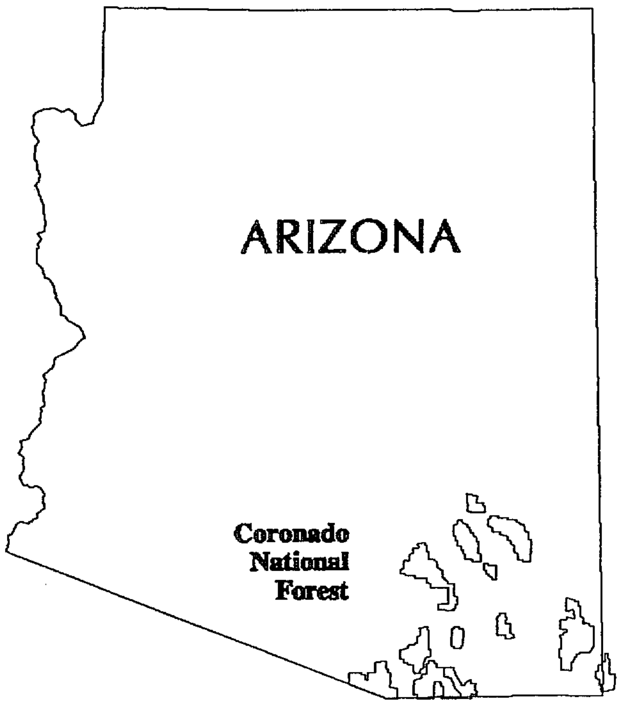
MLA 10-94

Mineral Land Assessment
Open File Report/1994

MINERAL APPRAISAL OF CORONADO NATIONAL FOREST, PART 14
Industrial Minerals



UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO.	
2.	
3. Recipient's Accession No.	
4. Title and Subtitle	Mineral Appraisal of Coronado National Forest, Part 14, Industrial Minerals
5. Report Date	
6.	
7. Author(s)	Robert C. Armstrong and Clay M. Martin
8. Performing Organization Rept. No.	
9. Performing Organization Name and Address	U.S. Bureau of Mines Intermountain Field Operations Center Bldg. 20, Denver Federal Center Denver, CO 80225
10. Project/Task/Work Unit No.	
11. Contract(C) or Grant(G) No.	(C) (G)
12. Sponsoring Organization Name and Address	
13. Type of Report & Period Covered	
14.	
15. Supplementary Notes	

16. Abstract (Limit: 200 words)

The U.S. Bureau of Mines conducted mineral appraisals of the 13 management units in the Coronado National Forest, which comprises approximately 1.85 million acres in five counties of southeastern Arizona and one county in southwestern New Mexico. Most industrial minerals found in the Forest are commodities of low unit value. Their development is highly dependent on accessibility and location relative to potential markets. Current production is limited to one marble/limesone quarry and a few sand and gravel quarries; production there is expected to continue. Subeconomic resources of silica flux contain appreciable byproduct metals, and may become economic if further investigation establishes higher tonnage and/or grade, or if the price of gold and/or silver increases. Two areas are possible targets for development of high-brightness marble products. Development of 137,000 st indicated resource of low-grade gypsum is unlikely under reasonably foreseeable economic conditions. Gypsum deposits outside the Forest are more likely targets for development. There is little likelihood for development of fluorspar occurrences in the Forest, due to their low volume and quality, and to decreased demand for fluorspar from the steel industry. Occurrences of common rock, and sand and gravel could be utilized as needed.

17. Document Analysis a. Descriptors

Mineral resources
Industrial minerals
Mining geology

b. Identifiers/Open-Ended Terms

Coronado National Forest
Mineral resources
Industrial minerals

c. COSATI Field/Group

18. Availability Statement:	
19. Security Class (This Report)	
20. Security Class (This Page)	
21. No. of Pages	
22. Price	

MINERAL APPRAISAL OF CORONADO NATIONAL FOREST

PART 14: INDUSTRIAL MINERALS

by

Robert C. Armstrong

and

Clay M. Martin

MLA 10-94
1994

Intermountain Field Operations Center,
Denver, Colorado

UNITED STATES DEPARTMENT OF THE INTERIOR
Bruce Babbitt, Secretary

BUREAU OF MINES
Hermann Enzer, Acting Director

PREFACE

A January 1987, Interagency Agreement between the U.S. Bureau of Mines (USBM), U.S. Geological Survey (USGS), and U.S. Forest Service (USFS) describes the purpose, authority, and program operation for forest-wide studies. The program is intended to assist the U.S. Forest Service in incorporating mineral resource data into forest plans as specified by the National Forest Management Act (1976) and Title 36, Chapter 2, Part 219, Code of Federal Regulations, and to augment the USBM's mineral resource database so that it can analyze and make available minerals information as required by the National Materials and Minerals Policy, Research and Development Act (1980). This report is based on available data from literature and previous field investigations.

This open-file report summarizes the results of part of a Bureau of Mines forest-wide study of the Coronado National Forest. The report is preliminary and has not been edited or reviewed for conformity with Bureau of Mines editorial standards. This study was conducted by personnel from the Intermountain Field Operations Center (IFOC), P.O. Box 25086, Building 20, Denver, CO, 80225-0086.

CONTENTS

Illustrations

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ct	carat
ft	foot
ft^3	cubic feet
in.	inch
mi	mile
mi^2	square mile
ppb	parts per billion
%	per cent
st	short ton, 2,000 pounds
st/yr	short ton per year
oz/st	troy ounce per short ton
yd^3/yr	cubic yard per year

MINERAL APPRAISAL OF CORONADO NATIONAL FOREST
PART 14: INDUSTRIAL MINERALS

by

Robert C. Armstrong and Clay M. Martin,
U.S. Bureau of Mines

SUMMARY

Between 1988 and 1994, the U.S. Bureau of Mines conducted mineral appraisals of the 13 management units in the Coronado National Forest, which comprises approximately 1.85 million acres in five counties of southeastern Arizona and one in southwestern New Mexico. This report summarizes information on resources and occurrences of industrial minerals in the Forest gathered during field investigations for these studies, and from other literature sources.

