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MINERAL RESOURCE POTENTIAL OF THE NORTH END ROADLESS AREA, COCHISE COUNTY, ARIZONA

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the North End Roadless Area (03112), Coronado National Forest, Cochise County, Arizona.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The North End Roadless Area is at the north end of the Chiricahua Mountains, near the southeast corner of Arizona. The study area adjoins the north and east sides of the Chiricahua National Monument and is 4 mi southeast of the Fort Bowie National Monument (fig. 1).

The overall mineral, rock, and hydrocarbon resource potential of the North End Roadless Area is assessed as moderate, and in about 10 percent of the area the resource potential for minerals is high. The area contains or may contain one or more disseminated or stockwork-type molybdenum deposits, copper-lead-zinc-silver veins, lead-zinc-silver limestone-replacement deposits, and tungsten-bearing contact-metamorphic skarn deposits. The area also contains rocks suitable for cement manufacture and marble dimension stone but analytical data are unavailable. The area has a low potential for petroleum and natural gas, but the assessment of hydrocarbon potential must be viewed as incomplete because deep seismic data recently obtained by oil companies are not available.

INTRODUCTION

The North End Roadless Area is at the northern end of the Chiricahua Mountains, Cochise County, southeastern Arizona. It covers an area of about 40 sq mi adjacent to the north and east sides of the Chiricahua National Monument, and midway between the villages of Portal and Bowie (fig. 1).

The favorable assessment of mineral resource potential for this roadless area is supported by two types of geochemical studies (Watts and others, in press), combined with airborne geophysical studies (Moss, in press), a general geologic field study all by the U.S. Geological Survey and a study of the mines and prospects in and near the study area (Bigsby, 1983) by the U.S. Bureau of Mines. The geochemical studies include analyses of alluvial material and mineralized rock chips. Interpretations of the geochemical results were combined with the geophysical and geological mapping. A composite mineral assessment map indicates areas of differing resource potential for metallic mineral deposits.

GEOLOGY

The North End Roadless Area (fig. 2) is underlain by a wide variety of sedimentary, igneous, and metamorphic rocks, many of which are strongly deformed. In places, these rocks are mineralized or contain other materials of possible current or future economic value. Certain rock types and geologic structures are more closely associated with these mineral occurrences than others, and therefore are described in greater detail than is shown on the geologic map and its explanation. Some pertinent information on areas adjacent to the roadless area is also included here.

The selection of particular rock types or geologic structures for special emphasis herein is based on the collective experience of many geologists over a broad region around the study area. This selection neither implies that mineral deposits are present simply

