DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

ATLAS OF METAL AND NONMENTAL MINERAL PROVINCES CONTERMINOUS U. S.

OPEN-FILE REPORT

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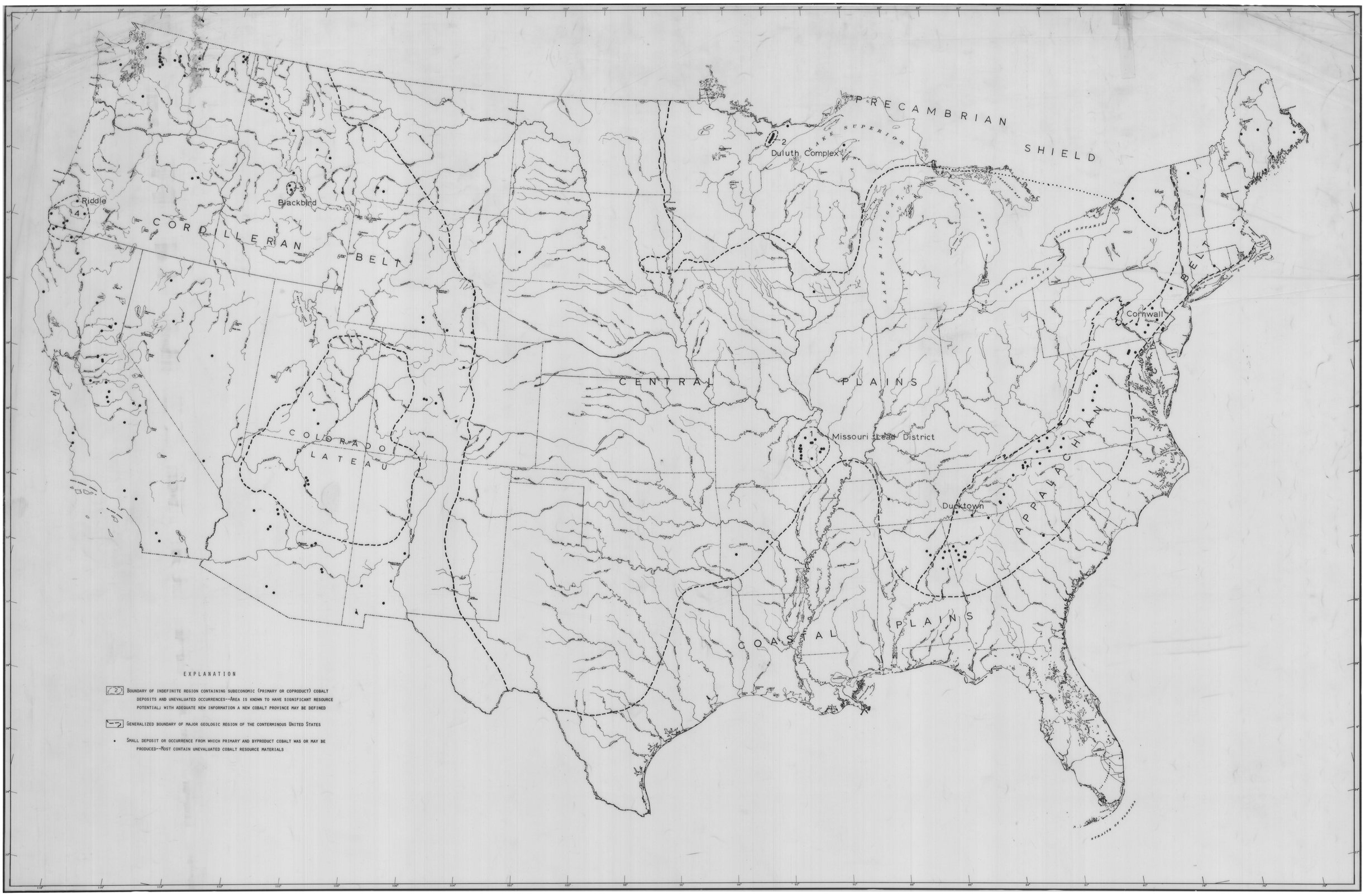
FOOSE AND McQUEEN —COBALT



Planimetric base from National Atlas 1:7 500 000, 1970

Scale 1:5,000,000

100 0 100 200 300 400 Mile

100 0 100 200 300 400 500 Kilometers

PRELIMINARY MAP OF COBALT OCCURRENCES IN THE CONTERMINOUS UNITED STATES

By

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INTRODUCTION

The map shows the known distribution of anomalous concentrations of cobalt, a metal which must be considered of critical national importance because of its use in the manufacture of jet engines. Cobalt is a hard, strongly magnetic, gray-white metal that is also important in manufacturing high-temperature alloys, superalloys, and permanent magnets. Unlike most other critical elements, cobalt is virtually never mined as a principal product; rather, it is extracted as a byproduct, primarily from the mining of copper, nickel, and silver. Cobalt production has also accompanied the mining of such diverse commodities as lead, zinc, gold, talc, and iron. The United States currently has no domestic production of cobalt, although it does have numerous occurrences of the metal which are shown on the map. This summary is intended to show how little is presently known about the distribution and quality of domestic cobalt resources, and also to show that additional geological possibilities for its presence exist and await systematic investigation. A report by Tooker (1979) discusses the rationale for the atlas of some metal and nonmental province maps, of which this a part, and some of the geologic environmental concepts and technical terms used in this report.