In general, the known occurrences of industrial minerals in the Forest are commodities of relatively low unit value, or value per ton. The economic development of such materials is highly dependant on accessibility and location relative to potential markets; mining and transportation costs can easily offset their commodity value.

At present (1994), production of industrial minerals in the Forest is limited to marble quarrying in the Santa Rita Mountains Unit and sand and gravel production in the Santa Catalina-Rincon, Atascosa-Pajarito-San Luis-Tumacacori, and Huachuca Mountains Units. Significant past production from the Forest includes fluorspar in the Whetstone and Chiricahua-Pedregosa Mountains Units, silica in the Santa Catalina-Rincon, Chiricahua-Pedregosa, and Whetstone Mountains Units, and carbonate rock products from the Dragoon and Huachuca Mountains Units.

Subeconomic resources of silica at locations in the Forest contain appreciable byproduct metals, and may become economic if further investigation establishes higher tonnage and/or grade, or if the price of gold and/or silver increases. These locations include the Gold Hill Mine in the Santa Catalina-Rincon Mountain Unit, the Copper Plate Mine in the Whetstone Mountains Unit, the El Tigre Mine in the Chiricahua-Pedregosa Mountains Unit, the Austerlitz District in the Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit, and the Tako #9 Claim in the Huachuca Mountains Unit. Occurrences of silica at the Southern Belle Mine in the Santa Catalina-Rincon Mountains Unit, the Ricketts Mine in the Whetstone Mountains Unit, and the Tungsten Reef Mine in the Huachuca Mountains Unit are less likely to be developed under reasonably foreseeable economic conditions.

Carbonate rock occurrences, including marble, limestone, and dolomite, are found in the Santa Catalina-Rincon, Santa Rita, Dragoon, Huachuca, and Chiricahua-Pedregosa Mountains Units. Continued production of carbonate rock products, including high-brightness fillers, is expected at the Santa Rita Quarry. The Marble Peak area and the Cochise White Marble claim are the most likely targets for future development in the Forest. Occurrences in the Huachuca and Dragoon Mountains Units have less probability for development.

Other types of undeveloped rock occurrences in the Forest include tuff in the Peloncillo Mountains Unit, common rock in the Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit, and pumice in the Chiricahua-Pedregosa Mountains Unit. In addition, sources for crushed aggregate occur extensively in the Forest and may someday be developed as resources.

A 137,000 st indicated resource and several undelineated occurrences of low-grade gypsum are in the Whetstone Mountains Unit. Development is unlikely under reasonably foreseeable economic conditions, due to factors including low grade, poor access, and difficult mining conditions. Gypsum deposits outside the Forest are more likely targets for development, should market conditions require a source of gypsum in the area.

Fluorspar occurs in the Whetstone and Chiricahua-Pedregosa Mountains Units of the Forest. The most significant occurrence is at the Lone Star Mine in the Whetstone Mountains Unit, where there is a possibility that fluorspar resources exist at depth at and near the area of past mining. Other fluorspar locations in the Forest are minor, often occurring as gangue minerals in association with metal deposits. There is little likelihood for development of a resource in the Forest, due to decreased demand for fluorspar from the steel industry.

Undeveloped occurrences of sand and gravel are widespread in the Forest; exploitable resources are likely to be found in areas of valley fill, stream terraces, active stream channels, and alluvial fans.

INTRODUCTION

The term "industrial mineral" is defined in the *Glossary of Geology* as "any rock, mineral, or other naturally occurring substance of economic value, exclusive of metallic ores, mineral fuels, and gemstones; one of the nonmetallics" (Bates and Jackson, 1980, p. 316). Industrial mineral occurrences in the Coronado National Forest include commodities with a wide range of properties, from common varieties such as sand and gravel to locatable deposits with well-defined qualities and/or grades, such as silica flux, fluorspar, or marble.

The known occurrences of industrial minerals in the Forest share an important characteristic not included in the formal definition: with few exceptions, all are mineral commodities of relatively low unit value, or value per ton. This is a significant factor, since the economic development of such materials is highly dependant on accessibility and location in relation to potential markets; mining and transportation costs can easily offset their commodity value. Thus, in areas such as southeastern Arizona, where there is limited heavy industry and highly variable population density, the industrial minerals most likely to be developed economically are those inexpensively produced and commonly used on a local basis (such as stone or sand and gravel), or those required for a specific local industry (such as copper smelting). An additional complicating factor is the possibility of varying demand caused by two changing factors in the local economy: rapidly increasing population (especially in the Tucson area), and the decline of the copper smelting industry. In recent years, increasingly restrictive environmental regulations have also affected industrial mineral development.