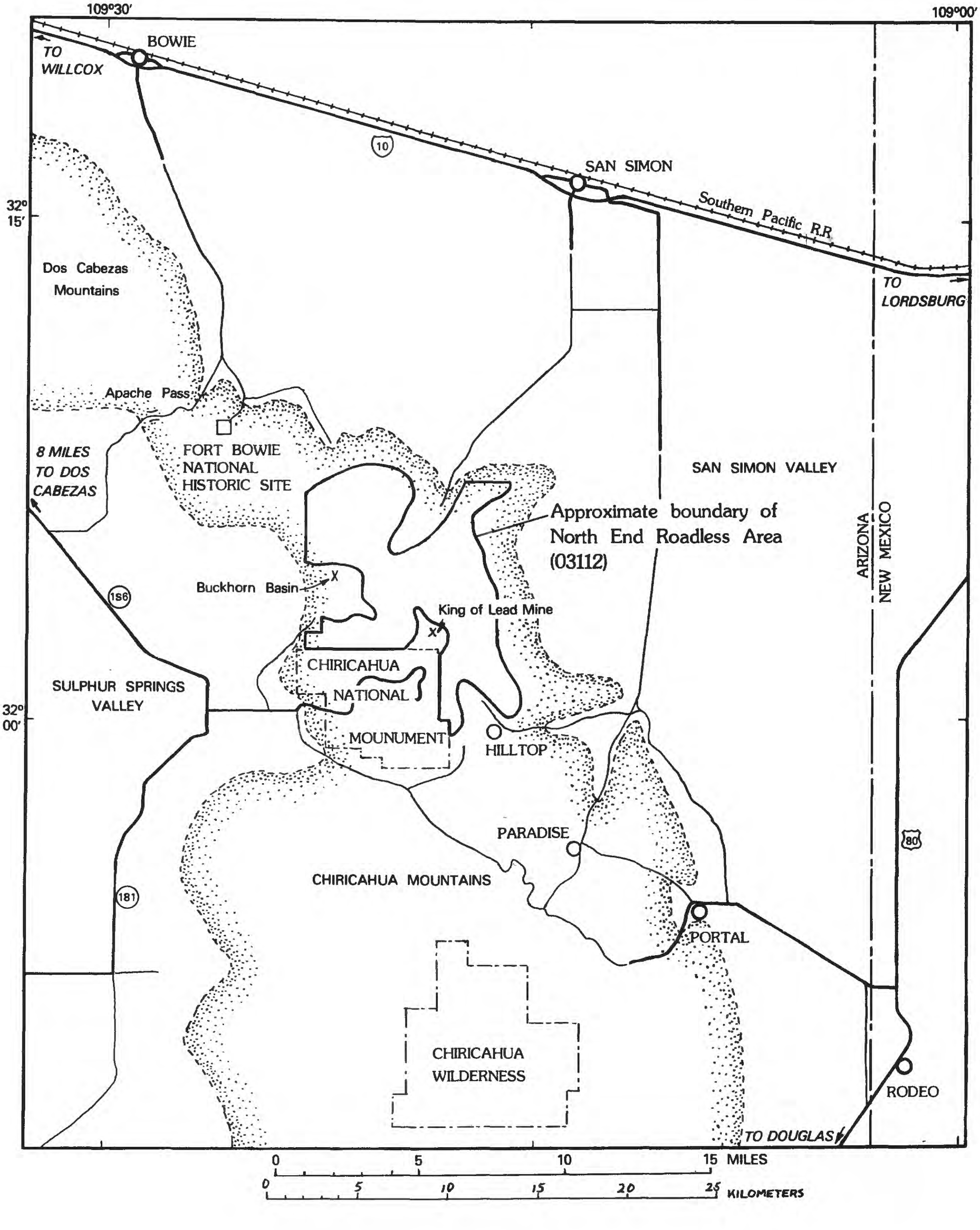

Figure 1.—Index map showing the North End Roadless Area (03112), Chiricahua Mountains, Cochise County, southeastern Arizona. Roads shown by heavy lines are paved. Shaded lines show mountain fronts.