Although the identified resources and minable deposits of cobalt throughout the world are actually quite large and widely distributed, political and economic problems make the availability of cobalt to the United States uncertain. Principally this uncertainty is due to instability in the supply of cobalt from Zaire which, in 1975, produced 53 percent of the world's primary cobalt (Sibley, 1977) and supplied 57 percent of the total United States' imports (Sibley, 1977). Further, economic problems complicate cobalt availability because the production of cobalt is largely controlled by the market demands for copper and nickel, the primary metals with which it is usually associated. Thus, cobalt supply is not usually responsive to increases in cobalt price.

Although the United States has not produced any domestic cobalt since 1971, it is the world's principal consumer. Its 1976 requirement of over 19 million pounds (about 8,400 metric tons) of cobalt represented approximately one-third of the world's total consumption (Sibley, 1977). Most cobalt is employed in a great variety of alloys, making secondary recovery difficult, but as its price rises, some increases in recycling may be achieved. Use of other metals to substitute for cobalt is also limited, and most of the acceptable substitutes are themselves critical materials.

Within the United States, large amounts of cobalt have been identified in a number of geologically different types of deposits. Vhay and others (1973) provide more details about the geology of cobalt and the problems in locating and evaluating the nation's cobalt resources than is possible here. The resources in domestic deposits, estimated (Vhay and others, 1973) at approximately 1,480 million pounds (840 million metric tons), would be sufficient to last the nation approximately 40 years at a 3.5-percent annual growth rate. However, none of these deposits are being developed, or, if mined, cobalt is not being recovered. Thus, largely because of economic, technologic, and environmental problems, these resources are currently unavailable for use.

DISTINGUISHING MAP FEATURES

The map shows most of the known cobalt occurrences in the United States. It differs from other atlas maps as only the distribution of occurrences are shown. At this time cobalt-bearing provinces cannot be identified largely because of our very incomplete knowledge about the distribution and mode of occurrence of this metal. Map compilation involved a state-by-state review of geologic literature and summary mineral resource reports. In addition, data from Vhay and others (1973) and unpublished data collected by J. Vhay in the U.S. Geological Survey's commodity files were utilized. The assistance of George Mason, Jr., in retrieving and plotting cobalt information in the computerized resource information bank (CRIB) of the U.S. Geological Survey is acknowledged.

Cobalt localities were plotted if an area, (1) had been reported on a state mineral occurrence map, (2) had a significant concentration of cobalt (usually greater than 0.04 percent), (3) produced mineral concentrates, which contained potentially recoverable amounts of cobalt, or (4) had reported cobalt-bearing minerals in association with other ore minerals. Some metal mining districts have potentially significant cobalt occurrences (shown as numbered areas), which someday will probably become economic and the cobalt recoverable. The majority of occurrences are unevaluated, are not now of economic interest, and existing information is inadequate to assess their resources and future potentials. Because of their diversity, poor definition, and subeconomic character, all of these occurrence localities are considered to be equivalent to type C occurrences, as defined in the accompanying atlas (Tooker, 1979).

Distribution patterns shown on the map, thus, are products of our current very preliminary geologic information about the mode of occurrences and the amount of cobalt in the conterminous United States. In some geographic areas and in some types of mineral deposits, economic and other factors have been sufficient to stimulate a collateral interest in cobalt, with the result that a good deal is known about the cobalt potential of these areas. For example, the cobalt occurrences in the southeast United States represent a potential byproduct from small manganese deposits, which were the subject of a special detailed geologic study (Pierce, 1944). Similar unstudied manganese deposits containing cobalt occur throughout the country and await similar assessment. Large areas of the country have no reported occurrences, primarily because no data were available. Further systematic resource assessment investigation undoubtedly will result in the discovery of many more occurrences in these areas.

Although the United States currently has no domestic cobalt production, significant cobalt potential does exist. The occurrences plotted on this map show broad areas which should be investigated in more detail. The numbered areas represent districts that are considered to have the best potential for becoming cobalt producers. Their geologic characteristics are described individually below, and are followed by consideration of some other potential geologic types of environments. A major conclusion of this study is that an accurate assessment of the United States' cobalt resources will not be possible until a considerably improved understanding of the geology of cobalt is achieved, and a more complete assessment of cobalt-bearing environments is made.

Background information relating to this map and others in the Atlas of Metal and Nonmetal Provinces in the Conterminous United States is published as U.S. Geological Survey Circular 792 (Tooker, 1979), available free of charge from the U.S. Geological Survey, Branch of Distribution, 1200 Eads St., Arlington, VA 22202.

