumstances of the time and a variety of considerations linked to them; they reflect the state of development of the earth sciences as they pertain to detecting concealed deposits; they reflect the needs of the audience for which they are prepared; and they reflect the inherent limitations of manpower, time, and budget. It follows that more refined and penetrating resource assessments will be made in the future, especially in the domain of undiscovered deposits.

These reservations notwithstanding, it should also be emphasized that the resource assessments presented here are in advance of any executed on comparable tracts and acreage anywhere in the World. In our 20 years of wilderness surveys we have broken much new scientific ground in understanding the geological structure and mineral endowment of the United States and in improving the methodologies of resource assessment. Because the methods developed appear to be reliable and applicable to all the public lands, when they are carried forward, they will furnish a practical assessment of the mineral value of the national domain.

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Director, Geological Survey

Robert C. Horton
Director, Bureau of Mines

PREFACE

The work on these volumes began in February 1982, but in a broader sense the production began nearly 20 years ago with passage of the Wilderness Act of 1964 that required the Geological Survey and the Bureau of Mines to conduct mineral surveys of Forest Service lands. This two-volume professional paper consists of summaries of the results of those mineral surveys and represents about 1,000 man-years of effort by professionals in the two agencies. Since the program began in 1964, the amount of land to be studied has increased from the original 14.8 million acres to 45 million acres, of which about 14 million acres have been added since 1979.

In February 1982, we began identifying the areas that should be included in this professional paper. The names and approximate boundaries of about 800 areas included in these 332 summaries are usually the same as they were at the time the work was done, but may differ somewhat from the current boundaries of the lands. These discrepancies are the result of revisions in boundaries and changes in names by legislative and executive acts during the 20 years of the program. After we had identified the areas that were to be included in these volumes, definitions of resources and resource potential for all metallic, nonmetallic, and energy minerals and a standardized outline for writing these summaries were determined. Resource and resource potential terminologies have changed during the last 20 years and differences may be seen from other published works. Techniques used for resource assessment have also evolved; those used in the early years of the program often are not those in use today. The summaries in these volumes reflect this evolution of methodology, as well as development of more advanced concepts about the assessment of mineral-resource potential. With all these differences, the use of a single set of definitions allows for comparison of resource potential described in work done within the 20-year framework of the wilderness program, including work that was not quite completed when this professional paper was being prepared.

The summaries in these volumes, which have been organized alphabetically by State, include a description of the character and geologic setting, a discussion of the resource potential, and a reference list of selected material published as part of the wilderness program. Many of the summaries include suggestions for further study. Our hope is that these summaries, designed to provide a quick overview of a 20-year program, will be of use to concerned individuals as well as to those legislators and administrators who must make difficult and critical land-use decisions that will affect our nation now and in the future.

From the inception of this project, the support and assistance of a large number of colleagues and administrators in the Geological Survey and Bureau of Mines have made it possible for us to collect, edit, and present these summaries. Special acknowledgment and appreciation are extended to those colleagues who reviewed the papers in these volumes; they are C.S. Bromfield, L. C. Craig*, R. E. Erickson, G. H. Goudarzi, M. E. MacLachlan, W. P. Pratt, P. K. Sims, V. E. Swanson, and R. B. Taylor, of the Geological Survey, and L. W. Gibbs of the Bureau of Mines. In addition, we wish to acknowledge the contributions of E. J. Swibas, who with the assistance of W. J. Gerstel and V. H. Sable, coordinated the preparation of the illustrations; and J.E.H. Taylor, who coordinated the typing and telecommunication of the text. The generous assistance of D. C. Schnabel was invaluable in speeding these volumes to completion. Finally, we appreciate the support, guidance, and advice of members of the Branch of Central Technical Reports and the Office of Scientific Publications of the Geological Survey during all phases of this project.

Sherman P. Marsh
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INTRODUCTION

By Donald A. Brobst and Gus H. Goudarzi

PURPOSE

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and subsequent related legislation, the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) have been conducting mineral surveys of wilderness and primitive areas, and of other national forest lands being considered for wilderness designation. The Wilderness Act directs that the results of these surveys are to be made available to the public and are to be submitted to the President and the Congress. This professional paper is a synopsis of the mineral surveys made from 1965 to 1983. It summarizes our current knowledge of mineral and energy resources and of the potential for the occurrence of undiscovered mineral and energy resources in 45 million acres of Federal lands, chiefly in national forests.

This book, in two volumes, consists of 332 summary articles, arranged alphabetically by State, in which the mineral-resource potential of about 800 individual areas is discussed. The summaries of the mineral surveys were written during 1982-83, generally by those who made the surveys. Index maps of each state show the location of the areas studied, numerically keyed to an alphabetic list. The national distribution of the wilderness lands studied is shown on the frontispiece. Where lands were in proximity or were added to expand previously designated areas, they often are described in a single article.

Each article begins with a short summary of the results of the mineral survey followed by a discussion of the character and geologic setting of the area. Mineral resources (if any) are discussed, and the potential for undiscovered mineral resources is assessed; these are keyed to the generalized geographic and geologic map of each area. Areas that have geologic characteristics indicative of different degrees of potential for the occurrence of mineral resources are shown in shades of red on each map. Some articles have a section on suggestions for further study to better define the mineral-resource potential of the area. A list of pertinent references (including many of the maps and reports prepared during the mineral survey) is provided at the end of each article.

This introduction contains some basic concepts about mineral resources and mineral-resource potential to try to make the book more useful to those who are not familiar with the fields of earth science and mineral-resource assessments. The legislation dealing with the wilderness program is reviewed briefly, because this evolving legislation has imparted a continuing and changing influence on the mineral-resource surveys. The introduction concludes with a description of the publications of the Geological Survey that report in greater detail the results of the joint wilderness studies by the Geological Survey and the Bureau of Mines.

REASONS FOR ASSESSING WILDERNESS MINERAL POTENTIAL

Minerals can be subdivided into metallic, nonmetallic, and energy (including uranium, fossil fuels, and geothermal waters) and these resources often are referred to as commodities. They are vital to our everyday lives. Nobody passes through a single day without using materials that have been made from, processed by, fertilized with, or are in some other way affected by products from mineral resources. Our highly productive agriculture has been made possible by extensive mechanization and efficient use of fuel, fertilizer, and soil conditioners. Most of our foods come from fields that are treated with phosphate and potash mineral fertilizers or with nitrogen-based fertilizers made from natural gas. Our food is cooked in metal pots (recovered from minerals) and is served on chinaware (made from clay minerals). Energy for cooking and baking comes from mineral fuels (gas or petroleum products) or from electricity produced from coal, oil, gas, or uranium in plants using generators made of metal. Even solar energy is collected and distributed by equipment made from metals and petroleum. Buildings, other than those made of wood, consist chiefly of processed materials of mineral origin—brick, concrete, glass, rock wool, insulation, ceramics, tile, metal fixtures, and plasterboard. Plastic products, which are pervasive in our society, are derived from oil, natural gas, or coal. We travel in vehicles made of metal and plastics and powered by mineral fuels.

Silver is used in the film for our cameras, and several rare metals (such as europium in color television picture tubes) are essential to electronic equipment.

Mineral resources are the foundation of our national economy, which now generates a gross national product (GNP) of slightly more than $3 trillion annually. The role of nonfuel minerals in the United States economy in 1982 is shown in figure 1. The value of domestically produced mineral raw materials (excluding fuels) was about $20 billion and the value of imported mineral raw materials was about $4 billion. On the basis of 1981 U.S. Department of Energy estimates, domestically produced fuels had a value of $178 billion and imported fuels, mostly oil and gas, had a value of $70 billion. The value of all the minerals (including fuel) represents an indispensable part of the GNP, about 10 percent.

The major metallic commodities produced in the United States in 1982, ranked by dollar value, are shown in table 1. Our reliance on imports, shown in this table as a percentage of domestic primary consumption, varies greatly from commodity to commodity because of some combination of geologic availability and economic conditions, such as price, demand, and cost of production. For example, although the United States has sufficient iron ore to increase production, the current economic conditions and those of the recent past make importing ore less costly. For bauxite, an ore of aluminum, the circumstances are quite different. Domestic deposits are small and their geologic nature make it unlikely that any new large deposits of bauxite will be found in the United States. Molybdenum, an element essential for alloying special types of steel, is abundant in the United States; our Western States supply nearly 65 percent of the world's production.

The domestic production of major nonmetallic mineral commodities in 1982, ranked by dollar value, is shown in table 2. The net import reliance, shown as a percentage of domestic primary consumption, is controlled by geologic and economic factors. The United States has large resources of phosphate rock, borates, and sodium carbonate, and is a leading producer and exporter of these nonmetallic minerals. Construction

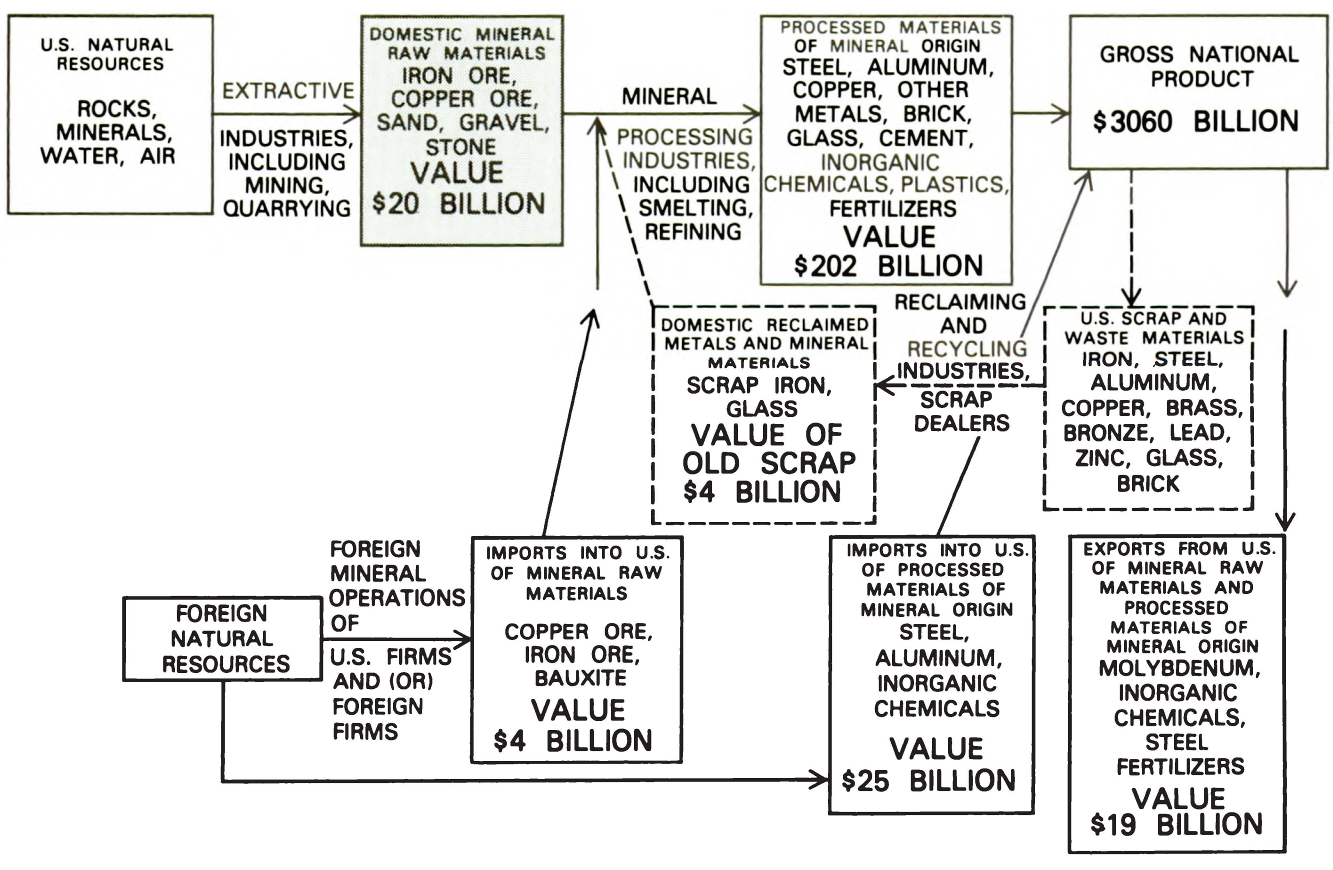

Figure 1.—The role of nonfuel minerals in the United States economy for the first 8 months of 1982. Statistical data from U.S. Department of Commerce.

TABLE 1.—*Domestic production of major metallic mineral commodities in 1982*

[Data from the U.S. Bureau of Mines]

Metallic mineral commodity	Estimated production (metric tons)	Estimated value (million dollars)	Estimated net import reliance (in percent) of domestic primary consumption
Copper ------	1,100,000	1,800	7
Iron ore -----	[1]35,900,000	1,500	36
Molybdenum -	36,500	362	Net export.
Lead --------	510,000	292	1
Silver -------	1,120	286	59
Zinc --------	300,000	255	53
Vanadium ---	[1]4,260	55	14
Tungsten ----	1,450	20	48
Bauxite -----	700,000	17	97
Mercury -----	860	[2]10	43
Platinum ---- group metals.	.19	1	85

[1]Preliminary estimate.
[2]Value calculated is based on an average price of $390 per flask.

materials (cement, crushed stone, and sand and gravel), are mined or produced close to where they are used because of their bulk, weight, and resulting high cost of transport.

With few exceptions, most minerals are consumed in use. Mineral commodities either are committed to an irretrievable use in a permanent structure (for example, sand, gravel, crushed rock, cement, glass, and steel and other metals used in roads and buildings); are converted into a useful product from which they cannot be reclaimed (chemicals, paints, plastics); or are converted chemically to products that are dispersed into the ground or into the atmosphere (fertilizers and fossil fuels). Although some metals, including aluminum, antimony, copper, lead, gold, iron, and silver, can be recovered by recycling and provide a substantial part of domestic consumption, a steady source of mineral raw materials, available in limited supply, is essential to maintain our present standard of living.

Concentrations of useful minerals rich enough to form ore deposits are rare phenomena. Commercially extractable concentrations form only where special physical and chemical conditions have favored their accumulation. Certain types of mineral deposits are associated with certain geologic environments as characterized by the type of rocks and structures, depth of formation, and source and nature of mineralizing fluids. For example, throughout the world many major deposits of copper, lead, zinc, silver, and gold are associated with granitic igneous rocks such as those found in the Western United States and in Western South America. Chromium deposits commonly are associated with other kinds of igneous rock; although these deposits are rare in North America, they are abundant in southern Africa. Large deposits of bauxite occur in deeply weathered rocks formed in tropical climates. Many of the world's largest deposits of lead and zinc are associated with limestone strata, like those of southeastern Missouri. The organic fuels—oil, gas, and coal—are formed from materials deposited in specific sedimentary environments. Field and laboratory observations and studies provide information about where and why minerals accumulate. Studies formulating the theoretical basis for resource accumulation have provided for the understanding of some of the many types of geologic environments that offer potential for the occurrence of mineral deposits (Brobst and Pratt, 1973). As a result of these studies, criteria have been established that define geologic, geochemical, and geophysical properties of these deposits (which may be referred to as modeling); that is, a comparison of data with known occurrences.