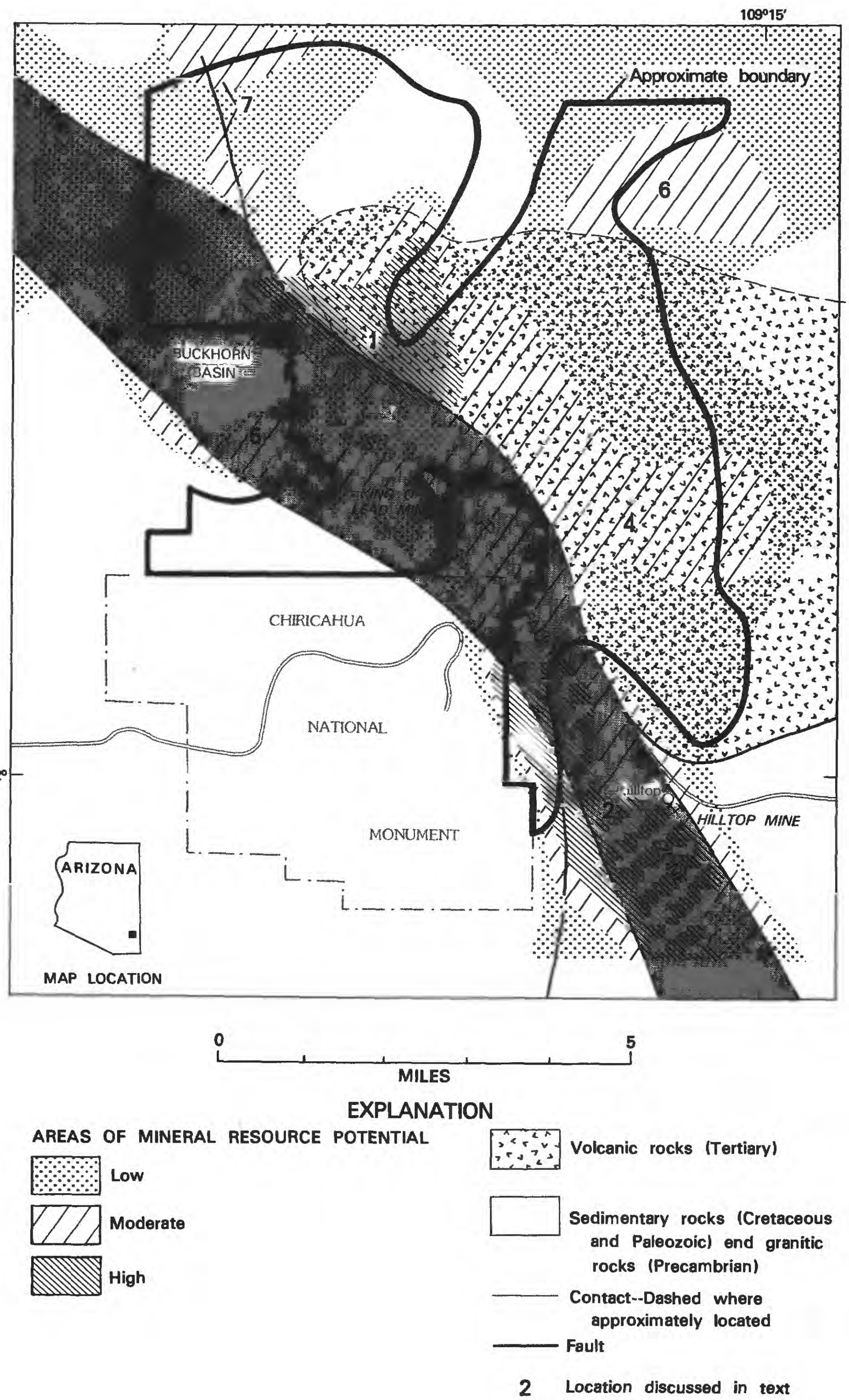

Figure 2.—Map showing mineral resource potential of the North End Roadless Area, Arizona.

because certain rocks or structures are found, nor that mineral deposits are not to be expected in other associations. Rather, these rocks and structures are meant to point to features of attraction and the reasons why they deserve this attention.

The most common types of mineral deposits in the region—disseminated porphyry, replacement or contact-replacement, pipe or stockwork, and vein—are mainly associated with Paleocene or older rocks and with rocks having suitable chemical and physical properties. Deposits of metallic minerals, most industrial minerals and building stone, and hydrocarbon fuels require conditions of heat and pressure within the crust, and possibly association with magmatic events that are commonly found only with the older rocks; only gravel, sand, clays, and a few other materials may appear in the younger rocks and surficial deposits.

Three rock types are potential hosts to the kinds of mineral deposits for which southeastern Arizona is noted: (1) alternating beds of impure limestone and sandy or shaly beds, (2) andesitic rocks, and (3) quartz latite porphyry intrusive rocks. Host rocks of type 1 occur in the Permian to Cambrian sedimentary rocks and Paleocene to Lower Cretaceous sedimentary to volcanic rocks. On more detailed maps of the area (Drewes, 1981b and 1982), such rocks are included in the upper part of the Coronado Sandstone and lower part of the overlying El Paso Formation (Cambrian and Ordovician), in part of the Devonian Portal Formation of Sabins (1957a), in the upper part of the Pennsylvanian Horquilla Limestone and overlying Lower Permian Earp Formation, and in the part of the Lower Cretaceous Bisbee Group named the Mural Limestone. Where several of these formations are present in a mineralized area, the lower beds are commonly more mineralized than the upper ones. Thus, the chemical properties of these rocks and the first limestone-bearing units encountered by rising ore fluids have determined the sites of mineralization in many nearby mining districts. In a few districts where mineralization was prolific, as at Bisbee, Arizona, to the southwest, replacement of purer limestones, such as the Mississippian Escabrosa Limestone and lower part of the Pennsylvanian Horquilla Limestone, also occurred.

Andesitic rocks (host-rock type 2) are abundant throughout the Oligocene to Lower Cretaceous volcanic sequence. The older andesites are better hosts to mineralization than the younger ones. With further geologic studies some of these geographically separated units may prove to be genetically related to each other and to the source of mineralizing fluids. Locally, along both the east and west Whitetail Canyons, andesite breccia sheets and some possible intrusive pods may mark old vent sites. In general, these rocks are brittle and therefore much fractured, are suitable for replacement, and lie close to volcanic centers that may overlie buried stocks.

Quartz latite porphyry plugs (host-rock type 3) are also common host rocks for mineral deposits. These rocks occur in Oligocene rhyolite or quartz latite porphyry, forming both small masses and many narrow dikes (shown on detailed maps, Drewes, 1981b and 1982). The typical so-called "ore porphyries" of some nearby mining districts, like those to the west near Tucson, are older—Paleocene rather than Oligocene—contain more abundant and larger biotite phenocrysts than do the rocks of the study area, and have doubly terminated or bipyramidal quartz phenocrysts. However, there are also similarities to porphyries of these two ages in that some of the porphyries of the study area, like the "ore porphyries," are highly fractured, have fracture surfaces that are stained with iron oxides apparently derived from altered pyrite, and contain plagioclase that is generally strongly altered, and both may contain breccia pipes. Part of the body west of Emigrant Pass is a breccia pipe. In both the North End area and regions having productive porphyry deposits, the porphyry bodies are probably genetically associated with granodiorite stocks, possibly forming a slightly younger intrusive phase, or they are intrusives that reached higher levels.

In much of the North End Roadless Area the pre-Oligocene rocks are metamorphosed. Typically, the limestone is recrystallized, and in places this alteration was sufficiently intense to have transformed the rock into marble. Thick-bedded limestone, free of thin siltstone partings and relatively free of chert, has been changed to a nearly white, moderately coarse grained to very coarse grained massive marble in the upper reaches of Marble Canyon about 1 mi northwest of the study area and also between east Whitetail Canyon and Hilltop, 0.5-2 mi southeast of the area. The Mississippian Escabrosa Limestone makes the most massive marble, followed in order by the lower part of the overlying Pennsylvanian Horquilla Limestone. These formations extend through the study area along both belts of older rock, and appear strongly marmorized mainly west of Emigrant Canyon and on Timber Mountain.