COBALT OCCURRENCES

Cobalt occurs in a wide variety of geologic environments, but only a few of these have traditionally been of economic interest and have significant potential as domestic sources of cobalt. In the past, the extraction of cobalt has depended on, (1) the presence of some primary commodity in sufficient quantities to be economically usable, (2) a sufficient concentration of associated cobalt, (3) the existence of a technology suitable for the recovery of cobalt, and (4) local and regional market conditions that encouraged the extraction of byproduct cobalt. The geologic types of deposits from which cobalt has been extracted are described below, and most of the occurrences shown on the map represent deposits of these kinds. Four of these types are numbered on the map and represent particularly significant regional concentrations: (1) Mississippi Valley type lead-zinc-copper ores in Missouri; (2) copper-nickel sulfide ores in an igneous complex in Minnesota; (3) hydrothermal massive replacement and vein copper-cobalt ores in Idaho; and (4) nickel-bearing lateritic soils in California and Oregon. Other types may assume importance as future sources when more is known about them in the conterminous United States.

Mississippi Valley type deposits.--Lead, zinc, and copper ores commonly containing some cobalt, occur in brecciated carbonate rocks of the Missouri lead district. Currently the cobalt is considered undesirable in lead and zinc production, and cobaltiferous ores are avoided in mining. However, given a technological advancement in cobalt extraction and recovery, these deposits could represent a major domestic source of cobalt.

Sulfide deposits in mafic igneous rocks.--Igneous intrusions of mafic and ultramafic compositions that host deposits of copper and nickel sulfide minerals may contain associated minor amounts of cobalt. Large sulfide deposits of this type are being utilized at Sudbury, Canada, and in the Soviet Union. Low-grade subeconomic occurrences of such materials occur in the Duluth igneous complex, near Ely, Minn., and represent one of the United States' greatest potential sources of nickel and byproduct cobalt.

Hydrothermal deposits.--Heated solutions moving through the Earth commonly form diverse kinds of vein and replacement deposits. The principal metals in these hydrothermal deposits may be associated with minor amounts of cobalt. Examples of this type are silver-zinc veins in the Coeur d'Alene district, Idaho, copper deposits in the Goodsprings district, Nevada, and silver-arsenide deposits near Cobalt, Ontario. A large copper and cobalt deposit that may be of this type occurs near Blackbird, Idaho, and represents one of the nation's most promising cobalt resources.

Laterite deposits.--Soils formed during the tropical weathering of ultramafic rocks (laterites) are commonly enriched in iron, nickel, and cobalt. Deposits of this kind are located in northern California and in Oregon. One of these deposits, at Riddle, Oreg., is mined for nickel, but no cobalt is recovered. Cobalt is produced from similar deposits in Cuba and in New Caledonia.

Contact metamorphic deposits.--The alteration effects caused by intrusive diabase dikes and stils in carbonate-bearing country rocks have formed the so-called contact metamorphic deposits of magnetite (iron), and chalcopyrite (copper), which contain some associated cobalt-bearing minerals. These minerals and associated iron sulfides locally have been an important source of cobalt, and until 1971, deposits of this kind located near Cornwall and Lebanon, Pa., represented one of the United States' few domestic sources of cobalt.

Sulfide deposits in metamorphic rocks.--Minerals composed chiefly of iron and sulfur (pyrite and pyrrhotite) and small amounts of cobalt occur in deposits that probably were genetically related to volcanic activity. Subsequent to their formation, most of these deposits have been altered by deformation and metamorphism. Although, they are mined principally for sulfur, iron, and copper, cobalt is recovered in some cases. Several deposits of this type occur in the Appalachian Mountains; the largest of these is at Ducktown, Tenn.

Stratabound deposits.--Stratigraphically concordant bodies containing principally copper, lead, or zinc frequently contain trace amounts of cobalt. The large copper-cobalt deposits in Zaire and Zambia are of this type and are the source of most of the world's primary cobalt. However, there are no known cobalt-bearing deposits of this type within the United States.

Seabed nodule deposits.--Cobalt also is found in several geologic environments from which it has not yet been commercially extracted. By far the most promising of these are the manganese-rich nodules found in the deep ocean basins. These nodules, which are also rich in nickel and copper, constitute one of the world's largest untapped resources of metals. Development of this resource has, however, been slowed by technological problems and by the lack of international agreements over mining in the deep oceans. On land examples of such sea bed occurrences may be in fossil nodule deposits, found in oceanic-derived crustal rocks.

Sources of lesser potential.--Other, much less economically favorable but largely unevaluated occurrences of cobalt are found in the uranium deposits of the southwest United States; associated with surface manganese deposits found principally in the southeast United States; and in some talc deposits in the northeast United States. Finally, although not shown on the accompanying occurrence map, coal beds often contain small but significant amounts of metals including cobalt. In the past, most of these metals have been separated from coal by washing and discarded. Increasing amounts of coal will be mined to meet the nation's growing energy requirements, and the byproduct recovery of some of the associated metals, including cobalt, may become economically and technologically feasible.

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