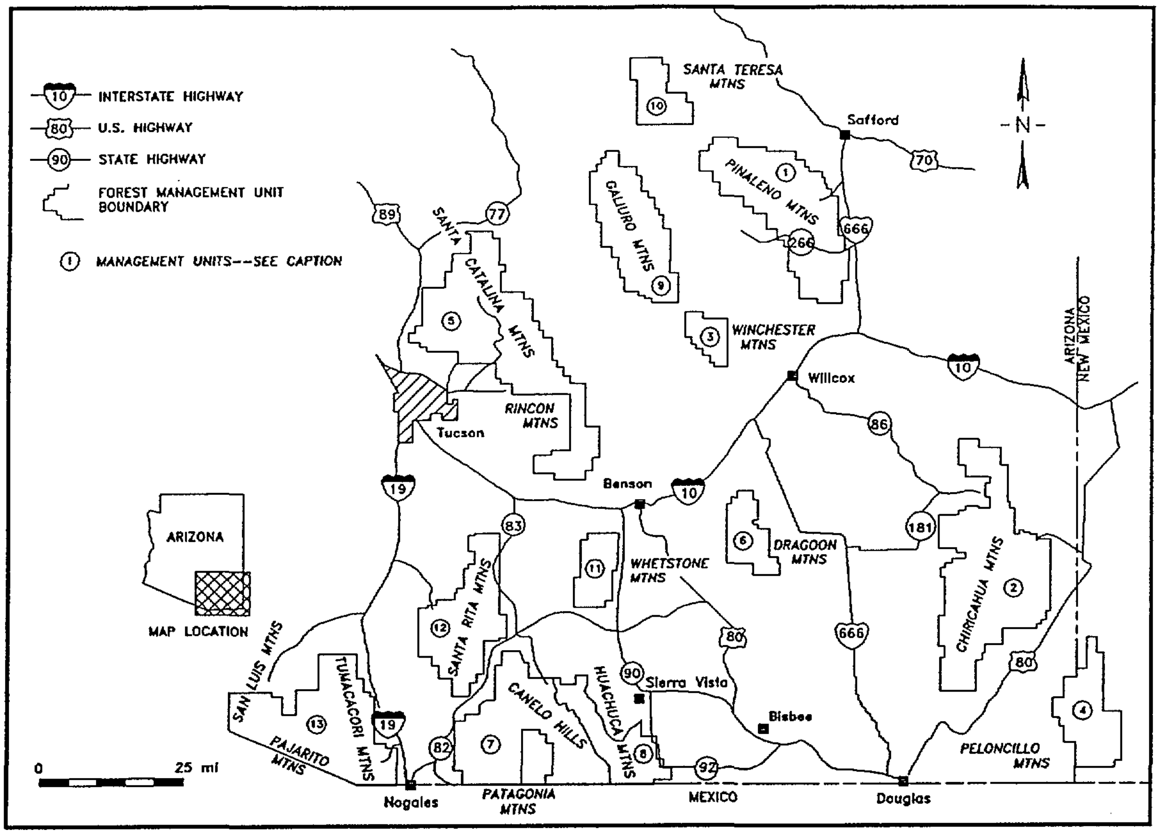
Low-unit value, common-variety industrial materials, such as sand and gravel, crushed aggregate, fill dirt, common rock, and pumice, are salable under the Materials Acts of 1947 and 1955, and not locatable under the General Mining Law of 1872. Permits are issued by the Forest Service on a short term basis to collect them from public land. Other occurrences of industrial minerals may be uncommon and of sufficient value to qualify as locatable under terms of the 1872 law. At times the distinction between the two classifications can be unclear, which sometimes results in litigation over the status of various deposits.

In the following sections, both physical characteristics and economic factors affecting individual industrial mineral occurrences are discussed, in order to assist in estimating the likelihood for reasonably foreseeable development of the various commodities.

Geographic setting

The Coronado National Forest includes 13 management units distributed throughout five counties of southeastern Arizona (figure 1). The Forest comprises approximately 1.85 million acres, of which about 270,000 acres are preserved in eight legislated Wilderness Areas. Elevations range from about 4,000 ft to over 10,000 ft. Mt. Graham, in the Pinaleno-Greasewood Mountains Unit, is the highest point at 10,713 ft. Other prominent peaks in the Forest include Mt. Lemmon in the Santa Catalina-Rincon Mountains Unit, Mt. Wrightson in the Santa Rita Mountains Unit, and Miller Peak in the Huachuca Mountains Unit. Terrain ranges from rolling hills to rugged mountains. Vegetation ranges from sparse desert scrub in the lower elevations to conifer forests at higher elevations.

Cities and towns near the Forest include Tucson, Nogales, Sierra Vista, Benson, Bisbee, Douglas, Willcox, and Safford. Access to the various management units is via Interstate Highways 10 and 19, U.S Highways 80, 89, and 666, several Arizona state highways, and numerous local paved and unpaved roads. Various Forest Service roads penetrate the nonwilderness portions of the Forest. The main Southern Pacific rail line through the area roughly parallels Interstate 10, with spur lines to Nogales and the Bisbee-Douglas area.



USFS Management Units:

1. Pinaleno-Greasewood Mountains
2. Chiricahua-Pedregosa Mountains
3. Winchester Mountains
4. Peloncillo Mountains
5. Santa Catalina-Rincon Mountains
6. Dragoon Mountains
7. Canelo Hills-Patagonia Mountains
8. Huachuca Mountains Unit
9. Galiuro Mountains Unit
10. Santa Teresa Mountains
11. Whetstone Mountains
12. Santa Rita Mountains
13. Atascosa-Pajarito-San Luis-Tumacacori Mountains

Figure 1.--Location map of USFS management units in the Coronado National Forest, Arizona.

Geologic setting

The Coronado National Forest is within the Basin and Range physiographic province. The geology of the Forest is complex; bedrock ages range from Precambrian to Tertiary and include widely varying sequences of igneous, sedimentary, and metamorphic units. The typical Basin and Range features found in the mountain ranges of the Forest were formed by faulting and magmatic intrusion during mid-Tertiary to Holocene time, but these processes were preceded by repeated cycles of sedimentary rock deposition, metamorphism, mineralization, magmatic intrusion, and at least five major periods of deformation. (See Drewes, 1981, p. 1-15, 38-45.)