Many of the sedimentary rocks of the study area were deposited in a marine environment; however, those of Cretaceous age are mixed stream and shallow marine or lagoon deposits, and the Tertiary sedimentary rocks are almost entirely stream deposits. A few of the formations that have marine or lagoon deposits contain small amounts of hydrocarbons, and also have or lie close to beds having permeability and porosity suitable for oil or gas accumulation. In the past, the sporadic and scattered exploration for oil and gas in the region focused on the Horquilla Limestone or the Bisbee Group, both present in the belts of older and most deformed rocks of the region. Far to the east, where these formations have been productive, reef deposits are more prominent in the Horquilla (or its correlative formations), and a marine facies is more widespread in the Bisbee (or its correlative formations) than in the rocks of the study area. Aside from these differences in the depositional features of the rocks between the productive areas to the east and the North End Roadless Area, there are also pronounced differences in the structural features of the rocks. The present exploration efforts for oil and gas in the region have focused on rocks at depths of 2 to 3 mi beneath the surface, rocks in a situation known as the Cordilleran overthrust belt that involves regional structural interpretations.

The Oligocene and older rocks of the North End Roadless Area are abundantly faulted and intruded, and locally folded. Among these faults are high-angle faults with a complex history of movement, and lowangle thrust faults. In the younger rocks, faults are widely scattered and mainly high-angle faults with a simple movement and history, and the intrusive bodies are few and small. Two groups of older faults, the Apache Pass fault zone and the Hidalgo thrust faults, are viewed, along with the intrusive bodies, as the most important structural features in regard to both the possible occurrence of mineral deposits and oil and gas accumulations.

The Apache Pass fault zone extends diagonally through the study area from northwest to southeast, and is recognized between the villages of Portal and Dos Cabezas (fig. 1). Throughout the study area it forms a zone 1-2 mi wide of branching fault strands, of which only the main strands are specifically identified on the geologic map. Other faults, like the Emigrant Canyon fault, splay off these strands to the north or, like the unnamed fault along the North Fork of Pinery Creek, splay off to the south. Individual faults are vertical or dip steeply, and branch and merge around large upended lenslike rock masses at many localities. From place to place along the 40-mi trace of the Apache Pass fault zone, the evidence of age, amount, and direction of movement varies. Movement probably occurred during Precambrian, Paleocene, Oligocene, and Miocene times; early movement was probably more than 6 mi and the latest much less; several phases of movement were left-lateral, but the latest was normal movement. Within the study area, for example, left-lateral movement of about 1 mi occurred along the Emigrant Canyon splay fault between the Late Cretaceous and Oligocene (probably during Paleocene time). The direction of movement is shown by an offset of that amount in upended rocks and in included bedding-plane thrust faults. The age of faulting is shown by geologic relations: the Upper Cretaceous rocks are faulted, and the younger Oligocene stocks intrude the fault or are only slightly sheared against the fault.

The Apache Pass fault zone is believed to be a major, deeply penetrating crustal flaw that has been reactivated many times during in its geologic history. Similar faults occur throughout southeastern Arizona and adjacent New Mexico (Drewes, 1980 and 1981a). They have been zones of fluid penetration, favored sites of intrusion of magmas and ore fluids and, no doubt, were avenues for the escape of any fluid hydrocarbons that may have been present. Clearly, this fault zone is a key geologic feature to the assessment of the mineral resource potential of the area.

The Hidalgo thrust faults trend east-west across the northern part of the study area and cross the Apache Pass fault zone obliquely near the northwest corner of the area. The Hidalgo is also a multiple-strand structure, of which only the lower, middle, and upper strands are specifically identified on the geologic map. The rocks beneath the lower strand are unfaulted or little-faulted crystalline basement rocks. Along the middle and upper strands some older rocks were moved over younger ones. The unnamed and probably smaller faults between and above these three strands emplaced younger rocks upon older ones; these faults branch and merge with each other or with the adjacent larger thrust faults, enclosing elongate lenslike rock masses that are typically oriented parallel or subparallel to bedding. The faults of the Hidalgo system, like the beds, thus generally dip moderately to steeply south to southwest, but locally they are about vertical. The rocks between these bedding-plane thrust faults are also cut by scattered cross faults or tear faults, some of which trend northeast and either merge with individual thrust faults or abut them. One effect of these tear faults is that a thrust plate may change abruptly in thickness or in the specific formations present, as occurs above the middle strand of the Hidalgo near the northwest corner of the study area. Some rocks in the thrust-fault zone are also folded, mainly along northwest-trending axes, as is shown only on detailed maps of the area (Drewes, 1981b and 1982). The upper plates have moved northeastward relative to the underlying rocks after the time of deposition of the Upper Cretaceous rocks and before the time of intrusion of the Oligocene stocks.