Just as not every haystack has a needle, not every favorable geologic environment has a mineral deposit of economic value. For example, of every 1000 mineral prospects examined in Canada in 1969, only one was favorable for mine development (Roscoe, 1971).

As might be expected from the wide geographic distribution of the wilderness lands (see frontispiece), these lands contain rocks formed in a great variety of geologic environments. Many of these environments are favorable for the occurrence of mineral resources and many kinds of resources may be present. As the authors of the Wilderness Act of 1964 realized, prudent use of land requires knowledge of its resources, including water, timber, wildlife, and recreational assets as well as minerals. In recognition of the importance of metallic, nonmetallic, and energy mineral resources to the economy, the Congress specifically required that these resources be surveyed on land in, or being considered for,

TABLE 2.—*Domestic production of major nonmetallic mineral commodities in 1982*

[Data from the U.S. Bureau of Mines]

Nonmetallic mineral commodity	Estimated production (thousand metric tons)	Estimated value (million dollars)	Estimated net import reliance (in percent) of domestic primary consumption
Cement ----------	57,500	3,260	4
Crushed stone -----	717,000	2,920	0
Sand and gravel ----	568,000	2,020	Net export.
Sulfur -----------	9,800	980	4
Phosphate rock ----	37,400	950	Net export.
Clays ------------	32,200	830	Net export.
Sodium carbonate --	7,090	721	Net export.
Lime ------------	12,800	700	2
Salt -------------	34,050	673	11
Boron (boria ------- B_2O_3).	550	385	Net export.

inclusion in the National Wilderness System, in order to aid those who must make decisions about land use.

THE NATURE OF MINERAL-RESOURCE ASSESSMENTS

The term "mineral resource" refers to a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such a form and amount that economic extraction is currently or potentially feasible. The assessment of mineral resources in a designated area requires both the estimation of the amount and grade of identified resources and the assessment of the potential for the presence of as yet undiscovered mineral resources. Identified resources are specific bodies of mineralized rock whose location, quality, and quantity have been measured. The likelihood of the presence of undiscovered mineral resources is determined from earth science information and is presented as a statement of mineral-resource potential.

The major difficulty in making assessments of mineral-resource potential is the need to describe and quantify an unknown that can be neither seen nor measured. At present, the best approach to assessment is to collect all available data on an area, to synthesize and integrate this data using geologic theories, and to compare all this with similar data from areas that have identified mineral deposits. This process of comparison, combined with experience and judgement, enables the earth scientist to reason the likelihood and types of deposits that might occur in an area.

CLASSIFICATION OF MINERAL RESOURCES AND MINERAL-RESOURCE POTENTIAL

If a body of rock containing concentrations of useful minerals is exposed at the Earth's surface or has been penetrated by drill holes, it can be sampled and its dimensions measured. The samples can be analyzed, and the size of the body can be calculated. The result is a quantitative measurement or estimate of the amount of mineral-bearing rock that is known to occur, and the quantities of metals, nonmetals, or mineral fuels that it contains. Most of the resource assessments in these volumes are for study areas in which mineralized rocks are not exposed or are only partly exposed at the surface and have not been penetrated by drill holes. Assessments of resources in these areas are qualitative rather than quantitative. Of equal importance is the assessment of the likelihood that mineral or energy resources may or may not occur in the area. Mineral-resource potential is the characteristic attributed to a geologic terrane that suggests the possible presence of mineral resources—metallic, nonmetallic, or energy. For consistency in these volumes only, therefore, the following terms and definitions were established so that uniform terminology would be used in these summaries of the many reports produced through two decades by many individuals.

1. Areas that have **substantiated** mineral-resource potential are shown in red on the maps. The term "substantiated" is based on a record of past production or the occurrence of identified resources, and (or) on an assemblage of geologic data that strongly indicate the presence of undiscovered mineral resources.

2. Areas that have **probable** mineral-resource potential are shown in pink on the maps. The term "probable" is based on an assemblage of data that support the interpretation that undiscovered mineral resources may be present. In some areas, probable and substantiated mineral-resource potential overlap. In these areas, a darker shade of red is used.

3. Where data could be obtained, the resources at mines, deposits, or quarries are specified by tonnage and grade (concentration of the desired material or materials per unit of measure, commonly expressed in such terms as percent, ounces per ton, grams per metric ton, or barrels per acre). Where a mineral resource is defined in terms of tonnage and grade, it is referred to as "identified," "demonstrated," and (or) "inferred" using the following definitions of the U.S. Bureau of Mines and the U.S. Geological Survey (1980, p. 2).

> **Identified resources** are those whose location, grade, quality, and quantity are known or estimated from specific geologic evidence.
>
> **Demonstrated resources** is a term for the sum of measured and indicated resources whose quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes and whose grade and (or) quality are computed from the results of detailed sampling.
>
> **Inferred resources** is a term for resource estimates that are based on assumed continuity beyond those of the measured and (or) indicated categories for which there is geologic evidence that might or might not be supported by samples or measurements.

Mines, quarries, or deposits of limited extent for which demonstrated or inferred resources are reported in the text are shown on the maps by a red mine symbol. Mines discussed in the text but for which no quantity of demonstrated or inferred resources can be reported are shown by a black mine symbol. Mineral occurrences for which no quantity of demonstrated or inferred resources is reported are shown by a black "X".

Subdivisions in use by the U. S. Geological Survey					Age estimates[1] of boundaries in million years (m.y.)	
Phanerozoic Eon	Cenozoic Era	Quaternary Period		Holocene Epoch	0.010	
				Pleistocene Epoch	2	(1.7-2.2)
		Tertiary Period	Neogene Subperiod	Pliocene Epoch	5	(4.9-5.3)
				Miocene Epoch	24	(23-26)
			Paleogene Subperiod	Oligocene Epoch	38	(34-38)
				Eocene Epoch	55	(54-56)
				Paleocene Epoch	63	(63-66)
	Mesozoic Era	Cretaceous Period		Late Cretaceous Epoch	96	(95-97)
				Early Cretaceous Epoch	138	(135-141)
		Jurassic Period		Late, Middle, and Early Jurassic Epochs	205	(200-215)
		Triassic Period		Late, Middle, and Early Triassic Epochs	~240	
	Paleozoic Era	Permian Period		Late and Early Permian Epochs	290	(290-305)
		Carboniferous Periods	Pennsylvanian Period	Late, Middle, and Early Pennsylvanian Epochs	~330	
			Mississippian Period	Late and Early Mississippian Epochs	360	(360-365)
		Devonian Period		Late, Middle, and Early Devonian Epochs	410	(405-415)
		Silurian Period		Late, Middle, and Early Silurian Epochs	435	(435-440)
		Ordovician Period		Late, Middle, and Early Ordovician Epochs	500	(495-510)
		Cambrian Period		Late, Middle, and Early Cambrian Epochs	~570[2]	
Proterozoic Eon	Late Proterozoic[3] or Proterozoic Z[4]				900	
	Middle Proterozoic[3] or Proterozoic Y[4]				1,600	
	Early Proterozoic[3] or Proterozoic X[4]				2,500	
Archean Eon	Late Archean[3]				3,000	
	Middle Archean[3]				3,400	
	Early Archean[3]				3,800?	

[1] Ranges reflect uncertainties of isotopic and biostratigraphic age assignments. Age of boundaries not closely bracketed by existing data shown by ~. Decay constants and isotope ratios employed are cited in Steiger and Jäger (1977).

[2] Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

[3] Geochronometric units

[4] Formerly used time terms

Figure 2.—Geologic time scale, showing major goechronologic units (Geologic Names Committee, U.S. Geological Survey, 1983).

4. For coal resources and coal resource potential, the reporting system was modified slightly. Demonstrated coal resources are estimated separately for coal in beds more than 28 in. thick and for coal in beds between 14 and 28 in. thick. Areas underlain by coal beds more than 28 in. thick are shown on the map in each summary as areas of substantiated coal resource potential. Areas underlain by coal beds between 14 and 28 in. thick are discussed in the text, but are not shown on the map.

5. The remaining areas are those that do not have identified mineral resources and (or) those lacking evidence of mineralization indicative of a potential for the occurrence of mineral resources.

PROCEDURES OF MINERAL-RESOURCE ASSESSMENTS

The staffs of the Geological Survey and the Bureau of Mines collaborated on the many investigations required to assess the mineral resources of the wilderness lands designated by Congress for study. The work involved geologic, geochemical, and geophysical studies by the Geological Survey. The Bureau of Mines sampled and mapped mines and prospects, compiled information on claims, and compiled data from exploration, mining, and production records.

A geologic map was prepared for each area. Data from field observations and measurements, with existing geologic maps as a starting point, were used to compile the map that shows the distribution and structure of the various types of rocks—features that generally control the location of mineral resources. The geologic maps were prepared at scales appropriate to show the information necessary to make the assessment, generally at scales between 1:50,000 and 1:100,000 (1 inch equals 0.8 miles and 1 inch equals 1.6 miles). A geologic time scale, which is a key to the ages of rocks discussed in the summaries, is shown in figure 2. In addition, more detailed geologic studies were made where they were considered necessary to the mineral-resource assessment. These studies included examination of rock sequences that may contain mineral resources; determination of the age and temporal sequence of the emplacement of intrusive rocks; determination of the time and nature of rock deformation and chemical alteration; and examination of hydrothermal (hot water) alteration zones and features that might be related to mineral deposits.

Geochemical surveys were made of most areas as a means of determining patterns of anomalous (unusually high) metal values that might indicate undiscovered mineral deposits. Many kinds of mineral deposits are characterized by suites of elements that can be used to classify deposit types. Geochemical studies are used to identify these suites and to help find and classify the areas that may have resource potential. The sampling and analytical techniques used were designed specifically to identify resource potential in the geologic environment of each particular area. Most geochemical samples were of stream sediments, but samples of rocks, soils, and waters, and of heavy concentrates from stream sediments, were also collected and analyzed in many areas. Mineral deposits that are being eroded impart anomalously high metal values to stream sediments and concentrates. These high values can readily be distinguished from the normal or background values from drainage areas in which no mineral deposits are exposed. Analyses of stream sediments and their heavy-mineral fractions provide information not only about the metals present in mineral and rock fragments, but also about metals adsorbed by clay minerals from surface or ground water.

Geophysical surveys using aeromagnetic, gravity, electromagnetic, and airborne gamma-ray techniques were made in many areas. These techniques provide information about the physical properties of the rocks and their distribution below the surface of the ground, and information that may be indicative of mineral and fuel deposits or of structures that might have controlled resource accumulation.

Studies of mines, prospects, and mining claims included some surveying and geologic mapping, the sampling of specific areas, the analyzing of samples, and the collecting of data on production and reserves on present and past exploration and mining operations. Possible extensions of mineralized structures in existing workings were evaluated and the quantity and grade of resources were determined where possible. Detailed studies included sampling of mineralized areas identified in the geochemical survey; metallurgical tests were made when necessary.

The results of all these studies were then integrated to compile a mineral-resource assessment report that describes the identified resources and outlines areas favorable for the occurrence of mineral resources.

Singer and Mosier (1981) reviewed more than 100 papers on regional mineral-resource assessment and found that of 15 methods of assessment the most widely used was one based on extrapolation from known areas, in which estimates were made directly by one or more individuals on the basis of their knowledge and experience. The extrapolation method has been used in the mineral assessments of wilderness lands because of constraints in time, money, and staff; the problems in dealing with undiscovered resources; and the lack of available subsurface data. The method necessitated that knowledgeable, experienced people be assigned to study the lands in question and to make the assessments.

The extrapolation method applied in the wilderness assessment starts with the synthesis of all available information on the geology, geologic history, and identified mineral and energy resources. The information thus generated sets general limits on the types of mineral deposits that might occur in a given area. The area under investigation could then be compared with areas of known ore deposits, petroleum reservoirs, geothermal fields, or other resources. In such a way can be reasoned the likelihood of the occurrence of resources, and hence the mineral potential of the area under study.

Activity by the mineral industry is one factor that must be considered in the assessment of an area. The presence of known deposits is a favorable attribute for any area, but the absence of known deposits does not necessarily indicate that the area has no mineral-resource potential. Even the lack of evidence of mineral development and exploration may not be a negative sign about mineral-resource potential, especially for remote areas in which high costs discourage activity, or for areas in which newly recognized types of deposits can now be postulated. The studies summarized in these volumes assumed that undiscovered mineral deposits might be present in any area until information indicated that there was little likelihood for the occurrence of resources. Thus, a positive approach was maintained and the resource potential of areas was not reduced merely because adequate data were unavailable.

The credibility of all assessments of mineral-resource potential is a matter of concern. The data available for virtually all wilderness lands are incomplete; subsurface data are lacking. Assessment of mineral-resource potential is by its nature speculative and involves considerable uncertainty. Construction of uniform quantified assessments is currently impossible. Assessing the resources of any mineral commodity on any parcel of land is a continuing process that as yet lacks universally applicable methods (Harris and Agterberg, 1981; Harris and Skinner, 1982). Thus, professional but subjective judgement is important to the assessments summarized in these volumes.

THE NEED FOR CONTINUING ASSESSMENTS

Assessments of mineral-resource potential are of a dynamic nature regardless of how they are conducted, or of the methods that are used. Final, once-and-for-all assessments of mineral-resource potential cannot be made. Areas should be reassessed periodically as new data become available, as new concepts of the factors that influence the concentration of minerals are developed, as new uses and extractive technologies for minerals are devised, and as the world's economy changes. For these reasons, the Congress specified that "recurring mineral surveys" of the wilderness lands should be made.

Geology, technology, and economics are tightly entwined in mineral-resource assessment. Mineral resources have geologic limits and controlling technologic and economic factors that govern their utility (DeYoung and Singer, 1981). This perspective was expressed by Downing and Mackenzie (1979) who favored continuing reevaluation of exploration and development data. They pointed out that geology offers information based on observation and concept, mineral-deposit genesis, and deposit modeling; that technology offers information on extraction methods, beneficiation, smelting, and refining and material use; and that economics offers information on market dynamics, the ability of a deposit or material to compete with other deposits or materials, and the effect of byproducts and coproducts on costs. Thus, the three fields are interrelated, and each has an important bearing on the others; communication between these fields needs to be nurtured and increased.