As a result of the geologic complexity, rock units with industrial minerals deposits and occurrences are found at scattered and discontinuous locations throughout the Forest. Carbonate rock products (marble and limestone) are found in Paleozoic limestone units, particularly the Mississippian Escabrosa Limestone and the Devonian Martin Formation, which crop out in the Santa Catalina, Rincon, Santa Rita, Dragoon, Huachuca, and Chiricahua Mountains. Gypsum occurs in the Late Permian Epitaph Formation in the Whetstone Mountains. The main sources of silica used for copper smelter flux are Tertiary-age quartz dikes and sills in the Santa Catalina, Whetstone, Chiricahua, and Huachuca Mountains. Tertiary quartz veins in Precambrian granite are the source of the largest fluorspar deposit in the Forest, located in the Whetstone Mountains. Exceptions to the tendency toward scattered and sporadic occurrences of industrial minerals include recently formed deposits of sand and gravel, which blanket most stream drainages and widespread areas of low-lying topography throughout the Forest.

Previous investigations

Most of the information for this report was compiled from the 13 USBM Mineral Land Assessment (MLA) Open-File Reports on individual Forest Service units in the Coronado National Forest. The series includes reports on:

- Pinaleno-Greasewood Mountains Unit (Brown, 1993a)
- Chiricahua-Pedregosa Mountains Unit (Brown, 1993b)
- Winchester Mountains Unit (Armstrong and Brown, 1993)
- Peloncillo Mountains Unit (Armstrong, 1993)
- Santa Catalina-Rincon Mountains Unit (USBM, in press, a)
- Dragoon Mountains Unit (Chatman, 1993)
- Patagonia Mountains-Canelo Hills Unit (Chatman, in press)
- Huachuca Mountains Unit (Tuftin and Armstrong, 1994)
- Galiuro Mountains Unit (Brown, 1993c)
- Santa Teresa Mountains Unit (Brown, 1993d)
- Whetstone Mountains Unit (Chatman, 1994)
- Santa Rita Mountains Unit (McDonnell, in press)
- Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit (USBM, in press, b)

Each of these studies was based on information from USBM field investigations, supplemented by data from the literature. For more information on the sources used, consult the reference lists in the individual reports.

A number of other publications covering Arizona industrial minerals were used as information sources. The USBM publishes an annual report on the mineral industry of Arizona; it includes a section on industrial minerals with information on current trends, production, and prices (Dupree and Coggin, 1994). The Arizona Department of Mines and Mineral Resources (ADMMR) has published a report on industrial minerals of the state, with information on many commodities and their locations (Phillips, 1987). The ADMMR also publishes an annual comprehensive directory of active mines in Arizona with brief descriptions of individual operations (Phillips and others, 1994).

Additional information on fluorspar occurrences in the Forest was taken from Elevatorski (1971) and McColley and Scott (1982). Information on gypsum in the Whetstone Mountains was taken from Wrucke and others (1983). Data from ADMMR mine data files (available at their office in Phoenix, Arizona) were also used in some sections.

MINERAL APPRAISAL

The information included in the following commodity evaluations was compiled from 13 USBM MLA reports, and from other literature (See Previous Investigations section); no field work was done specifically for this report. Locations described are shown on plate 1 with a commodity symbol and location identifier. Appendices A through F contain tables showing production and resources of the various commodities.

A number of industrial mineral locations referred to in the literature contain, or are likely to contain, only occurrences of minerals, with little possibility of development as a resource. Brief summary descriptions of these locations are presented in appendix A for completeness and are shown on plate 1.

Silica

Introduction

Silica (SiO_2) is commonly used in the steel and copper industries as a flux for reduction of metalloids in slag, for deoxidation of molten metal, and as an alloying agent. The economic viability of a deposit mined primarily for silica flux depends on its purity (percent SiO_2), recoverable gold, silver, and/or copper content, and transportation costs and accessibility to viable markets. Silica flux may also be either a primary product or a byproduct, as economic circumstances dictate. In southern Arizona, the market is exclusively the copper smelting industry. Smelters currently operating in the region include San Manuel, Arizona (Magma Copper Co.), Hayden, Arizona (Asarco, Inc.), Hidalgo, New Mexico (Phelps Dodge Corp.), and Chino, New Mexico (Phelps Dodge Corp.). Copper smelters prefer rock containing 90 to 95% silica and no more than 5% alumina or 3% iron oxide. A smelter may typically pay $12/st (delivered) for barren (non metal-bearing) silica flux. However, transportation distances are likely to be 20 to 30 mi by truck and another 200 mi by rail. Therefore, to be economically viable, silica deposits must contain significant concentrations of byproduct metals; such as minimum concentration levels of approximately 0.2 oz/st gold, 1 oz/st silver, and/or 1% copper. (Joe Wilhelm, Asarco Ray Unit Smelter Manager, Hayden, Arizona; oral comm., 1994)

Production of silica for use as a flux in copper smelting has occurred at several locations in the Forest, including the Gold Hill and Southern Belle Mines in the Santa Catalina-Rincon Mountains Unit, the Ricketts and Copper Plate Mines in the Whetstone Mountains Unit, and the El Tigre Mine in the Chiricahua-Pedregosa Unit. Although there is no recorded production, the Tako #9 claim in the Huachuca

Mountains Unit has subeconomic resources of silica flux. The only recent silica production has been from the Gold Hill Mine. Exploration for silica flux was planned at one time at the Tungsten Reef Mine in the Huachuca Mountains Unit, but permits were never obtained and the project was dropped (Tuftin and Armstrong, 1994, p. 19). Production and resource information for silica locations in the Forest are shown in appendix B.