The Hidalgo thrust faults are viewed as part of a regional thrust system of the Cordilleran overthrust belt (Drewes, 1976, 1980, and 1981a). The upper plates of this thrust system were moved a long distance with respect to the lower ones, perhaps on the order of 120 mi, in response to east-northeastward-directed compression. The Hidalgo thrust faults within the study area may be a segment of the bottom of the thrust system, or the dêcollement part, with an unknown but possibly large part of the leading edge of the thrust plates eroded away. According to this interpretation, the Hidalgo thrust faults are chiefly a subhorizontal fault zone that flattens downward to the southwest as shown on the structure sections accompanying the detailed geologic map (Drewes, 1982). Such a fault system would have had lesser influence on upward-moving fluids than would the northwest-trending flaws, and the fluids may have dispersed along flat-lying parts of the Hidalgo fault zone or may have been concentrated along the steeper parts of it. The rocks beneath such a thrust plate are particularly significant with respect to oil and gas exploration in the region. Much of the region near the study area is probably underlain, at depth, by additional sedimentary rocks, as well as by Precambrian granodiorite and schist like the rocks exposed north of the Hidalgo thrust-fault zone. Such conditions of sedimentary rocks concealed beneath the thrust-fault zone may also exist beneath the study area. Seismic evidence bearing on the regional interpretation is favorable, but the local seismic records remain unavailable.

Stocks, smaller intrusive pods, and dikes are abundant along the Apache Pass fault zone and also occur along the trace of the Hidalgo thrust-fault zone east of the Apache Pass zone. The dikes trend north to northwest and are so numerous that they are shown only on detailed geologic maps of the area (Drewes, 1981b and 1983). Volcanic necks also lie along or near the northeast strand of the Apache Pass fault zone. The intrusive bodies typically have steep walls and sharp contacts with narrow chilled margins. Many of the bodies intrude faults, or abut faults as if bounded by them rather than being offset along them.

The Tertiary stocks are mainly granodiorite and, less commonly, quartz monzonite or diorite. Smaller bodies probably range in composition from quartz latite porphyry to rhyolite porphyry. An aplite phase is associated with the stock at Buckhorn Basin, and a quartz latite porphyry body appears to be a shallow-level extension of a deeper seated stock along east Whitetail Canyon. Some bodies contain abundant large inclusions of sedimentary rocks; others have only a few, mainly small inclusions. The quartz-latite porphyry southwest of Emigrant Pass has brecciated and nonbrecciated phases, and most of the vent breccias are coarse volcanic breccias. With the possible exception of two undated andesite plugs (?Cretaceous-Tertiary), the intrusive rocks are 34-25 m.y. old, based on radiometric or fission-track ages. The age range of the stocks overlaps that of the Tertiary volcanic rocks and probably indicates related volcanic and subvolcanic events.

The host rocks around the stocks and small intrusive pods are metamorphosed for a distance of a few thousand feet in some places, but elsewhere for a mile or two. Sedimentary rocks are metamorphosed and some skarn is developed. The metamorphic patterns and the abundance of small intrusive pods between some large stocks suggest that the stocks are connected at relatively shallow depth, and that the stocks are cupolas or apophyses, like the tips of icebergs, which are largely concealed. For example, the Cambrian to Permian sedimentary rocks near Hilltop, midway between the stocks in east Whitetail and Jhus Canyons, are all metamorphosed. Likewise, all the rocks surrounding stocks between Red Mountain and Wood Mountain are metamorphosed. However, many of those near Dug Road Mountain and at and southeast of Timber Mountain are little altered or unmetamorphosed. Thus, within the study area, three or four major subsurface igneous bodies may exist: the Jhus-East Whitetail Canyon stock, the Buckhorn Basin stock, the Red Mountain-Wood Mountain stock, and possibly another body east of Wood Canyon. Deep in the crust, all of these bodies, as well as the dike swarm and volcanic rocks, may have a common site of origin and a common route of upward movement along the Apache Pass fault zone.

GEOCHEMISTRY

The study by Bigsby (1983) resulted in a map showing areas of mines and prospects where both base and precious metals were found, and where there may be similar occurrences to those not exposed. In addition, areas of possible skarn alteration of limestone, which indicates possible small low-grade tungsten deposits, were delineated. Some of the areas in which both kinds of deposits might be found were judged to have a high mineral resource potential; others only had a moderate potential. Where one line of evidence suggested the presence of a mineral deposit, the area was considered to have a low mineral resource potential.

From the chemical analyses of the alluvial samples, in conjunction with other available information, maps were compiled showing areas of possible vein deposits, replacement deposits, and disseminated porphyry deposits, as well as estimates of the relative depth of occurrence of these deposits (Watts and others, in press). The dispersal patterns of selected groups of metals indicate the likely vertical positions of these deposits, as based on typical geochemical patterns in the more common kinds of mineralization models that fit the southeastern Arizona geologic environment.