Man cannot create mineral deposits, but he does create mineral resources as he learns to use the materials of the Earth, or, as Zimmerman (1964) said, "Resources are not, they become." Most regions on the Earth's crust may contain mineral deposits of some possible use if a market for the materials in the deposit should develop. To say that an area has no mineral-resource potential is inadvisable, even though some areas may be classified as having little chance for the occurrence of resources of a particular mineral. Some of the areas that have no identifiable resource potential may contain new types of mineral deposits, recognizable and exploitable only in the future. For example, gold deposits of the Carlin-type (Nevada) in which the gold is too finely disseminated to be visible would not have been recognized prior to 1962; their characteristics were not known. Many common rocks contain small amounts of valuable minerals, but are not considered resources at present because extraction is too costly, or requires too much energy. Technology of the future may change what is now considered common rock into a useful resource if lower cost energy can be made available, a trend not currently seen.

LEGISLATIVE HISTORY OF THE WILDERNESS SURVEYS

The wilderness concept was formalized by the Forest Service, U.S. Department of Agriculture, in 1924 with the designation of the Gila Wilderness in the Gila National Forest in New Mexico. The designated wilderness areas (Wild and Primitive) totalled 88 units, containing 14.6 million acres by 1964.

The Wilderness Act of 1964 designated as wilderness 54 National Forest System areas comprising 9.3 million acres. It also required a study of each of the 34 National Forest primitive areas totaling 5.5 million acres, with a report to Congress by 1974 as to their suitability or nonsuitability for wilderness. Included in the provisions of the Wilderness Act was a requirement for the Secretary of the Interior to direct mineral surveys of suitable areas under his jurisdiction in the National Park and National Wildlife Refuge Systems.

The mineral-resource assessments of Federal lands described in these volumes were made in response to the Wilderness Act, Public Law 88-577, September 3, 1964. The Act specified in Sec. 4(d)(2) that the Geological Survey and the Bureau of Mines shall conduct mineral surveys of wilderness lands on a planned and recurring basis. The law also specified that the wildernesses would remain open to mining access until January 1, 1984, at which time all the areas would be closed to access under existing mining and leasing laws.

The resource assessments of the primitive areas began in 1965 because those areas had to be reported upon by September 1974. By the time the studies of the primitive areas were completed in 1973, many of the boundaries had been revised and 1.6 million acres had been added, an increase in area of about 30 percent.

In 1970, the Forest Service, because of public and congressional interest, began to add new areas as candidates for wilderness designation. By 1973, these parcels, now referred to as study areas, included 3.7 million acres in 53 designated areas.

In October 1973, the Forest Service added 274 more study areas in a program sometimes referred to as RARE (Roadless Area Review and Evaluation) that comprised about 12.3 million acres, including 1.9 million acres previously designated for study.

In 1974, interest in establishing some wildernesses in the Eastern States led to a request by the Forest Service for mineral studies in about 600,000 acres in 58 proposed areas in that region. Congress passed the Eastern Wilderness Act (Public Law 93-622) on January 3, 1975, which designated 207,000 acres as wilderness and 125,000 acres of study areas to be examined and reported to the Congress by January 1980.

In 1974, Interior Secretary Rogers C. B. Morton requested a mineral survey of about 7.8 million acres in six areas administered by the Interior Department. These areas included: Glacier Bay National Monument, Alaska; Charles M. Russell Wildlife Refuge, Montana; Charles Sheldon Antelope Range, Sheldon National Antelope Refuge, and Desert Game Range, Nevada; and Kofa Game Range and Cabeza Prieta Game Range, Arizona.

By early 1975, a total of 32.2 million acres of National Forest land had been designated wilderness or wilderness study areas, a designation that necessitated management according to wilderness standards, and that also required mineral surveys.

The second Roadless Area Review and Evaluation (RARE II) was begun in June 1977. It identified 2,920 roadless areas encompassing 62 million acres in National Forest and National Grasslands. The administration released the results of the study on April 16, 1979, and recommended that 36 million acres be assigned to nonwilderness, that 15.4 million acres be assigned to wilderness, and that decisions on 10.6 million additional acres be deferred for further planning for all options. The status of lands in the "further planning" category was to be decided by 1985 through the regular land-management planning process by the Forest Service.

In 1980, the 96th Congress established several wildernesses and wilderness study areas in New Mexico, Idaho, Alaska, Colorado, South Carolina, Missouri, Louisiana, and South Dakota. Mineral surveys were required in wilderness study areas (totaling 2.7 million acres) within 3 years of the passage of these "State" bills. The rapid increase in the amount of land that required mineral surveys is shown on figure 3.

The legislative acts, with their dates, that are pertinent to the evolution of the wilderness system can be obtained from the U.S. Forest Service. The legislative history and the texts of all the acts are available for inspection at the Library of Congress in Washington, D.C.

WILDERNESS PROGRAM PUBLICATIONS

Many of the results of mineral-resource assessments have been published as U.S. Geological Survey Bulletins. Some information was released as Open-File Reports to meet legislative and adminstrative requirements, and some were republished as more complete, formal reports. In 1979, a new publication format was introduced that uses maps for presentation of most data. The joint report on mineral-resource potential by the Geological Survey and the Bureau of Mines is a map with a marginal text and an accompanying pamphlet, in the U.S. Geological Survey Miscellaneous Field Studies Map (MF) series. The mineral-resource potential report summarizes the information that led to the conclusions and outlines the areas of mineral-resource potential of each area. Other maps in the MF series on each area generally include the following: (1) a geologic map with a marginal text; (2) geochemical maps showing distribu-

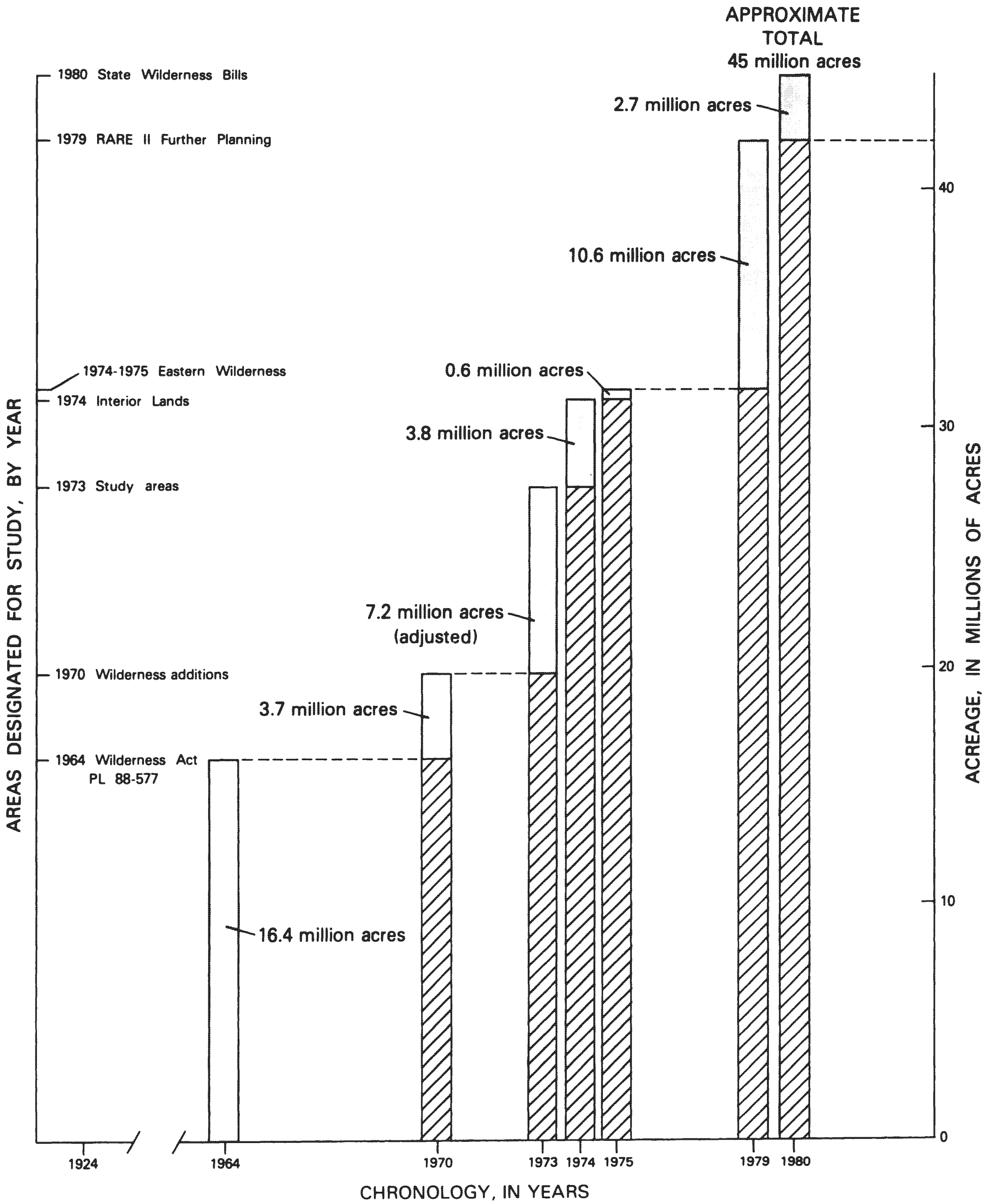

Figure 3.—Graph showing cumulative acreage of Federal lands designated for mineral surveys, 1965–1983.

tion of analytical values and anomalous areas for one or more chemical elements, with a marginal text; (3) geophysical maps showing various kinds of data and marginal notes of explanation; and (4) mine, prospect, claim, and sample-site maps with explanatory text prepared by the Bureau of Mines.

Much of the raw geochemical and geophysical data supporting the resource assessment have been released as Open-File Reports by the Geological Survey. Much of the Bureau of Mines data have been released as Open-File Reports; these are available at their field centers and in Washington, D.C. Both the Geological Survey and the Bureau of Mines announce the release of their respective Open-File Reports in their monthly list of publications.

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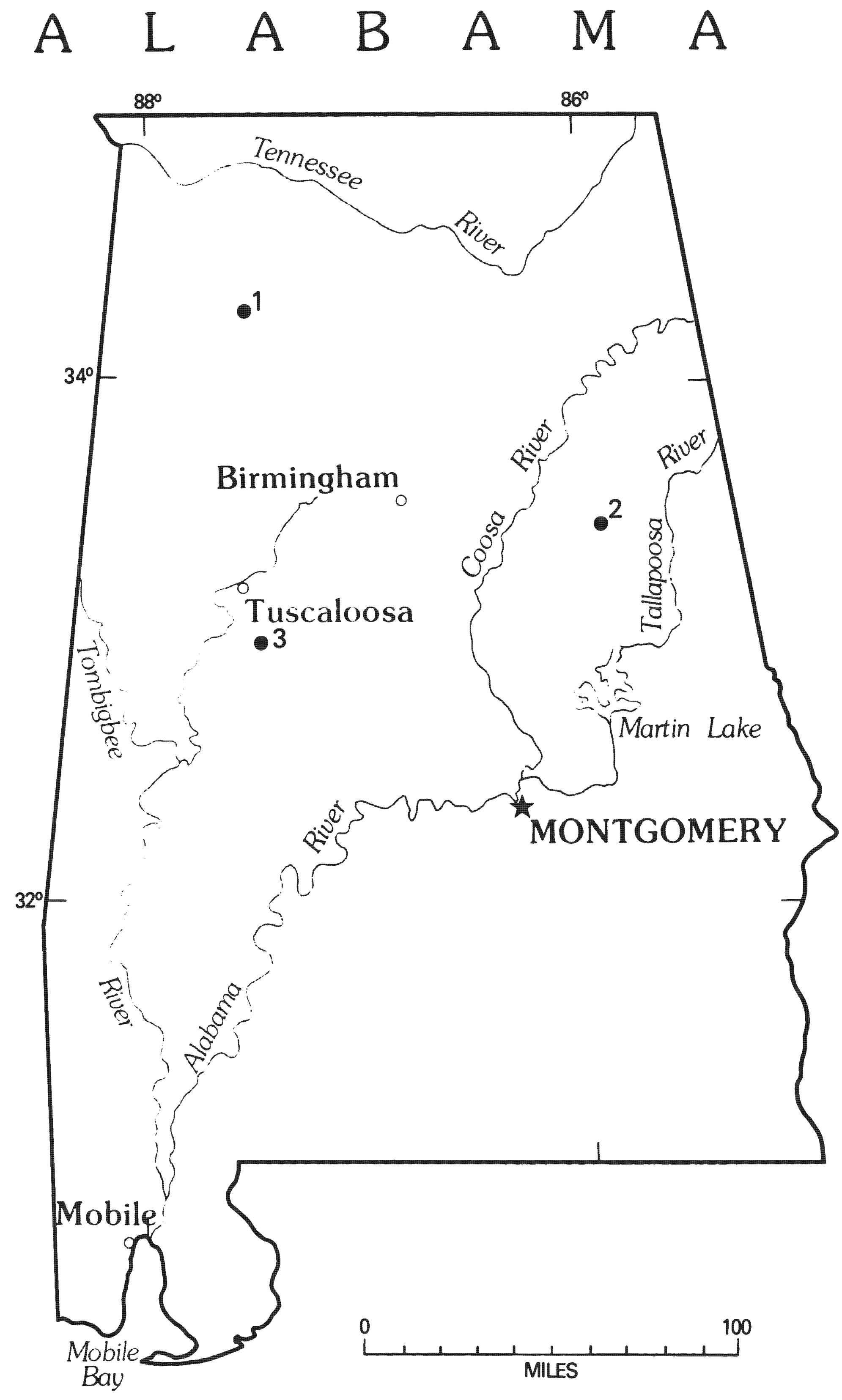

Location of areas studied.