Gold Hill Mine

The Gold Hill Mine (plate 1, Sil1), located in the northern Santa Catalina Mountains, is an open-pit mine owned by Silica Mines, Inc., Oracle, Arizona. The mine produced silver-bearing silica from the Precambrian Dripping Springs Quartzite for use as flux at Asarco's Hayden, Arizona, smelter. Total production was 60,000 st of silica flux containing 0.5 oz/st silver. The last period of production was in 1991, when 2,000 st of silver-bearing silica flux was shipped. Production was apparently halted due to the low silver content of the remaining ore. Resources remaining at the mine include approximately 5 million st of silver-bearing silica, and possibly as much as 50 million st of barren silica (USBM, in press, a).

Southern Belle Mine

The Southern Belle Mine (plate 1, Sil2), in the Southern Belle Patent Group, is located about 3 mi southeast of the Gold Hill Mine. The mine produced 18,000 st of ore from quartz veins, containing 0.2 to 0.5 oz/st gold, between 1885 and 1888. An unknown amount of gold-bearing silica flux was also reportedly produced. The remaining resource at the Southern Belle is reported to be 618,000 st of unknown grade (USBM, in press, a).

Ricketts Mine

The Ricketts Mine (plate 1, Sil4) is an open pit mine located about 7 mi southwest of Benson in the Whetstone Mountains Unit. It is owned by Phelps Dodge Corp. and was active in the 1950's, providing silica flux for the Phelps Dodge copper smelter in Douglas, Arizona. Total production was about 300,000 st of silica at an unknown grade. The mine has been inactive since about 1960 (or slightly earlier); the Douglas smelter was shut down in 1987.

Silica at the Ricketts Mine was produced from a quartz dike, averaging 70 ft in width, of probable Precambrian age (Chatman, 1994, p. 15). Chatman surmises (1994, p. 16) that there may be additional silica tonnage equal to past production remaining at the deposit, but notes that maintaining a stable pit slope at the mine could reduce minable resources. In addition to the silica resource at the present mine site, there is an outcrop of the same quartz dike approximately 500 ft to the west containing an indicated resource of about 15 million st at an undetermined grade (plate 1, Sil5). In this area the dike may be as much as 1,000 ft thick. (See Chatman, 1994, p. 16.)

USBM representative samples of the quartz dike at the Ricketts Mine contained no detectable gold or silver. Only one sample, from a small enrichment zone in the dike, contained a significant precious metal concentration, 0.17 oz/st silver (Chatman, 1994, p. 16).

A more definitive site investigation would be needed to fully evaluate possible resources at the Ricketts Mine. However, the apparent lack of significant concentrations of precious metals or copper and the potential distance to markets make this an unlikely site for exploration and development in the foreseeable future.

Copper Plate Mine

The Copper Plate Mine (plate 1, Sil6), located in the southern Whetstone Mountains Unit about 8 mi southwest of the Ricketts Mine, also produced silica flux from an open pit for the Phelps Dodge smelter in Douglas. The property was owned by International Mines, Inc. during its production period, which ended about 1960. Production figures for the mine are incomplete and sometimes conflicting, but it appears that total mine production was at least 1,600 st of silica flux containing 1.2 to 1.6% copper and 0.6 to 1 oz/st gold. (See Chatman, 1994, p. 10-11.)

The silica deposit at the Copper Plate Mine occurs in a horizontal, 2.5-ft-thick malachite-bearing silicified zone in a sandstone unit of the Cretaceous Bisbee Group. It may be genetically related to the Granite Peak stock, although it is more than 1 mi west of the stock perimeter. In 1982, the USBM estimated that 2,000 to 4,000 st of inferred subeconomic resources remained, with a maximum metal content of 0.6 oz/st silver and 0.79% copper, but no detectable gold (McColly and Scott, 1982, p. 6; Chatman, 1994, p. B3, C3).

El Tigre Mine

The El Tigre Mine (plate 1, Sil9) is located in Pinery Canyon in the northern Chiricahua-Pedregosa Mountains Unit. At this site, massive quartz veins are intruded into limestones and shales of the Cretaceous Bisbee Group and an unnamed Tertiary rhyolitic tuff. The veins have been mined both for their metal content (silver, gold, and copper) and for silica flux with byproduct metals. Metal production occurred between 1941 and 1982. In 1973 and 1974, 700-800 st/yr of silica flux was shipped to the Phelps Dodge smelter in Douglas (Brown, 1993b,

p. 23, 99). Tsuji (1984, p. 130) estimates that up to 158,000 st of flux ore with a minimum grade of 0.52 oz/st silver remain in place at the El Tigre Mine, and that an area in the same vein system 2 mi southeast of the mine contains up to 571,000 st of ore with a minimum grade of 0.18 oz/st silver.

Other occurrences

The Austerlitz Mine vicinity in the Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit (plate 1, Sil3), contains a small silica flux occurrence. This area consists of a gently-dipping, near-surface silica zone with 0.2 oz/st gold and 1.9 oz/st silver (in press, b, figure 3).

The Tungsten Reef Mine (plate 1, Sil7) in the eastern Huachuca Mountains Unit, about 8 mi south of Sierra Vista, was primarily a producer of tungsten concentrates during the World Wars. Scheelite occurs in a quartz blanket deposit at the base of the Cambrian Abrigo Limestone. This deposit also contains small amounts of gold. In the 1980's, Goldsil Mining and Milling Co., Denver, had plans to explore and develop the area for precious metal-bearing silica flux, but the project was dropped after the USFS denied exploration permits, partly due to the proximity of the area to recreational facilities in Carr Canyon. USBM samples taken from an accessible adit at the site contained from 150 ppb to 2,180 ppb (0.06 oz/st) gold, but grab samples from dumps at several inaccessible workings contained no significant concentrations of gold or other metallic elements (Tuftin and Armstrong, 1994, p. 24).