A mineralized-chip study (Watts and others, in press) overlapped only in minor ways with the other geochemical studies. Mineralized chips were collected from some of the same mines and prospects sampled by Bigsby (1983), but most of the coverage was of widely scattered prospects, and of mineralized outcrops that had not been prospected. In places, this mineralization was also reflected in the alluvial samples, but the techniques used in sample preparation differed, and the factors of natural dilution of material from a single prospect lead to different results. The rock-chip study resulted in a map showing areas where indicator elements and those elements likely to go into solution in an alluvial environment were present.

GEOPHYSICS

The geophysical study involved primarily airborne magnetometer data interpreted by Moss (in press). Using the distribution, shape, and intensity of magnetic anomalies, an included map shows both known and suspected concealed stocks, from which mineralized border zones were inferred. The general depth of concealed stocks also was estimated from the configuration of certain anomalies.

MINING DISTRICTS AND MINERALIZATION

Base-metal and silver ore has been produced from several mines near the study area. The larger mining camps of Dos Cabezas and Hilltop (fig. 1) lie, respectively, 12.5 mi to the northwest and 1 mi to the southeast of the roadless area along the Apache Pass fault zone. Small amounts of ore probably were produced from the King of Lead mine and from the mines in the Buckhorn Basin, all of which are within about 0.5 mi of the area boundary. Only scattered prospects occur within the study area, and for these no production records are available.

In general, the parts of the roadless area that have the greatest mineral resource potential lie along the Apache Pass fault zone, or within a northeast extension of that zone about 0.5 to 1.5 mi wide (fig. 2) (Drewes, 1981b and 1982). The Apache Pass fault zone is a major zone of fractured rock along which many types of fluids, magmas, hydrothermal water, and ground water, have migrated. Zones of lesser mineral potential extend beyond and border the northeast side of the fault zone. The zones of lesser potential may include extensions of favorable rock types, branch faults, and buried stocks; although the strength of the mineralization in these zones is seen only as moderate, they have not been previously explored.

Mining began in 1881 in the vicinity of the roadless area with the early development of claims that later became the Hilltop mine, 1 mi south of the area. Scattered prospects and a few patented claims lie within, or just outside the roadless area. During the time of the study, there was sporadic development work at the King of Lead mine and nearby claims lying in an area between the Chiricahua National Monument and the roadless area. Base-metal and silver ore has been produced from the Hilltop mine (about $1.1 million production between 1902 and 1950), and a small amount of similar ore was probably produced from the King of Lead mine and from mines in the Buckhorn Basin about 0.5 mi west of the roadless area.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Seven areas of high and moderate mineral resource potential were identified in this study (fig. 2). These areas are discussed in order of their decreasing significance (although a few successive sites are of nearly equal significance), based on their known or inferred geologic, geophysical, and geochemical features.

Area 1.—Although area 1 contains only a few small prospects, it is regarded as having high mineral resource potential. It lies along the Apache Pass fault zone and is, in part, underlain by metamorphosed Paleozoic limestone, two Tertiary rhyolitic plugs, and a Tertiary granodiorite stock. Volcanic rocks in the northeastern part of area 1 are extensively pyritized and oxidized. Rock chip samples from prospects and outcrops show copper, lead, zinc, molybdenum, barium, and silver mineralization. Geochemical anomalies in stream-sediment samples from area 1 suggest a possible focus of mineralization many hundreds to a few thousand feet below the center of the area (Watts and others, in press). Three types of mineralization could occur in area 1: vein or replacement deposits of lead, zinc, and silver in the sedimentary rocks, skarn contact-metamorphic deposits of tungsten near the granodiorite stock; and copper or molybdenum porphyry-type mineralization at moderate depth.

Area 2.—Area 2 contains the Hilltop mine and numerous prospects (Bigsby, 1983), and extends to the southeast beyond the North End Roadless Area. It also lies along the Apache Pass fault zone and is underlain by Mesozoic and Paleozoic sedimentary rocks, a small Tertiary granodiorite stock and rhyolitic plugs north of Hilltop, and a large Tertiary granodiorite stock on its southern side. Data on samples from the area show anomalously large concentrations of base metals and silver. From aeromagnetic data, we infer that the crest of the large stock plunges gently northwest beneath Hilltop. A mineralized zone like that at the Hilltop mine also is inferred to plunge to the northwest, extending below part of the study area, defining a zone of high mineral resource potential for base metals and silver.

Area 3.— Area 3 has a moderate mineral resource potential for small lead-zinc-silver replacement or vein mineralization at moderate depths like that at the King of Lead mine (Drewes and others, 1983). This area also lies along, or within, the Apache Pass fault zone, and it is underlain by Mesozoic and Paleozoic sedimentary rocks and some small plugs and dikes (Sabins, 1957b; Drewes, 1981b and 1982). There is less observed mineralization than in areas 1 and 2, and anomalously high concentrations of copper and molybdenum are more widely scattered. Aeromagnetic data (Moss, in press) show positive anomalies, suggestive of small buried stocks favorable for mineralization.