ALABAMA

Map No.	Name of Area
2	Adams Gap and Shinbone Creek Roadless Areas
3	Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas
1	Sipsey Wilderness and Additions

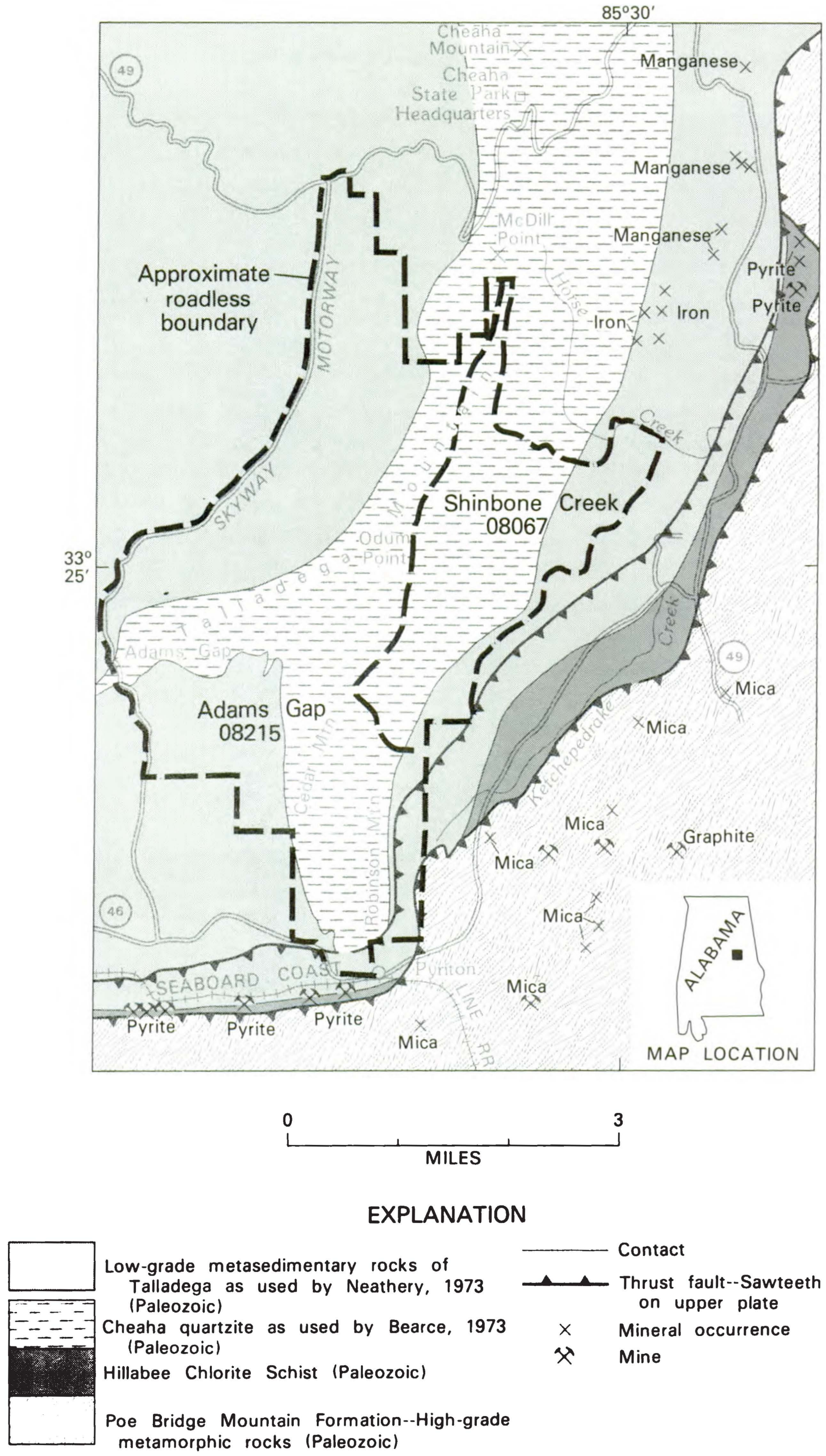

Figure 4.—Adams Gap and Shinbone Creek Roadless Areas, Alabama.

the southern end of the study area. Operations were discontinued because of excessive iron content, but two samples of quartzite collected several miles north of the quarry meet standards for refractory brick (Harrison and Armstrong, 1982, p. 14). Impurities in much of the rock and prohibitive quarrying and crushing costs make the Cheaha in the study area unattractive for both silica refractory or silica sand use. The quartzite in the study area is suitable for crushed stone, riprap, or common building stone but abundant resources for this commodity exists outside the area.

The Hillabee Chlorite Schist, outside the east and south boundary of the study area, contains pyrite, copper, zinc, and gold which occur in lenticular pods or zones. However, the geologic relationships of this unit indicate that it is not present in the study area.

Mineral resources associated with the high-grade metamorphic rocks of the Poe Bridge Mountain Formation include mica, graphite, and gold. Mica has been mined outside the study area from small tabular or lens-shaped coarse-grained granitic rocks within the formation. Graphite, associated with graphitic schists, and gold, associated with quartzite layers, also occur in this formation. There is no current or recent production of mica, graphite, or gold from this group of rocks. The Poe Bridge Mountain Formation occurs only in a small southern part of the study area, and geological relationships indicate it does not underlie the rocks in the study area.

The rocks of the Talladega in the study area have been thrust over younger unmetamorphosed sedimentary rocks (Thomas and others, 1980). These younger sedimentary rocks may contain oil and gas resources. The low degree of metamorphism implies that both oil or natural gas could be present at appropriate depths. Because of the thrust fault contact separating the Talladega from underlying rocks, surface structures in the Talladega cannot be used to determine subsurface structures (and possible hydrocarbon traps) beneath the plane of the thrust fault.

SUGGESTIONS FOR FURTHER STUDIES

Detailed seismic studies and deep drilling tests are needed before a reasonable estimate of hydrocarbon potential can be made.

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BIG SANDY, WEST ELLIOTTS CREEK, AND REED BRAKE ROADLESS AREAS, ALABAMA

By SAM H. PATTERSON,[1] U.S. GEOLOGICAL SURVEY, and

MICHELLE K. ARMSTRONG, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys done in 1979–80 in the Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas, Alabama, indicate that the areas have little promise for the occurrence of metallic mineral resources. The three areas, however, have a probable potential for oil or gas. Probable coal resource potential exists in the Big Sandy and the West Elliotts Creek Roadless Areas. Clay and abundant sand resources occur in the roadless areas. Clayey sand has been used to stabilize USFS roads and in road grade construction. The clay and sand have little value as mineral resources because these commodities are abundant elsewhere in the region.

CHARACTER AND SETTING

The Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas are located about 10 mi south of Tuscaloosa in west-central Alabama. The Big Sandy Roadless Area occupies 5 sq mi of which most is in Tuscaloosa County but small parts extend into Hale and Bibb Counties. The West Elliotts Creek Roadless Area containing 6.6 sq mi is in Hale County. The Reed Brake Roadless Area of 1 sq mi is in Bibb County.

The exposed rocks in the three areas consist of the Coker and Gordo Formations that make up the Cretaceous Tuscaloosa Group and Pleistocene and Holocene alluvium (Szabo and Patterson, 1983). The two Cretaceous formations consist chiefly of sand, silt, and clay and contain minor quantities of gravel and sandstone. The Coker is 400–500 ft thick and the Gordo is 100–400 ft thick. The alluvium is composed of lenticular beds of fine- to coarse-grained sand, gravel, and clay. It occurs under the flood plains of the major streams.

The Tuscaloosa Group is unconformably underlain by Paleozoic sedimentary rocks. The Paleozoic rocks underlying the Big Sandy and West Elliotts Creek Roadless Areas are equivalent to the Pennsylvanian Pottsville Formation of Pennsylvania. Where exposed in the central and northern parts of Tuscaloosa County this formation consists of sandstone, shale, clay, and coal, and it has a thickness of 2500–4400 ft. The Pottsville Formation is probably missing below the Tuscaloosa Group in the Reed Brake Roadless Area where it is presumably underlain, at depths of no greater than 700–800 ft below the surface, by one or more of the 19 pre-Pottsville formations known to be present in outcrops in easternmost Tuscaloosa County and the central part of Bibb County.

The Cretaceous Tuscaloosa Group in the three areas has undergone little deformation, but older rocks are more disturbed. The strata in the Tuscaloosa Group dip uniformly to the southwest at 30–40 ft/mi; no faults or folds were found in them in the three areas. The Pottsville Formation below the major unconformity between the Cretaceous and Paleozoic formations dips approximately 175 ft/mi to the southwest. The pre-Pottsville rocks that probably underlie the Tuscaloosa Group in the Reed Brake Roadless Area are likely to be folded and faulted much like those cropping out farther to the northeast.

MINERAL RESOURCES

Bituminous coal of the Pottsville Formation is currently mined in northern and central Tuscaloosa County, and in northeastern Bibb County. Eight coal groups, each containing two to six coal beds, are recognized in Tuscaloosa County. Approximately half of the estimated 34 coal beds exposed in the county have been mined commercially. Coal has been mined 9.5 mi northeast of the Big Sandy Roadless Area in Tuscaloosa

[1]With contributions from Peter C. Mory, USBM.

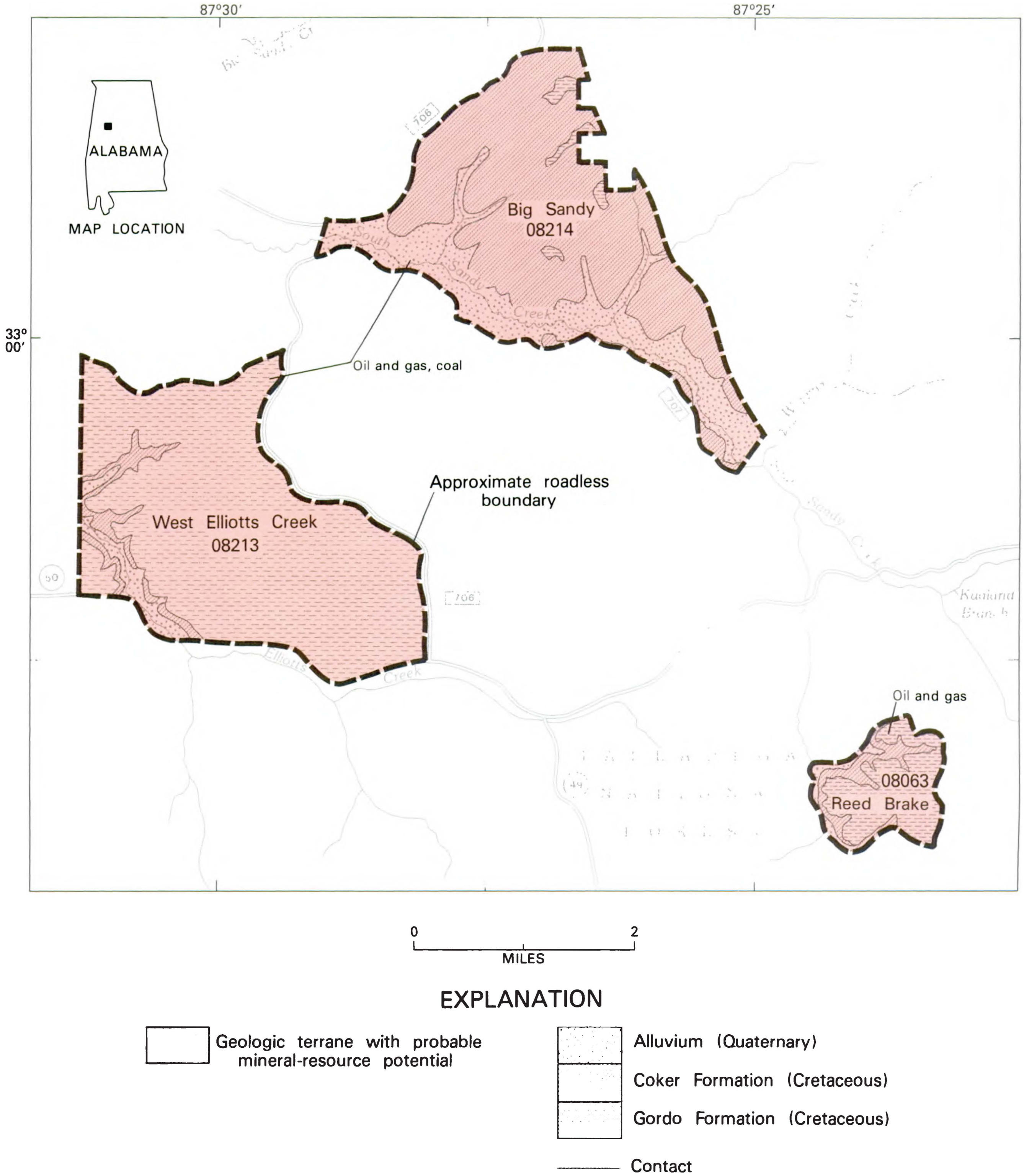

Figure 5.—Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas, Alabama.

Roadless Area is intermittently active and has been the only mining in the three areas in recent years.

The sand deposits in the three roadless areas are not shown on the map because of the large resources scattered throughout the region. The USFS has several inactive borrow pits outside the three roadless areas which are adequate for local needs. The city of Tuscaloosa, located about 10 mi north of the Big Sandy Roadless Area, is amply supplied with sand and gravel by extensive deposits in the Tuscaloosa Group and terraces along the Black Warrior River. Similar deposits occur along the Cahaba River, about 10 mi east of the roadless areas.

SUGGESTIONS FOR FURTHER STUDIES

Meaningful contributions to the energy resource potential of the three roadless areas would require new information on the rocks at depth, that are likely to contain coal and possibly oil and gas. Costly geophysical investigations and drilling would be required to obtain such information.

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SIPSEY WILDERNESS AND ADDITIONS, ALABAMA

By STANLEY P. SCHWEINFURTH,[1] U.S. GEOLOGICAL SURVEY, and

PETER C. MORY, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic, geochemical, and mineral surveys made in 1978–79, the Sipsey Wilderness and additions are deemed to have little promise for the occurrence of metallic mineral resources. Although limestone, shale, and sandstone resources that occur in the area are physically suitable for a variety of uses, similar materials are available outside the area closer to transportation routes and potential markets. A small amount of coal has been identified in the area, occurring as nonpersistent beds less than 28 in. thick. Areas underlain by beds less than 28 in. thick, despite their contained coal, are not shown on the map. Oil and (or) natural gas resources may be present if suitable structural traps exist in the subsurface. Therefore, the area has a probable oil and gas potential. Small amounts of asphaltic sandstone and limestone, commonly referred to as tar sands, may also occur in the subsurface.