The Tako #9 claim (plate 1, Sil8) is located in the southern Huachuca Mountains Unit, about 4 mi south of the Tungsten Reef Mine. It is owned by Tako

Mining of Sierra Vista, Arizona. A 27- to 50-in.-wide quartz vein in fine-grained sandstone, siltstone, and mudstone of the Cretaceous Morita Formation contains a subeconomic resource of 20,000 st of gold, silver, and copper-bearing silica (Tuftin and Armstrong, 1994, p. 19).

Conclusions

Significant resources of silica exist in the Forest, but all are subeconomic under current conditions. Silica deposits at the Gold Hill, Copper Plate, El Tigre, and Austerlitz Mines, and the Tako #9 claim, all contain appreciable byproduct metals and may become economic if further investigation establishes higher tonnage and/or grade, or if the price of gold and/or silver increases. Occurrences of silica at the Southern Belle, Ricketts, and Tungsten Reef Mines are less likely to be developed under reasonably foreseeable economic conditions.

Carbonate rocks

Introduction

Carbonate rocks (limestone, dolomite, and marble) occur in the Santa Catalina-Rincon, Santa Rita, Dragoon, Huachuca, and Chiricahua-Pedregosa Units of the Forest. The majority of occurrences are in the Mississippian-age Escabrosa Limestone, a unit generally regarded as the best in the region for producing commercial carbonate rock products (Phillips, 1987, p. 18). Locally, the Escabrosa Limestone has been metamorphosed to a high-brightness, high calcium carbonate content marble. At some locations discussed in this section, the varying degrees of metamorphosism the rock has undergone allow a variety of carbonate rock products to be produced from a single site. Typical products include dimension and decorative stone, paint fillers, wall board materials, marking chalk, landscaping material, various types of industrial filler materials, and materials for plastic and glass production. Appendix C gives production and resources data for marble locations; appendix D gives production data only for limestone and dolomite locations.

Current production

Three current producers dominate the carbonate rock product market in southern Arizona. Although only one is located partly in the Forest, the others are worth mentioning since occurrences in the Forest (including past producers and undeveloped locations) would have to be competitive with the current operations in order to be considered economic.

Specialty Minerals, Inc., operates the Santa Rita Quarry (plate 1, Marb2) on mixed USFS and BLM land near Helvetia in the Santa Rita Mountains Unit. The company estimates that reserves exist to produce 100,000 to 200,000 st/yr over a mine life of 75 years. The rock mined at the Santa Rita Quarry is Escabrosa Limestone; quality ranges from high calcium carbonate, high-brightness marble to very low quality rock. The company maintains that all qualities of rock at the deposit are utilized by blending them to specification for various customers. An on-site plant produces such products as various types of filler materials, wallboard materials, marking chalk, material for plastic and glass production, decorative stone, and landscape material. (See McDonnell, in press, figure 2.)

The White Rock Mine (plate 1, Marb14), operated by Catalina Marble, Inc., is located outside the Forest, about 9 mi east of the Santa Catalina-Rincon Mountains Unit. Products made from white marble quarried at the mine include veneer and decorative stone, plaster sand, animal feed additive, and highway subgrade material (Phillips and others, 1994, p. A9).

The Andrada Marble Quarry (plate 1, Marb15), operated by Georgia Marble Co. of Arizona, is also located completely outside the Forest, about 2 mi north of the Santa Rita Unit and about 5.5 mi northeast of the Santa Rita Quarry. The company produces calcium feed additive, plastering material, decorative stone, roofing granules, and filler material (Phillips and others, 1994, p. A11).

Past production

In addition to the Santa Rita Quarry mentioned above, minor production has occurred at several other sites in the Forest. Marble was quarried at eight sites at the northern end of the Dragoon Mountains Unit from the mid-1950's to early 1960's by Ligier-Arizona Marble Quarries, Inc. and its successor, Dragoon Marble Quarries (plate 1, Marb5 through Marb12). The primary commodity produced was crushed marble chips, used for making terrazzo and roofing granules. Dimension marble was quarried from two of the sites in the early 1950's: the Breche Saguaro Quarry, and one of the Apache Yellow Quarries (See Chatman, 1993, p. 10, and figures 2-7.).

Limited development of limestone and dolomite has also occurred in the northern part of the Dragoon Mountains Unit. Based on pit dimensions, about 2,000 st of limestone and dolomite were quarried at six sites. About 1,200 st of rock was removed from the largest of the quarries (plate 1, LS3). It may have been used as crushed stone fill or aggregate.

The Corbett Marble Quarry (plate 1, Marb4) is located in the southeastern part of the Huachuca Mountains Unit on homesteaded land. A crushing and sizing plant produced several sizes of white marble chip for roofing chips marketed in Tucson and Phoenix. Some production occurred about 1959; otherwise, no information is available on this operation (Johnson, 1959, p. 1).

The Stump Canyon limestone prospect (plate 1, LS2) is in the southeastern Huachuca Mountains Unit, 1.5 mi north of Coronado National Monument. The prospect is a trench and a 35-ft-long adit in Permian Naco Formation limestone. Limestone in the trench is shaly, iron-oxide stained, highly fractured, and of poor quality, but exposures in the adit are unfractured and less iron-stained. Roughly 275 st of rock has been removed, based on the adit dimensions. (USBM unpublished field notes, available in Denver). Whether any of this material was used is unknown; a possible use is crushed rock for fill or aggregate to be used locally. No resource assessment can be made from the information available.