Area 4.—Area 4 lies northeast of the Apache Pass fault zone and is underlain by Tertiary volcanic rocks cut by some breccia pipes and normal faults. The area shows almost no signs of prospecting. Samples of mineralized carbonate reefs along the faults have high values for lead, zinc, barium, molybdenum, and silver. Aeromagnetic data show the possible presence of a stock beneath the eastern end of area 4. In combination, this information indicates moderate resource potential for base metals and silver beneath the volcanic cover, possibly in veins along faults.

Area 5.—Area 5 lies largely outside the roadless area and also follows a strand of the Apache Pass fault zone. The area is underlain by Mesozoic and Paleozoic rocks that are intruded by a Tertiary granodiorite stock and by plugs and dikes. Observations of mineralized rock at the surface and of geochemical and geophysical features are suggestive of a moderate mineral resource potential for small replacement, vein, or contact-metamorphic deposits of base and precious metals and tungsten.

Area 6.—Area 6 also has a moderate mineral resource potential for base and precious metals but lies largely outside the roadless area. The area is underlain by the same kind of sedimentary rocks as the other areas but its thrust-faulted terrane has only a few plugs and dikes. The area contains a few small mines and prospects and also geochemical anomalies; aeromagnetic data suggest that the area is above the south flank of an eastward-plunging stock. The area is favorable for buried vein or replacement mineralization at accessible depths, and may also contain deeper contact-mineralized rocks.

Area 7.—Area 7 has moderate mineral resource potential for base and precious metals, though evidence is somewhat weaker than for the other areas. It is underlain mainly by Mesozoic and Paleozoic sedimentary rocks that are intruded by Tertiary stocks and dikes. Some Precambrian granitic rocks are in the northern part of the area. All of these rocks are cut by a strand of the Apache Pass fault zone and by a splay fault branching from the zone. Scattered prospects occur in this area, and rocks at some of them contain copper, lead, zinc, arsenic, antimony, and silver. Geochemical data on samples of the alluvium suggest concealed mineralized rocks near the boundary of the study area. Aeromagnetic data suggest that a stock exposed west of the area has a crest that plunges gently northeastward below these possibly mineralized rocks.

Marble and lime rock occur in the roadless area, and other commodities—silica rock, sand and gravel, and graphite—are present or have been reported present in or near the roadless area. All these products are more accessible and abundant at and near old quarries or outcrops outside the roadless area.

The North End Roadless Area lies within the overthrust belt (Drewes, 1980, 1981a) and has become a region of interest for exploration for petroleum and natural gas resources. Although rocks deep in the subsurface could contain traps for these fluids, the abundant steep faults and stocks in the roadless area suggest that such fluids would not likely be preserved.

Industrial minerals and rocks

The resource potential for industrial minerals and rocks is moderate to low in the roadless area. Marble, lime rock for cement, silica rock for flux, sand and gravel, and graphite are reviewed because they have been produced within Cochise County or have been reported in or near the study area.

Marble has been quarried for use as dimension stone from a patented claim about 1 mi northwest of the study area, and another such claim lies southeast of the study area along Whitetail Canyon. The production from the marble quarry was from contact-metamorphosed Mississippian Escabrosa Limestone, one of the formations mapped separately in other studies (Drewes, 1981b and 1982). The marble is commonly coarsely crystalline and comprises alternating thick sheets of white and gray rock containing scattered loaf-shaped chert nodules. The quarried rock is from a thick white sheet in which chert was either a very minor initial component or was replaced by minerals not detrimental to the requirements of building material. The rock also is generally free of fractures, apparently reflecting the absence of strong stresses on rocks in this wide part of the Apache Pass fault zone. Near the quarry and in Whitetail Canyon, the lower part of the next overlying formation, the Pennsylvanian Horquilla Limestone also is metamorphosed to a white coarse-grained marble, but this formation has not been quarried beyond exploratory levels.

Both formations that contain the marble also occur within the study area, and near some stocks the limestone is marmorized. Commonly, these places are fairly inaccessible and the rocks are much fractured. The possible constraints placed by the abundance and condition of chert are unknown.

Lime rock of suitable quality for cement production is obtained both from the Mural Limestone within Cochise County and from the Horquilla Limestone near Tucson. Both formations occur within the study area. The Mural Limestone is part of the Bisbee Group of Cretaceous age and is mapped separately elsewhere (Drewes, 1982). However, in the roadless area the Mural contains so much less limestone through lateral depositional changes that it is an unlikely source of raw material for cement. Near Tucson the Horquilla Limestone is metamorphosed and sufficiently free of silica and iron to be quarried for cement rock. Metamorphosed Horquilla Limestone is abundant along the Apache Pass fault zone, both within and outside the study area. Although, at first glance, the rock from outside the area would seem a more likely source of this commodity because it is more accessible, a final assessment cannot be made without analyses of the rock specifically designed to test its suitability for cement production.