CHARACTER AND SETTING

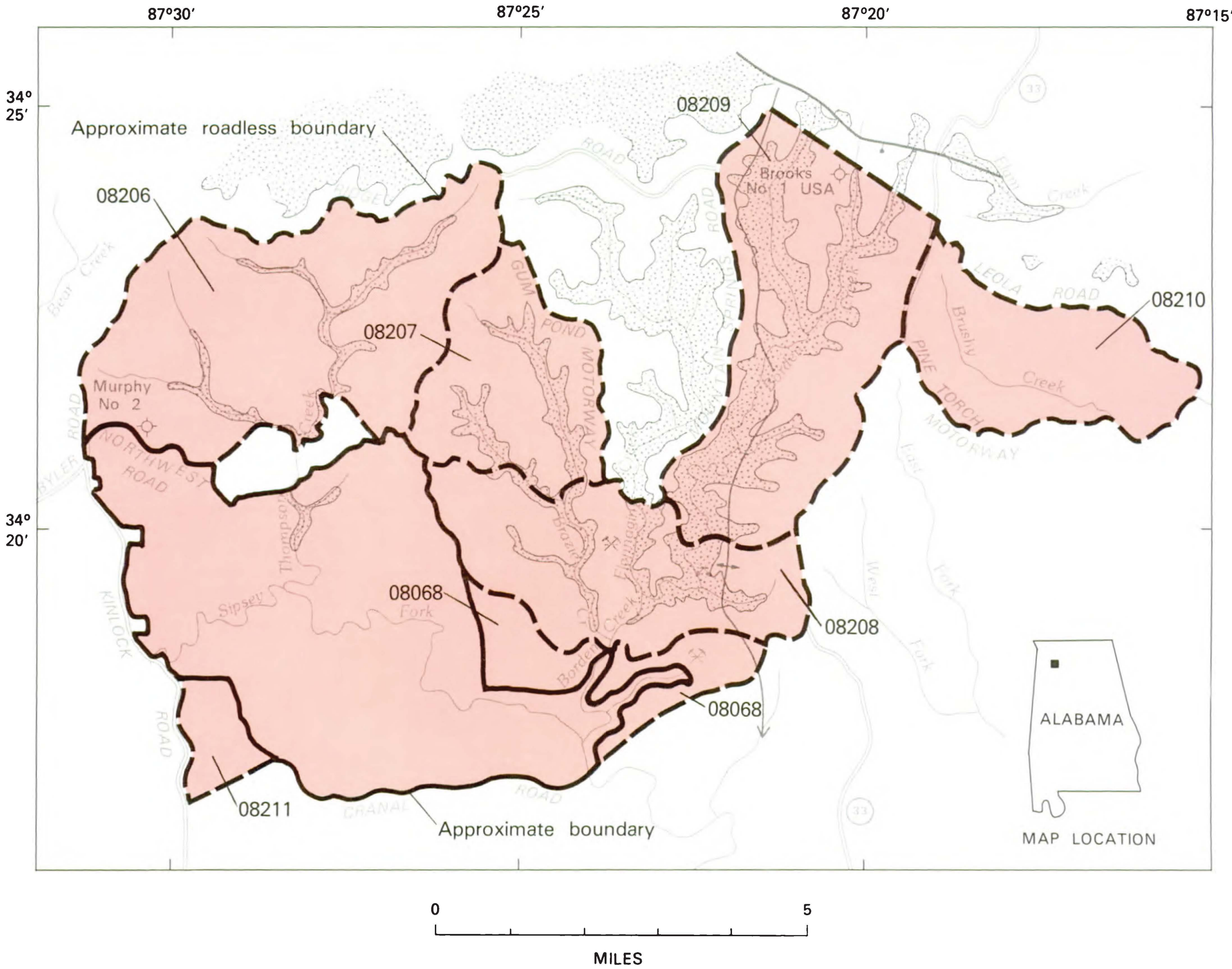
The combined Sipsey Wilderness and seven roadless areas, hereinafter called the study area, comprise about 66 sq mi in the William B. Bankhead National Forest, Lawrence and Winston Counties, Alabama. These tracts are about 14 mi south-southwest of Moulton, Alabama, the county seat of Lawrence County. The U.S. Government owns about 95 percent of the surface and mineral rights in the study area. A mineral survey was made in 1978–79 and the results were published by Schweinfurth and others (1982).

The study area lies in the Cumberland Plateau section of the Appalachian Plateaus physiographic province and is near the northern edge of the Warrior coal field. It is situated in the most rugged part of the north-central section of Alabama and is traversed by deeply incised stream valleys with high, rock-cliff walls which contain numerous rock shelters and caves, and an occasional natural bridge or stand of rock pinnacles. Altitudes of the plateau surface in the study area range from about 1050 ft along the northern boundary to about 880 ft along Cranal Road on the south. Topographic relief averages approximately 400 ft throughout the study area.

[1]With contributions from Robert B. Ross, Jr., and Paul T. Behum, USBM.

About 880 ft of Upper Mississippian to upper Lower Pennsylvanian sedimentary rocks crop out in the study area, and as much as 6800 ft of older Paleozoic sedimentary rocks may be present in the subsurface (Schweinfurth and others, 1981). The basal part of the exposed section consists of marine limestone assigned to the Bangor Limestone of Late Mississippian age. Overlying rocks of the Parkwood (Pennsylvanian) and the Pottsville (late Early Pennsylvanian) Formations consist of interbedded, coarse- to fine-grained, clastic continental and marine rocks. The Parkwood Formation crops out along valley walls and the Pottsville Formation forms the upland throughout the study area. The Bangor Limestone is separated from the overlying Parkwood Formation by an erosional unconformity, which may be angular in the eastern third of the study area. The Parkwood in turn is separated from the overlying Pottsville Formation by an erosional unconformity that is angular in the eastern third of the area. Deposits of locally derived colluvium mantle the valley walls. Alluvium, consisting of unconsolidated clay, silt, sand, gravel, and large boulders, lies along the valley floors.

The strata of the western part of the study area dip to the south at an average rate of about 55 ft/mi. The eastern part of the area is dominated by a low-relief, southward-plunging structural nose. The average plunge of the crest of this nose is about 40 ft/mi to



EXPLANATION

Geologic terrane with probable oil and gas potential

Dry oil and gas test-hole

Rocks of Pennsylvanian age

Rocks of Mississippian age

Contact

Fault--Bar and ball on downthrown side

Structural nose of anticline, showing direction of plunge--Approximately located

Abandoned coal adit

Abandoned quarry

Figure 6.—Sipsey Wilderness and Additions, Alabama.

the south. The nose is believed to be the result of at least two periods of local uplift during Early Pennsylvanian time followed by southward tilting in post-Pennsylvanian time. A large positive gravity anomaly and a large positive magnetic anomaly are associated with the structural nose. No faults were found in the study area, but evidence from nearby areas suggests that normal faults having throws of as much as 100 ft may exist within it.

MINERAL RESOURCES

Limestone is the major resource found in the Sipsey Wilderness and additions and a large tonnage has been quarried from the Bangor Limestone near the study area, although most quarries have been abandoned. Road-abrasion and polish tests indicate the limestone is suitable for road metal and paving aggregates. Because of its durability and lack of porosity, the limestone may also be suitable for dimension stone. The USFS has quarried the Bangor Limestone for road metal and for construction of bridge abutments but in recent years crushed stone has been trucked in from quarries outside the national forest. Chemical analyses of sampled beds indicate that they have a high calcium-carbonate content, and are low in silica and magnesium carbonate (Mory and others, 1981). However, limestone resources are not shown on the map because extensive deposits of Bangor Limestone occur north of the study area in the Moulton Valley where they are more favorably located relative to transportation routes and potential markets.

Large resources of clay, shale, and sandstone are present within the study area in the Parkwood and Pottsville Formations. Preliminary ceramic tests of clay and shale samples show that all samples were suitable for structural clay products such as building brick, floor brick, and tile. Five samples bloated during quick-fire tests and may indicate materials suitable for expanded lightweight aggregate. These commodities also are not shown on the map because similar materials are available outside the area closer to transportation routes and markets.

Thick beds of high-silica sandstone occur within the study area and some thinner beds of quartzose, feldspathic, and ferruginous sandstone also occur. Weakly cemented high-silica sandstone may be suitable for use as filter, furnace, molding, and abrasive (sand-blasting) sand, and low-grade glass sand. Other potential uses include construction sand, filler sand, and engine (traction) sand. Some dense, well-cemented sandstone may be suitable for rough building stone, or dimension stone. Access to the sandstone within the study area is poor and more accessible sandstone resources are widely distributed throughout northern Alabama.

As many as five thin, nonpersistent coal beds may be present in the Parkwood Formation in or near the study area. Of the five coal beds observed within the study area, only two beds are between 14 in. and 28 in. thick and contain demonstrated resources of coal; the remainder are less than 14 in. thick. Demonstrated coal resources are separately estimated for coal beds more than 28 in. thick and for coal in beds between 14 and 28 in. thick. Areas underlain by beds less than 28 in. but more than 14 in. thick, despite their contained coal, are not shown on the map. Analyses of weathered coal samples from one of the beds indicate that the bed has a high ash content and a low to high sulfur content. The demonstrated coal resources of the area underlain by the two beds are estimated to be 727,000 short tons. Both coal beds are exposed in relatively steep valley walls where they are overlain by a thick sequence (as much as 300 ft) of massive beds of sandstone and shale. Coal has been mined for local domestic and blacksmithing use but no attempt was made to quantify the amount of coal removed from the study area; past mining is considered negligible.

Heavy oil, dead oil, oil staining, and shows of natural gas have been reported from several rock units penetrated by tests drilled in or near the study area, but neither oil nor natural gas has been produced. The structural nose in the eastern part of the area does not show closure at the surface but it is associated with strong geophysical anomalies and may contain closure at depth. Normal faults which are present near and possibly within the study area could produce structural traps in the subsurface in conjunction with the structural nose. Normal faults alone may also produce structural traps in the regionally southward dipping strata lying to the east and west of the stuructural nose.

The structural nose has been tested by only one drill hole, the Brooks No. 1 U.S.A. (State permit No. 919), which was drilled to a total depth of 1815 ft in Upper Ordovician rocks. Oil shows were reported in the Bangor Limestone, Hartselle Sandstone, and Tuscumbia Limestone of Mississippian age. This test well did not penetrate the entire stratigraphic sequence reported to have had shows of oil and gas in other tests in northern Alabama. For example, a large show of natural gas was recorded in rocks of the Knox Group of Ordovician and Cambrian age penetrated in a test well (State permit No. 2284) about 8 mi southwest of the study area. The Knox is considered by Haley (1981) to have the best possibility for the discovery of oil or gas in the area, but it was not reached in the Brooks test well. One other test hole was drilled in the study area. The Murphy Oil Corp. test No. 2 (State permit No. 1587), was completed as a dry hole at a depth of 908 ft in the upper part of the Hartselle Sandstone. Slight shows of oil and asphalt were reported in the Hartselle. The Sipsey Wilderness and additions is assessed as having a probable oil and gas resource potential.

Limestone and sandstone beds of Mississippian age contain potentially valuable tar-sand deposits in northern Alabama. Asphaltic sandstone has been mined from outcrops of the Hartselle Sandstone in northern Lawrence County and used as road metal (Haley, 1981). However, the Hartselle does not crop out in the study area and the two tests drilled in the study area did not penetrate any major tar-sand impregnated intervals.

No metallic mineral deposits were identified in the study, and none have been reported in the literature. A geochemical survey of the area disclosed no major geochemical anomalies (Grosz, 1981).

SUGGESTIONS FOR FURTHER STUDIES

The available geologic, geochemical, and geophysical data indicate that there is little promise for the occurrence of metallic mineral resources in the study area. Oil and gas resources may underlie the area, but additional exploration, especially deep drilling, is necessary before the area can be fully evaluated.

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Location of areas studied.

ALASKA

Map No.	Name of Area
1	Chugach National Forest, study areas
2	Glacier Bay National Monument Wilderness study area
5	Granite Fiords Wilderness study area
4	Tracy Arm-Fords Terror Wilderness study area and vicinity
3	Western Chichagof and Yakobi Islands Wilderness study area

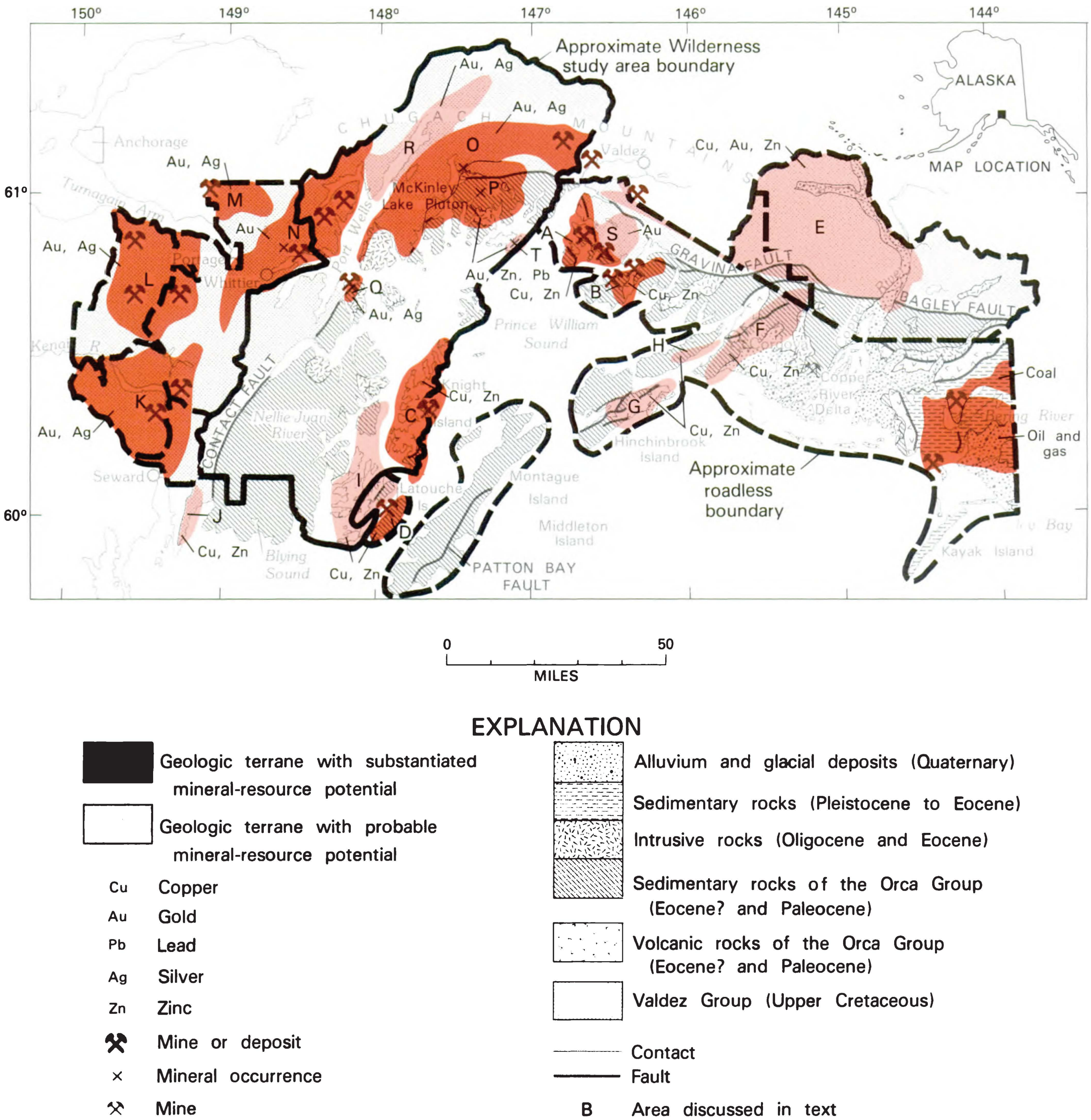

Figure 7.—Study areas within the Chugach National Forest, Alaska.