Undeveloped occurrences

Several undeveloped locations of carbonate rock occur in the Forest. A large outcrop in the Marble Peak area of the Santa Catalina-Rincon Mountains Unit (plate 1, Marb1) includes Escabrosa Limestone and probable Martin Formation, and covers roughly 0.8 mi^2, with a typical thickness of 800 ft (Braun, 1969, plate 4). The area is mostly on patented land owned by Oracle Ridge Mining Partners, a company that produces copper from skarns associated with the limestone. The company has no plans at this time to produce marble products (Murray Strachan, Geologist, Oracle Ridge Mining Partners, Oracle, Arizona; oral comm., 1994).

The Escabrosa also crops out over a large area of the northern Santa Catalina Mountains (USBM, in press, a, plate 2, area F) (plate 1, LS1). A 517-ft-thick section of limestone and dolomite in Nugget Canyon appears to be free of primary impurities, according to Creasey (1967, p. 37-39). This outcrop covers about 0.2 mi^2. However, the possibility of development of this occurrence may be reduced due to its proximity to Peppersauce Cave, a popular recreation site in the Forest.

In the same township as the Santa Rita Quarry in the Santa Rita Mountains Unit, an additional, and possibly similar, area of marbleized Escabrosa limestone has been mapped (plate 1, Marb3). The outcrop covers about 0.1 mi^2, but no other information is available.

The Cochise White Marble patented placer claim is in the Chiricahua-Pedregosa Mountains Unit just east of Chiricahua National Monument (plate 1, Marb13). Escabrosa Limestone that has been partially metamorphosed to marble is exposed on both sides of Whitetail Creek. The marble is predominantly white, soft, massive, and medium- to coarse-grained (Paige, 1909, p. 310). No information is available on tonnages at this site.

Conclusions

Future development of carbonate rock resources in the Forest depends on the establishment of a viable market in the region. In his report on the mineral resources of the Dragoon Mountains Unit, Chatman (1993, p. 13-15) researched the marketing of crushed rock and carbonate products in southern Arizona, providing a fairly complete discussion of the economics of carbonate rock production, most of which applies to occurrences in the Forest as a whole. The information on products, processing and transportation costs, and pricing is summarized below.

Typical combined mining and processing costs for marble chips are about

$2.30/st; landscaping boulders could be quarried for approximately $1.40/st. Truck transportation costs would be about $1.50/mi in 20 st loads; rail costs are about $0.047/st/mi.

The sale price of various products varies widely. Roofing granules sell for as low as $21/st, while colored marble chip products sell for $32 to $40/st. Decorative marble boulders sell for about $85/st. Dimension limestone is valued at $8 to $12/ft^3 for quarried blocks without fractures or seams, but blocks of lesser quality sell for $3 to $7/ft^3 less. The value of marble dimension stone is highly dependent on color and marbling. Unfractured quarried blocks without seams are valued at $30 to $50/ft^3; lesser quality blocks may sell for as low as $15/ft^3. (See Chatman, 1993, p. 13-15; Tim Lardner, New Mexico Travertine Plant, Belen, New Mexico; oral comm., 1994).

In the foreseeable future, continued production of carbonate rock products is expected at the Santa Rita quarry due to the large quantity of reserves and variety of products. For possible future development, high quality marble and location on patented land make the Marble Peak area and the Cochise White Marble claim the most likely targets in the Forest. The Corbett Marble Quarry in the Huachuca Mountains Unit of the Forest may have moderate resources of marble; the location of the quarry on private land, within 5 to 10 mi of the mid-sized market area of Sierra Vista, could make a small operation feasible. Dimension stone occurrences in the northern Dragoon Mountains Unit may also be attractive sites for future development, and limestones and dolomites in the same area may have low-unit-value uses such as crushed stone for fill (dolomite and limestone), and (limestone only) as crushed stone for aggregate, raw material for portland cement, and use as a sulfur-dioxide scrubber for stack emissions at power plants and smelters.

Other areas in the Forest have a lesser probability for development, but creation of a viable market in the region may make them attractive for development of low-end products, including colored marble chips for use as decorative landscaping rock, white marble chips for use as roofing granules, marble or limestone boulders for decorative landscaping rock, and crushed limestone or marble as aggregate or fill. In the past, both colored and white marble chips were produced for making terrazzo, but the market for this product has apparently dwindled since the 1960's (Chatman, 1993, p. 11).

Miscellaneous rock products

Aside from marble/limestone quarrying, there is currently (1994) no production of other types of stone in the Forest. There has been minor past production, and several areas have been investigated but never developed. A small prospect for decorative or dimension stone, the Ligier Tufa Mine (plate 1, CR3), is in the western Peloncillo Mountains Unit, about 1 mi west of the Arizona-New Mexico state line (Armstrong, 1993, p. 11). Eight claims were originally staked as locatable rock, but the BLM ruled that the site contained common variety rock, which is a salable commodity. There is no evidence of production; apparently, only a few blocks were removed for test purposes or for local use. The nearest market is Douglas, a distance of 40 mi. Transportation costs would likely be prohibitive in developing a resource.

There are two locations in the Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit where common rock has been collected as decorative landscape material. The first is at the Clarke Pit (plate 1, CR1) in the Calabasas Canyon; the second is about 1 mi west in Walker Canyon (plate 1, CR2). The local rock is an off-white to cream colored rhyolitic tuff. No information is available on marketing or prices paid for the product.