Silica rock for use as flux in smelters is quarried in several nearby mountain ranges. Production of this commodity is mainly from quartz sandstone, commonly part of the sedimentary rocks of the Mesozoic Bisbee Group. Where quarried, the rock has a high concentration of sandstone relative to shale, which may reflect depositional conditions or colluvial and talus concentrations. Sites near smelters are favored, and accessibility to a railroad or a good highway is desirable.

The Bisbee Group is present in the study area, and some sandstone beds occur in its upper part, as shown on a detailed geologic map (Drewes, 1981b). However, the sandstone is not particularly concentrated, nor are the sites readily accessible to transportation routes or near a smelter.

Sand and gravel deposits for use in aggregate or in road construction are widely available around the Chiricahua Mountains. Because they are far more practical to obtain in the low areas outside the study area than from terrace deposits within the study area, there is little likelihood that the deposits in the mountains will be used as a source of sand and gravel.

Graphite has been reported in a prospect in the saddle between Anderson and Maverick Canyons about 650 ft outside the northwest side of the wilderness study area. At this prospect, in a jeep-track cut, a small amount of slaty graphitic shale occurs in sheared rock mapped as the Cintura Formation of the Bisbee Group. The rock is mildly metamorphosed, mostly argillic, gray to brownish gray, and unmineralized.

Graphite also forms sheared lenses a few inches thick along a fault next to the Bisbee Group in a stream bank immediately south of the facilities at the Fort Bowie National Monument, about 4 mi northwest of the study area (Drewes, 1984). This fault extends into the study area, as do the rocks of the adjacent Bisbee, but graphite is not known to occur there. Such shear-zone sites lack sufficient volume of graphite, and the Bisbee is not known to be sufficiently carbonaceous to provide a suitable source of graphite even where the rock is adequately metamorphosed.

Petroleum and natural gas

In the search for oil and natural gas in southeastern Arizona, three kinds of targets have been considered: shallow targets in the Tertiary sedimentary deposits of the intermontane basins; moderately deep targets in the Mesozoic or Paleozoic sedimentary rocks like those exposed in the ranges; and deep targets of sedimentary rocks below thrust faults within an overthrust belt. In their geophysical and geological investigation of the petroleum potential of southeastern Arizona, Aiken and Sumner (1974) considered only the first two kinds of targets, and described only certain stratigraphic and geophysical features without drawing conclusions on particular resource potential. Three exploratory holes drilled about 4 mi northeast and east of the study area appear to have focused on the shallow target; they reached depths of less than 7,600 ft and did not penetrate below the Tertiary deposits (Sabins, 1957b; Conley, 1974; Drewes, 1980). However, in recent years exploration efforts have focused on the possibility of finding oil or, more likely, natural gas, in rocks as much as 20,000 ft deep beneath an overthrust belt proposed by Corbitt and Woodward (1970) and Drewes (1976, 1980, 1981a).

Interest in targets beneath a regional overthrust plate has grown in response to the discovery of large quantities of gas in the overthrust belt in Utah and Wyoming, and in similar situations near Monterrey, Mexico. The development of seismic-reflection techniques to obtain information on rocks at these great depths has provided a means of exploration not available until a few years ago.

The North End Roadless Area lies within the proposed southeastern Arizona overthrust belt, and probably lies near a northern erosional edge of a major northeastward-directed thrust lobe. In several ranges near the northern Chiricahua Mountains, as well as along the northwestern part of the study area itself, overthrust faults of older-over-younger rocks are mapped, along with the more widespread normal faults of younger-over-older rocks. During the Late Cretaceous or Paleocene, the upper plates typically moved east-northeastward relative to the lower plates. Other deformation, such as Basin-and-Range high-angle faulting, has complicated the structural patterns, and volcanic rocks and gravel deposits, which lack petroleum potential, cover much of the older terrane.

Interpretations which project rocks into positions beneath the regional thrust plate are the crux of assessing the gas potential in the North End Roadless Area. Nearby exposures of terrane believed to be beneath the plate in the roadless area consist of Precambrian rocks, which is not a favorable indication. However, within the study area, Precambrian rocks have been thrust into position above younger rocks. Other than by drilling, the only way to evaluate the sequence of rocks in the deep subsurface beneath such thrusts is by seismic records; these records are unavailable to us.

Local mapping studies provide evidence unfavorable for the likelihood of the presence of gas in the study area. Steep faults, such as the reactivated segments of the Apache Pass fault zone that postdate and cut the thrust faults, may provide pathways for fluids to leak upward and be lost. The presence of post-thrust stocks likewise would heat those rocks where gas might accumulate and drive off the volatile hydrocarbons. If the aeromagnetic anomalies away from the fault zone indeed indicate concealed stocks like those which are exposed, then they too would be post-thrust and would be detrimental for oil and gas retention.

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