STUDY AREAS WITHIN THE CHUGACH NATIONAL FOREST, ALASKA

By STEVEN W. NELSON, U.S. GEOLOGICAL SURVEY, and

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SUMMARY

A multidisciplinary mineral survey conducted from 1979-82 in the Chugach National Forest wilderness study lands, including roadless areas and the College Fiord-Nellie Juan Wilderness Study Area, has determined that there are areas with substantiated resource potential for gold, silver, copper, and zinc and areas with probable resource potential for all of the above metals as well as molybdenum, nickel, manganese, chrome, antimony, and lead. Areas in the southeast part of the national forest have substantiated potential for coal, oil, and gas resources.

CHARACTER AND SETTING

The Chugach National Forest, located in the Kenai-Chugach Mountains physiographic province of Alaska is an area of about 9000 sq mi. It is located 45 mi by road from Anchorage. The towns of Whittier and Cordova are within the forest boundary; Valdez lies north of the national forest.

Much of the region encompasses Prince William Sound, one of the largest embayments in the coast of Alaska. The area was extensively glaciated and glaciers are still present in the Chugach Mountains which attain an altitude of 13,250 ft within the forest.

The Chugach National Forest is underlain principally by two major geologic units, the Valdez Group (Upper Cretaceous) and the Orca Group (Paleocene to Eocene?). Both groups consist of metamorphosed graywacke, siltstone, and shale in deposits forming marine turbidites. They also include mafic complexes consisting of sheeted dikes, pillow basalt flows, and minor gabbro and ultramafic bodies. Sedimentary rocks younger than the Orca Group range from Eocene to Pleistocene in age. These rocks were deposited in a continental margin basin where marine regression and transgression took place during the middle Eocene and possibly during the early Miocene and are only exposed in the southeastern part of the forest.

Plutonic rocks were emplaced in the Eocene and Oligocene. Most of the plutons are granitic in composition, but an early phase of the Oligocene plutons ranges in composition from quartz diorite to gabbro.

Geochemical surveys were conducted to help identify the resource potential of the national forest (R. J. Goldfarb and Peter Folger, written commun. 1982; R. J. Goldfarb and others, written commun., 1982; Jansons, 1981). Stream-sediment, panned concentrate, rock, and mineral samples were collected and analyzed. Suites of elements present in anomalous concentrations were used to assist identification of areas with potential for the various types of mineral resources which occur within the national forest.

A gravity study shows a regional decrease in gravity from south to north and west, of about 130 milligals, which probably represents an approximate 12-mi increase in crustal thickness between the Continental Shelf and the Chugach Mountains. A major gravity feature that is well developed is an arcuate high that trends northward from Elrington Island, through Knight Island and apparently connects with an eastward trend from Glacier Island through Ellamar and further eastward. This gravity high roughly coincides with outcrops of the Orca Group mafic volcanic rocks, and indicates a thickness of as much as 6.5 mi for these rocks. Regional gravity data in this area is probably not useful for detailed analysis or detection of local mineralization.

The aeromagnetic survey data show a pair of regional gradients defined by contours almost paralleling the northern and western boundaries of the national forest and indicating a decreasing field strength to the north and west. Almost all of the other major features of the magnetic data seem to be associated with the distribution of the more magnetic mafic volcanic rocks. Most granitic plutons seem to have weak magnetic signatures and low susceptibilities. The Perry Island pluton has the strongest magnetic expression of these plutons and has several unique features including minor amounts of tungsten in associated quartz veins.

Placer gold was discovered on the Kenai and Russian Rivers in 1848. Placer mining began in the Hope area in about 1896 and continued into the early 1900's. Since 1980, 15–20 placer operations producing 1000–2500 oz gold/year were active during the 3- to 4-month mining season in the Kenai Peninsula area. Currently approximately 1860 placer claims are located within the Chugach National Forest. Lode gold has been mined at several places in the national forest. The first lode claims were located in 1898. Although production figures are incomplete, an estimated 264,400 oz of gold has been recovered from the national forest from both lode and placer sources.

Copper prospects have been developed in the area since 1897 and substantial production has come mainly from four mines and minor amounts from at least 17 other operations. Production from the national forest is estimated at nearly 206,400,000 lb of copper; silver and gold were also recovered from copper ores.

Coal was produced intermittently in the early 1900's from the southeastern part of the national forest. About 20,000 tons were extracted.

Petroleum exploration started in 1901, and oil was produced from the southeastern part of the national forest and refined at Katalla from 1904 to 1933. Production was nearly 154,000 barrels.

MINERAL RESOURCES

The principal areas of probable and substantiated resource potential for base and precious metals are made up of Valdez and Orca Group volcanic and sedimentary rocks. Although it has been commonly accepted that the Valdez and Orca Groups represent two different mineral provinces (Tysdal and Case, 1982), the Valdez Group characterized by gold mineralization and the Orca Group characterized by copper mineralization, the current study indicates that both kinds of mineralization occur in each group. Substantiated resource potential for base or precious metals occurs in 11 areas and 9 additional areas have probable resource potential for base or precious metals. Numerous mines with demonstrated resources are shown on the map.

Four areas have substantiated resource potential for copper-zinc sulfide deposits (areas A-D, on map) that are spatially related to mafic volcanic rocks. The base-metal sulfide deposits may represent sites of submarine thermal hot springs which provided both the sulfur and the metals by leaching from ocean floor sediments and underlying rocks. Six additional areas have probable potential for copper-zinc sulfide deposits (areas E-J). Additional resource potential for lead, nickel, chrome, gold, and silver would occur in these areas.

The geology of the gold mineralization is somewhat more complex. Gold in the Valdez Group is found in quartz veins that have been dated at 53 million years which cut sedimentary rocks, and quartz veins in 34-million-year-old plutons in the Port Wells district. Within the Valdez Group sedimentary rocks, the gold-bearing quartz veins occur along fractures and shears which crosscut regional structure and fabric. Seven areas of substantiated precious-metal resource potential (areas K-Q) and three areas of probable precious-metal potential (areas R-T) are in the Valdez Group rocks. In the Orca Group, gold mineralization is restricted to quartz veins cutting sedimentary rocks near the 51-million-year-old McKinley Lake pluton, quartz veins cutting greenstone on Culross Island, and on Bligh Island and Blue Fiord. These areas have a substantiated base- and precious-metal resource potential. Favorable conditions for gold mineralization were met both near granitic plutons of both Eocene and Oligocene age, and regionally where the rocks were subjected to low greenschist facies metamorphic conditions. Mineral-resource potential for copper, lead, zinc, molybdenum, arsenic, and antimony as byproducts occur in the areas of precious-metal resource potential.

Placer gold resources are principally confined to the Kenai Peninsula area on the west side of the national forest, although occurrences have been identified in almost all of the metal-bearing resource potential areas. These areas are not shown on the map because of problems of scale.

Extensive coal deposits occur in rocks in the Bering River area on the east side of the national forest. Although the extent of the field is great and structurally complex, large tonnages of minable coal appear to be present. The area is classified as one of substantiated coal resource potential; the coal rank includes bituminous, semianthracite, and anthracite.

The Katalla area, just south of the Bering River area, is one of substantiated potential for oil and gas. Although the production of the Katalla field over a 30-year period was relatively small, and the complex structure and lack of suitable reservoir rocks in the area suggest that major fields are unlikely. The past history of production and abundant surface evidence—including oil and gas seeps—may indicate that continued exploration is warranted.

SUGGESTIONS FOR FURTHER STUDY

Future study in the Chugach National Forest should focus on several aspects of the geology and mineral-resource occurrences to improve the understanding of the deposits. The determination of sedimentary facies associated with sedimentary hosted copper deposits would help to identify areas of greatest resource possibility. A study of stable isotopes in massive sulfide deposits is needed to better define genesis of the deposits. The study of the low-flow ground-water component of glacial melt would assist in the geochemical assessment of areas with extensive glacial cover. A study of stratigraphic units and sedimentary facies of the Orca Group would help to decipher controls for mineralization. An investigation of the relationship of metamorphic grade to the gold lode deposits and evaluation of zinc and barium geochemical anomalies found on Kayak Island and in the Don Miller Hills is needed to better assess resource potential. A study of textural and geometric relationships of sulfide minerals from deposits in shear zones and from unsheared areas will provide for a better understanding of the structural controls of sulfide mineralization. The study of the trace elements in sulfide minerals, and an attempt to establish timing of sulfide mineralization in sediment and volcanic hosted sulfide deposits is needed for a better understanding of the genesis and distribution of these resources.

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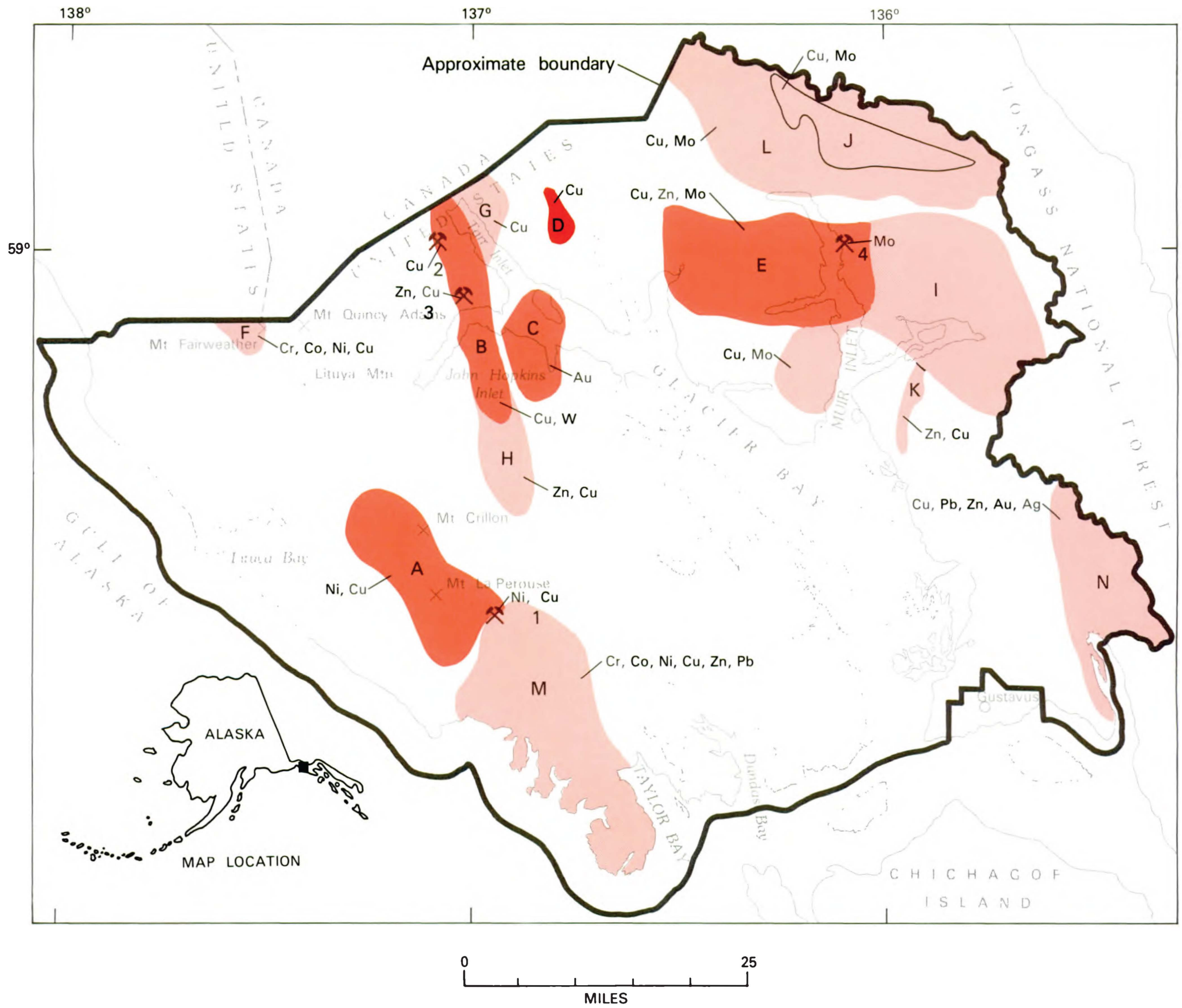

EXPLANATION

(dark)	Geologic terrane with substantiated mineral-resource potential
(light)	Geologic terrane with probable mineral-resource potential
Cr	Chromium
Co	Cobalt
Cu	Copper
Au	Gold
Pb	Lead
Mo	Molybdenum
Ni	Nickel
Ag	Silver
W	Tungsten
Zn	Zinc
⚒	Mine or deposit
B	Location discussed in text

Figure 8.—Glacier Bay National Monument Wilderness study area, Alaska.

The Brady Glacier nickel-copper deposit (no. 1 on map) is a largely glacier covered magmatic-segregation sulfide occurrence in peridotite and gabbro at the base of a layered gabbro complex of unknown age in the Crillon-La Perouse area. The deposit is estimated to contain 90 million tons of demonstrated resources of 0.53 percent nickel, 0.33 percent copper, and resources of platinum group metals. An additional 90 million tons of resources of the same grade are also likely to be present.

The Margerie Glacier copper deposit (no. 2) is a fairly well exposed porphyry-copper occurrence in granitic rocks of probable Tertiary age. The deposit is estimated to contain 160 million tons of demonstrated resources of 0.2 percent copper, 0.008 oz gold/ton, 0.13 oz silver/ton, and 0.01 percent tungsten. Higher grade sulfide-bearing quartz veins occur within this large volume.

The Orange Point deposit (no. 3) is interpreted to be a volcanogenic zinc-copper sulfide occurrence. The host rocks are moderately well exposed metamorphosed andesites of late Paleozoic or Mesozoic age. The deposit is estimated to contain 270,000 tons of demonstrated resources of 2.7 percent copper, 5.2 percent zinc, 0.03 oz gold/ton, and 1.0 oz silver/ton, and an additional 530,000 tons of demonstrated resources of 0.4 percent copper, 0.3 percent zinc, 0.006 oz gold/ton, and 0.35 oz silver/ton.

The Nunatak molybdenum deposit (no. 4) is a porphyry-molybdenum occurrence in hornfels of original early to middle Paleozoic age and is probably related to nearby Tertiary granitic bodies. The well-exposed deposit is estimated to contain 145 million tons of demonstrated resources of 0.04 to 0.06 percent molybdenum and 0.02 percent copper accessible to surface mining, and an additional 9.1 million tons of demonstrated resources containing 0.06 percent molybdenum and 0.02 percent copper below sea level near shoreline. Within this volume is a potentially important higher grade section.

In addition to the four known deposits, five areas within the monument are considered to have substantiated mineral-resource potential: the Crillon-La Perouse nickel-copper area (A, on map), Margerie Glacier porphyry copper area (B), Reid Inlet gold area (C), Rendu Glacier copper area (D), and Muir Inlet copper, zinc, and molybdenum area (E).

Six areas considered to have probable mineral-resource potential are recognized within the monument. They are, from west to east, the Mount Fairweather chrome, cobalt, nickel, and copper area (F), Margerie Glacier northeastern extension copper area (G), Margerie Glacier southern extension zinc-copper area (H), Muir Inlet extension copper and molybdenum area (I), Casement Glacier porphyry copper and molybdenum area (J), and White Glacier zinc and copper (K) favorable areas.

Three other areas are also believed to have probable mineral-resource potential as they contain previously unknown geochemical and (or) geophysical anomalies that may indicate the existence of undiscovered resources. The anomalies which have not been field checked are porphyry copper and molybenum (L), chrome, cobalt, nickel, copper, lead, and zinc (M), and copper, lead, zinc, silver, and gold (N).

SUGGESTIONS FOR FURTHER STUDIES

There are a few areas in the northern part of the monument that have not yet been mapped in even reconnaissance fashion, a great many intrusive bodies of undetermined Jurassic or Cretaceous age that are critical to the definition of contrasting intrusive belts, and a major ancient suture zone; all of these may have had direct or indirect effects on the mineralization and more detailed studies would improve our understanding of the resource potential.

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GRANITE FIORDS WILDERNESS STUDY AREA, ALASKA

By HENRY C. BERG, U.S. GEOLOGICAL SURVEY, and

TOM L. PITTMAN, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys in 1972–73 and in 1975–78 of the Granite Fiords Wilderness study area revealed areas with probable and substantiated mineral-resource potential. In the northeastern sector, areas of probable and substantiated resource potential for gold, silver, and base metals in small, locally high grade vein and disseminated deposits occur in recrystallized Mesozoic volcanic, sedimentary, and intrusive rocks. In the central part, areas of probable resource potential for gold, silver, copper, and zinc in disseminated and locally massive sulfide deposits occur in undated pelitic paragneiss roof pendants. A molybdenite-bearing quartz vein has been prospected in western Granite Fiords, and molybdenum also occurs along with other metals in veins in the northeastern sector and in geochemical samples collected from areas where there is probable resource potential for low-grade porphyry molybdenum deposits in several Cenozoic plutons. No energy resource potential was identified in the course of this study.

CHARACTER AND SETTING

The Granite Fiords Wilderness study area is in southeastern Alaska, about 35 mi northeast of the town of Ketchikan. About 18 mi of the northern border is the International Boundary between Alaska and British Columbia. The area is entirely within the Tongass National Forest and encompasses about 1000 sq mi of remote, nearly virgin wilderness. There are no roads or well-developed trails in the study area. The Granite Fiords Wilderness study area was incorporated into Misty Fiords National Monument by the Alaska National Interest Lands Classification Act of 1981.

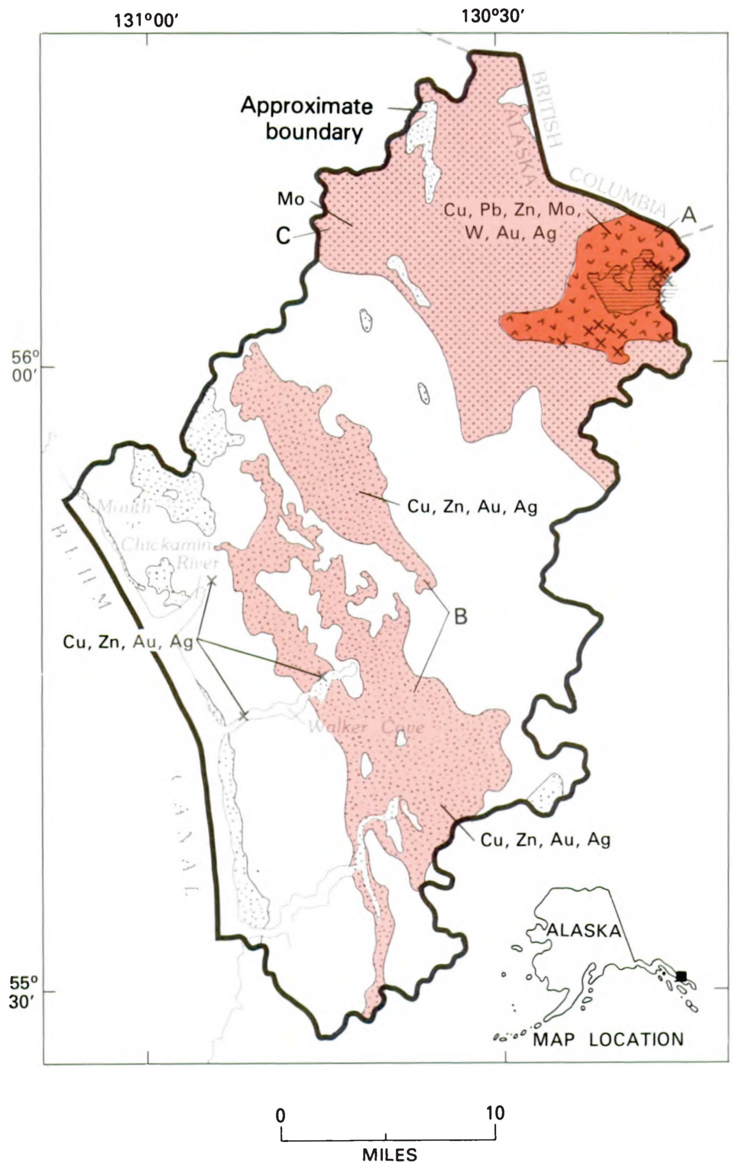
The part of the area that borders Behm Canal is accessible by boat. Elsewhere, access is by foot and helicopter, and by float-equipped airplanes that can land on several of the lakes. The northeastern part of the area can also be reached by glacier and cross-country trek from the head of an old, partly obliterated trail that leads from the village of Hyder to the eastern boundary of the study area.

The scenery in Granite Fiords is dominated by glacially sculpted features such as deep fiords and broad U-shaped valleys walled by sheer cliffs more than 3000 ft high. Most of the area was completely overridden by glacial ice, resulting in broad, rounded ridge crests. In the northern reaches, however, the mountains locally stood above the highest level of the ice and are characterized by matterhorns and knife-edged ridges, punctuated by spires and pinnacles. Small permanent snowfields and ice tongues dot the mountains throughout the study area but in the northern reaches, the land is still in the grip of glacial ice. There, only isolated spires and razor-backed ridges of bedrock penetrate the massive icefields and coalescing valley glaciers.

The average elevation of the rounded ridges is about 3000 ft. Along the deep fiords that indent the western part of the study area, these ridges rise directly from sea level, resulting in spectacular halfdomes and buttresses closely resembling those in Yosemite Valley, California. The highest peaks in Granite Fiords are along and near the northern boundary. At 7499 ft, Mount John Jay on the International Boundary is the highest, and at least half a dozen other nearby peaks exceed 6000 ft.

The climate is characterized by heavy precipitation, probably equivalent to more than 100 in. of rainfall per year. Vegetation consists of dense, nearly impenetrable rain forest at low elevations, and brush, moss, and lichen at higher levels. Significant forest cover is restricted to the area near Behm Canal and along the major river valleys.

Granite Fiords Wilderness study area lies mainly within the Coast Range batholithic complex, a terrane mainly of Mesozoic or Cenozoic plutonic rocks and of



EXPLANATION

(black box)	Geologic terrane with substantiated mineral-resource potential
(white box)	Geologic terrane with probable mineral-resource potential
Cu	Copper
Au	Gold
Pb	Lead
Mo	Molybdenum
Ag	Silver
W	Tungsten
Zn	Zinc
x	Mineral occurrence

(pattern)	Granodiorite and quartz monzonite (Tertiary)
(blank)	Undivided plutonic and subordinate metamorphic rocks (Mesozoic or Cenozoic)
(pattern)	Granodiorite (Mesozoic)
(pattern)	Andesitic volcanic and sedimentary rocks (Mesozoic)
(pattern)	Paragneiss (Age unknown)
(line)	Contact
B	Area discussed in text

Figure 9.—Granite Fiords Wilderness study area, Alaska.

elsewhere in the study area. A major prophyry molybdenum deposit currently (1982) under development about 10 mi south of the study area is in a mid-Cenozoic granite porphyry stock similar to those found in area C.

SUGGESTIONS FOR FURTHER STUDIES

Although the Granite Fiords Wilderness study area contains no productive mines or extensively explored prospects, there are two major mineral deposits close to its borders. The Granduc copper mine in British Columbia is about 1 mi from the northeastern extremity of the study area, and the Quartz Hill porphyry molybdenum deposit is about 10 miles south of the southern boundary. Our reconnaissance investigations suggest that additional detailed geochemical, geophysical, or geological mapping studies, combined with drilling or other physical exploration might reveal comparable mineral deposits within the boundaries of Granite Fiords.

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TRACY ARM-FORDS TERROR WILDERNESS STUDY AREA AND VICINITY, ALASKA

By DAVID A. BREW, U.S. GEOLOGICAL SURVEY, and

A. L. KIMBALL, U.S. BUREAU OF MINES

SUMMARY

The spectacularly scenic Tracy Arm-Fords Terror Wilderness study area lies on the southwest flank of the Coast Range about 45 mi southeast of Juneau, Alaska. A mineral-resource survey of the area in 1972–1975 identified two areas with substantiated mineral-resource potential: the Sumdum Glacier mineral belt with gold, copper, and zinc potential; and the Endicott Peninsula area with zinc, silver, and gold potential. The Sumdum Glacier belt is estimated to contain between 3 and 15 mineral deposits and there are 5 known mining areas in the Endicott Peninsula.

CHARACTER AND SETTING

The study area consists of about 1250 sq mi on the southwest side of the Coast Range in southeastern Alaska; it is about 45 mi southeast of Juneau, Alaska. An additional 550 sq mi between the study area and the International Boundary with Canada and in part contiguous with the southwest boundary of the wilderness study area, was evaluated because of its importance to the mineral-resource assessment of the area. The information presented here is abstracted from Brew and others (1977) and from a revised version of that same report (Brew and others, 1983).

The area is one of spectacular scenery, with fiords, forests, glacier-covered peaks to 8095 ft high, tidewater glaciers, icebergs, and some broad river valleys.

Studies by the USGS in 1972–1975 included reconnaissance geochemical sampling of stream sediments and rocks; and study of geologic relationships of some of the mines, prospects, and mineral occurrences. The mineral-resource evaluation also utilized an aeromagnetic survey of the area. Mining engineering studies by the USBM included mining-claim records search; onsite claim, mine, and prospect investigations; and mapping and sampling of stained zones, altered zones, and geochemically anomalous sites.

About 670 claims, approximately 90 percent of them lode, are recorded in the area studied. Seventy percent of these were within the wilderness study area. Approximately 24,000 oz of gold and probably a similar quantity of silver were produced from the Sumdum Chief lode property at the turn of the century.

Geologically, the area spans most of the Coast Range plutonic-metamorphic complex (an informal term). The Coast Range complex is bounded on the west by a long foliated tonalite sill of probable early Tertiary age; to its northeast lies the main part of the complex, consisting of a broad terrane of complexly deformed amphibolite-facies gneiss, marble, and some schist of uncertain, but probably original late Paleozoic and (or) Mesozoic age. Near the International Boundary with Canada, this terrane is intruded by a series of generally unfoliated granodiorite bodies of mid-Tertiary age which are locally associated with migmatite zones. To the west of the sill, the rocks consist of low-grade metamorphics which are locally intruded by granite and other rocks.

MINERAL RESOURCES

Almost all of the mineralization within the wilderness study area occurs in the western metamorphic belt, parallel and adjacent to the western side of the Coast Range batholithic complex (an informal term). Little significant mineralization appears to be present within the batholithic complex.

The western metamorphic belt has been recognized as having mineral-resource potential since the early 1900's when most of the occurrences investigated were located. The present study has identified two areas within this belt in the study area with substantiated resource potential for gold, copper, zinc, and silver; these are, in the order of decreasing importance, the Sumdum Glacier mineral belt and the Endicott Peninsula area.

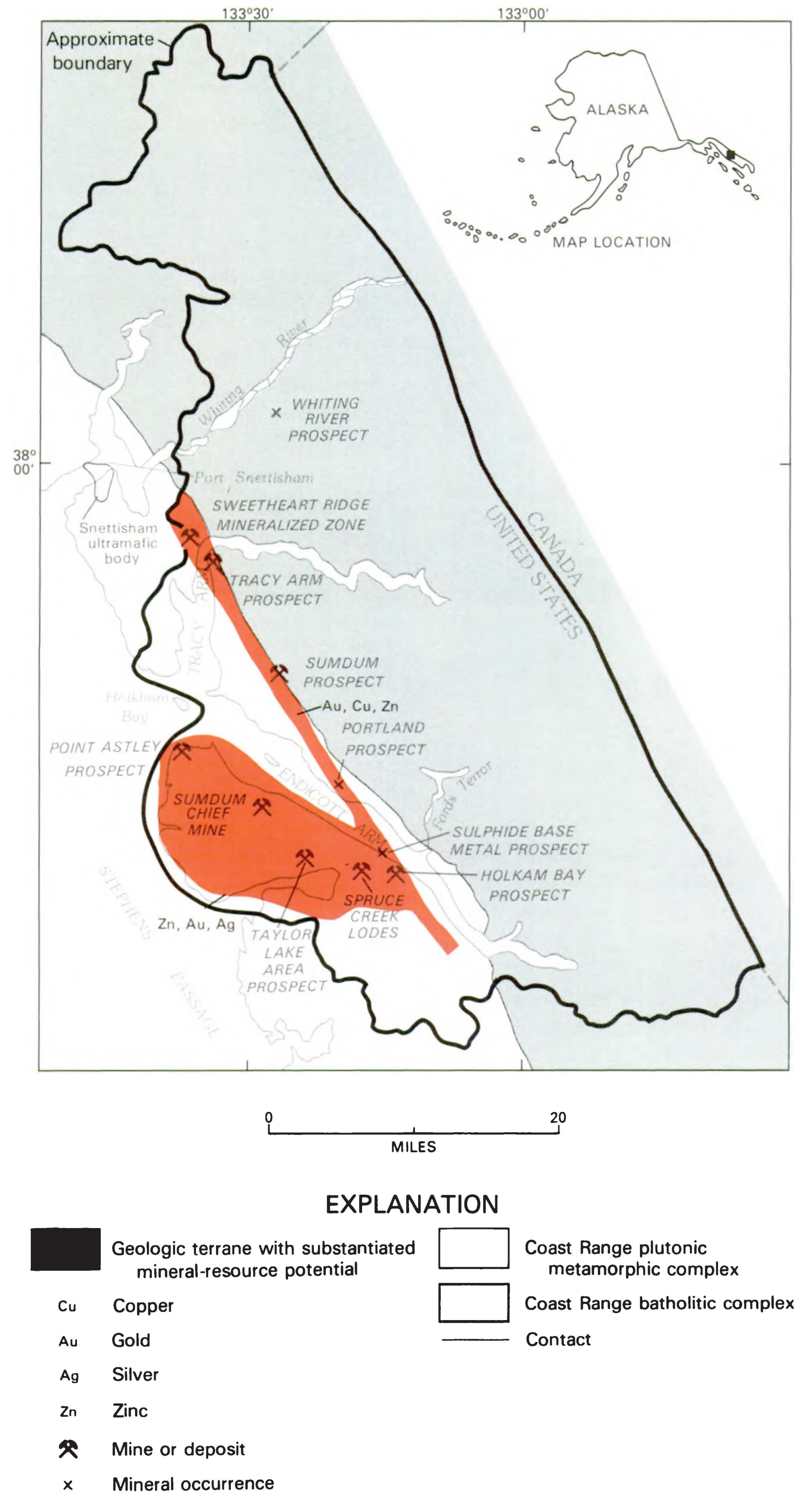

Figure 10.—Tracy Arm-Fords Terror Wilderness study area and vicinity, Alaska.

The Sumdum Glacier mineral belt extends for about 32 mi along the southwest side of the Coast Range batholithic complex and contains three known important mineralized areas: the Tracy Arm zinc-copper prospect, the Sumdum copper-zinc prospect, and the newly discovered Sweetheart Ridge gold-copper occurrence. The deposits in the belt consist of pyrrhotite, chalcopyrite, sphalerite, pyrite, galena, and some gold in lenses and pods parallel to the foliation or disseminated in the metamorphic rocks.

These three deposits have demonstrated resources and warrant further exploration. The Tracy Arm zinc-copper deposit is estimated to contain 187,000 tons of rock averaging 3.42 percent zinc, 1.42 percent copper, 0.43 oz silver/ton, and 0.008 oz gold/ton. The Sumdum copper-zinc prospect is estimated to contain 26.7 million tons of rock averaging 0.57 percent copper, 0.37 percent zinc, and 0.30 oz silver/ton. A 147-ft-long portion of the Sweetheart Ridge mineralized zone is estimated to contain 7300 tons of rock per 100 ft of depth that average 0.23 oz gold/ton and 0.7 percent copper.

The entire Sumdum Glacier mineral belt is considered favorable ground for the occurrence of mineral deposits and the available information is used to suggest, therefore, that the number of deposits that may occur is somewhere between 3 and 15. The minimum number represents the deposits described above; the additional 12 could include some of the poorly known or unexplored prospects or mineral occurrences already known in the belt.

The Endicott Peninsula area has been prospected since before 1869 and several occurrences have long been known: the Point Astley zinc-silver deposit, the Sumdum Chief gold mine, the Taylor Lake area prospects, the Holkam Bay gold prospect, and the Spruce Creek area gold lodes and placers. The deposits in the area are largely either sulfide minerals in lenses and stringers along the foliation in phyllite or disseminated through it, or gold-bearing quartz veins in shaly limestone, limy slate, or phyllite. The area, as a whole, is poorly exposed because of extensive timber and brush.

The one known significant deposit in the area consisted of gold-bearing quartz veins in shaly limestone at the Sumdum Chief gold mine. The Sumdum Chief deposit was mined before 1905; it produced about 24,000 oz of gold from ore that contained about 0.4 oz gold/ton. The other prospects and mines had very little or no production. The Taylor Lake occurrences are geologically similar to the Sumdum Chief. The Point Astley zinc-silver prospect has not been thoroughly explored. The deposit appears to be extremely irregular and the lateral and vertical continuity of the mineralized zones are not known. The gold mines and prospects near Spruce Creek occur mainly along quartz stringers in broad altered zones, and all appear to have low gold contents that only rarely exceed 0.25 oz gold/ton. The Holkam Bay prospect is similar and had some small production.

The area was studied for radioactive minerals, oil, gas, coal, and industrial mineral deposits as well as geothermal energy, but there is little promise for the occurrence of these resources.

SUGGESTIONS FOR FURTHER STUDY

Since release of the report by Brew and others (1977), several exploration companies have been active in the Sumdum Glacier mineral belt, but further work, particularly in the southern part of the belt, would be of significant help in refining the evaluation of that area. Relatively little activity has occurred in the Endicott Peninsula area; intense geochemical and geophysical work would remove many of the present uncertainties and probably would refine the present limit of the favorable areas.

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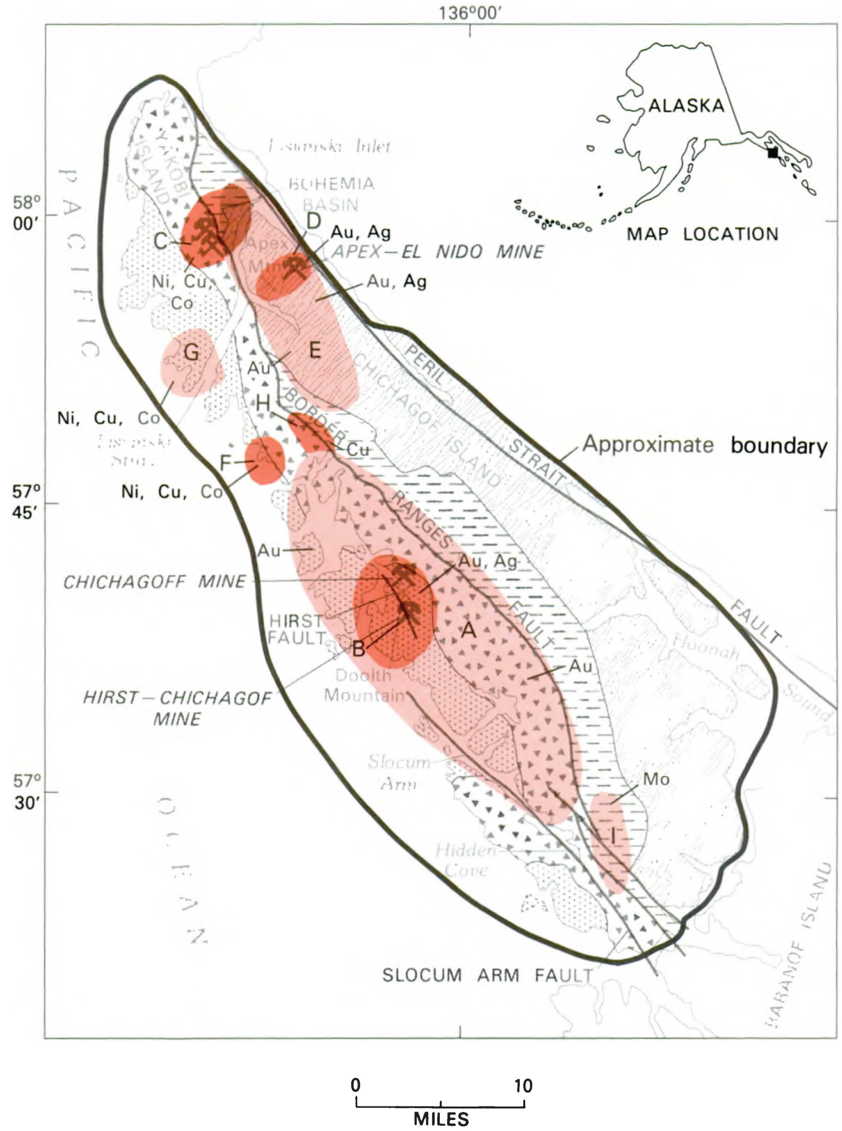

EXPLANATION

(dark pattern)	Geologic terrane with substantiated nickel, copper, and chromium resource potential and probable gold resource potential
(dark pattern)	Geologic terrane with substantiated mineral-resource potential
(blank)	Geologic terrane with probable mineral-resource potential
Co	Cobalt
Cu	Copper
Au	Gold
Mo	Molybdenum
Ni	Nickel
Ag	Silver
⚒	Mine or deposit

	Sitka Graywacke (Cretaceous)
	Kelp Bay Group (Cretaceous)
	Greenstone and marble (Triassic)
	Metavolcanic and metasedimentary rocks (Paleozoic and Mesozoic)
	Contact
	Fault
B	Area discussed in text

Figure 11.—Western Chichagof and Yakobi Islands Wilderness study area, Alaska.

mining district. The occurrences are in weakly metamorphosed sedimentary and volcanic host rocks of the Kelp Bay Group and the structurally overlying Sitka Graywacke. The host rocks are cut by numerous strike-slip and thrust(?) faults and mineralization in the form of hydrothermal gold-quartz veins commonly occurs along northwesterly striking, steeply dipping shear zones within graywacke, schist, and marble. Numerous precious-metal prospects occur within area A and several small mines have produced small amounts of gold and silver. There is a probable resource potential for additional occurrences of gold along faults in this area. Area A surrounds a center of mining activity and production at Doolth Mountain (B). This area has substantiated gold and silver resource potential and contains the Chichagoff and Hirst-Chichagof mines, which have demonstrated resources of 316,000 oz gold and 88,000 oz silver, almost all of the gold resources of the study area.

The Chichagoff mine is located along the Chichagof fault, which has a traceable strike length of at least 12 mi. The mine opened in 1905 and closed in 1942 with a recorded production of 660,000 oz of gold and 200,000 oz of silver from over 600,000 tons of ore. The mine and adjacent mineralized area consists of 29 patented claims and ranks as the third largest lode-gold producer in Alaska. Mining reached a depth of 2700 ft below sea level, and underground workings explore the fault for 4800 ft in a horizontal direction and 4300 ft vertically. Twenty-three percent of the area explored by underground workings was mined. Almost all mine workings are currently inaccessible.

The Hirst-Chichagof mine is along the Hirst fault which is parallel to and approximately 0.8 mi southwest of the Chichagof fault. The property was staked in 1905 and operated from 1922 to 1943. The structure is explored along 5000 ft of strike, as much as 2200 ft vertically and mining reached a depth of 1800 ft below sea level. It produced 131,000 oz of gold and 33,000 oz of silver from over 140,000 tons of ore. Old records indicate that less than ten percent of the area explored by underground workings was mined. Almost all the old workings are currently inaccessible. The mine and adjacent mineralized area are partially covered by 12 patented claims.

The Lisianski Gold area of probable gold and silver resource potential (area E) is characterized by gold-quartz occurrences along northeast-striking faults, fractures, and shear zones in diorite, amphibolite, greenstone, and schist within the belt of Mesozoic or older metamorphic rocks. Area E includes five properties that produced about 18,000 oz of gold and 2,500 oz of silver and twelve others with reported gold occurrences. Based on gold production area D is an area of substantiated gold and silver resource potential which contains a number of gold occurrences (130 recorded claims), including the Apex-El Nido mine, and is the most important portion of the Lisianski Gold area (E).

The Apex and El Nido gold-bearing quartz veins were discovered in 1919 and 1920, respectively, and produced about 17,000 oz of gold and 2400 oz of silver in the periods 1924–28, 1934–35, and 1937–39. Currently, there are 41 unpatented lode and 3 placer claims, mostly on the northeast side of Apex Mountain. The deposits consist of steeply dipping, gold-bearing quartz veins, 1 to 4 ft thick, along faults in diorite and amphibolite. Sporadically distributed scheelite ($CaWO_4$) also occurs in the veins.

Nickel-copper-cobalt deposits occur in 3 areas having resource potential in the wilderness study area (two substantiated and one probable). The deposits are massive sulfide magmatic segregations in noritic and gabbro-noritic facies of composite Tertiary(?) stocks that are generally potassium poor and vary widely from tonalite to norite. The stocks intrude Cretaceous metavolcanic and metasedimentary rock of the Kelp Bay Group and turbidites of the Sitka Graywacke. Contact metamorphic halos surround the stocks. The deposits consist generally of pentlandite, chalcopyrite, and pyrrhotite in either massive or disseminated bodies. The massive sulfide bodies are podlike, small, and difficult to explore or delineate without extensive drilling.

Bohemia Basin is an area of substantiated nickel-copper-cobalt resource potential (area C), on Yakobi Island. It is the largest of the three known nickel-copper-cobalt areas and 980 mining claims have been recorded since 1920, of which 265 are unpatented active claims and 9 are patented claims. Extensive surface exploration and more than 50,000 ft of diamond drilling have partially delineated three mineralized bodies. The two largest bodies in this area are reported to contain at least 20,100,000 tons of demonstrated resources averaging 0.31 percent nickel, 0.18 percent copper, and 0.04 percent cobalt (Inspiration Development Company, press release, April 3, 1978).

Similar magmatic segregations are known in an area of substantiated nickel-copper-cobalt resource potential in mafic rocks 15 mi to the southeast, on Chichagof Island near Mirror Harbor (area F). These occurrences have been known since 1911 and 330 claims have been recorded, with 114 claims presently current. Exploration, including diamond drilling, has been conducted during the past several seasons in this area and although tonnage estimates are not available, seven diamond drill holes have intercepts of nickel, copper, and cobalt similar in grade to Bohemia Basin. The Squid Bay-Lost Cove area of probable nickel-copper-cobalt resource potential (area G) is about 8 mi south of

Bohemia Basin on Yakobi Island and northwestern Chichagof Island. Host rocks at this locality are similar to the Mirror Harbor occurrences, but USBM samples from this area contain low copper values, with minor nickel and cobalt.

Ninety claims have been recorded near Mt. Baker, an area of substantiated copper resource potential (area H). The largest known concentration of copper is in a northwesterly striking vertical zone in greenstone 350 to 400 ft long. Several trenches (now sloughed), a shallow shaft, and a crosscut have been opened. Sample analyses from a trench at the southeastern end of the zone show 2.0 percent copper across a 13 ft width, and from a shallow shaft at the northwest end of the zone show 7.5 percent copper across a 2 ft width. Minor gold and silver values are also present.

The Slocum Arm Molybdenum area (I) is 1.5 mi east of Hidden Cove, at the southern end of Slocum Arm. Ten claims are currently active. Molybdenum mineralization occurs in small quartz veins, dikes, and country rock across an area 0.75 mi wide by 1.5 mi long near a dioritic intrusion. The area has probable molybdenum resource potential.

SUGGESTIONS FOR FURTHER STUDIES

Current knowledge of the detailed geology of the study area is confined to areas adjacent to the well-known mineral deposits such as at Doolth Mountain and at Bohemia Basin. The remainder of the study area is well mineralized, but the extent of mineralization is inadequately known. Detailed geologic and geochemical studies of the lesser known areas such as Squid Bay-Lost Cove, Mt. Baker, and Slocum Arm would provide a more complete resource assessment.

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