A reported pumice deposit, known as the Nature's Pride claim (plate 1, Pum1), is in the southern Chiricahua-Pedregosa Mountains Unit, about 12 mi southwest of Portal. Pumice is used in industry as an abrasive, lightweight aggregate, and as an ingredient in building blocks, bricks, and pozzolan. The owner of the Nature's Pride claim, Jim Vaughn, reported that 10 million st of gray pumice was at the site, but the claim was dropped when he was unable to develop a market. A field examination (Greeley, 1988, p. 1) showed most of the rock to be rhyolite, with some outcrops of possibly pumiceous tuff. The field report gave no indications of a significant pumice deposit. The site was not investigated during USBM field work in the Chiricahua-Pedregosa Mountains Unit.

Although there has been little demand in the past, sources for crushed aggregate production occur widely in the Forest. In general, desirable source rocks include sandstone, conglomerate, limestone, dolomite, and various igneous rocks such as even-grained granites, diabases, and basalts. All of these rock types occur at various locations in the Forest and may someday be developed as resources.

Given the wide range of lithologies in the Forest, possible sources of other types of rock suitable for dimension and decorative stone, aggregate, and other industrial uses undoubtedly exist. Future economic development of a resource would depend on the location and raw materials requirements of a specific customer. Due to the low unit value of these commodities, however, there has been little investigation of resources, and literature on the subject is sparse.

Gypsum

Gypsum has a variety of industrial uses, depending on its purity. Common applications include use as a soil additive and as an ingredient in plaster, wallboard, paint, and glass manufacturing (Keith, 1969a, p. 372). Pure gypsum is a hydrous calcium sulfate ($CaSO_4 \cdot 2H_2O$). Gypsum rock containing at least 80% gypsum is required for most commercial uses, but 90% gypsum rock is preferable. Rock containing as little as 50% gypsum may have some low-end uses, such as soil conditioner and fertilizer (Phillips, 1987, p. 16).

No gypsum production has occurred in the Coronado National Forest. The Whetstone Mountains Unit is the only area of the Forest containing significant occurrences of the mineral. They are described in detail by Chatman (1994, p. 24-29). A summary of findings is given below.

Gypsum in the Whetstone Mountains Unit occurs in the middle member of the Permian Epitaph Formation which crops out along the center of the Whetstone Mountains Unit. Wrucke and others (1983) designated large areas of the Epitaph Formation in the Whetstones as having high potential for gypsum occurrences. A USBM field examination, however, determined that most of the high potential area is limestone rather than gypsum. Chatman defined only three locations of significant gypsum occurrences, all in the southern portion of the Whetstone Mountains Unit (Chatman, 1994, figure 12). The most promising area contains a 137,000 st indicated resource of low-grade gypsum (plate 1, Gyp1). The larger part of the resource, a 91,000 st block with 70.7% purity, is within a single lower gypsum bed. The rest of the resources are in an upper bed, and contain 46,000 st of 73.9% purity. Both beds dip into the hillside. The low-grade quality of the gypsum would limit its application to low-unit-value uses such as soil conditioners or fertilizer.

Several factors reduce the likelihood of this resource being mined. They include the low purity of the gypsum, mining difficulties presented by the geologic structure of the deposit and the rugged terrain of the area, the remote location in relation to potential markets, the significant competition already in place in the region, and the fact that undeveloped deposits in the region (but outside the Forest) are closer to markets and have a higher grade and tonnage (Chatman, 1994, p. 30).

The other two gypsum occurrences outlined by Chatman are less significant. One (plate 1, Gyp3) has significant amounts of the mineral anhydrite, which is considered a deleterious component, the other has talus cover over most the gypsum bed, making determination of the extent of outcrop impossible by surface mapping (plate 1, Gyp2).

A fourth location (plate 1, Gyp4), in Lone Pine Saddle near Apache Peak, about 3 mi north of Gyp1, was outlined (Wrucke and others, 1983), but not examined during USBM field investigation. The area is geologically similar to Gyp1 through Gyp3, and could contain low-grade gypsum. However, this location would be even less favorable economically than the others, due to steep terrain and lack of road access to the area. These factors suggest that further work in the area is not warranted.

Development of gypsum resources in the Forest is unlikely under reasonably foreseeable conditions. Factors including low grade, poor access, and difficult mining conditions are likely to deter development. Low-grade gypsum such as is found in the Forest sells for $13 to $18/st at the quarry; transportation costs would add \$1.50 to \$1.75/st/mi (Chatman, 1994, p. 29). Gypsum deposits south and west of the Whetstone Mountains Unit (plate 1, Gyp5 through Gyp8) are more likely targets for development, should market conditions require a source of gypsum in the area. Appendix E summarizes information on these locations and other minor occurrences.

Fluorspar

Introduction

Fluorspar, or fluorite (CaF_2), is the principal source of the element fluorine. It has numerous industrial applications, including use as a flux for steel making, as an electrolyte in aluminum smelting, in enameling and glazing, and as an ingredient in the manufacture of hydrofluoric acid. Fluorspar is marketed in three grades, defined according to CaF_2 content and amounts of impurities: acid grade, ceramic grade, and metallurgical grade (metspar). Acid-grade fluorspar contains at least 97% CaF_2, not more than 1.1% silica, and low concentrations of $CaCO_3$ and sulfur; ceramic-grade fluorspar contains at least 95% CaF_2, not more than 2.5% silica, and not more than 0.12% iron oxide; metallurgical fluorspar contains 60 to 70% effective CaF_2, not more than 5 to 6% silica, less than 0.5% sulfur, and less than 0.25% lead. Effective CaF_2 is the calcium fluoride percentage minus 2.5 times the silica content. (See Elevatorski, 1971, p. 3-4.)

The only major past producer of fluorspar in the Forest is the Lone Star Mine in the Whetstone Mountains Unit. An unnamed mine in the Chiricahua-Pedregosa Mountains Unit had minor past production. Production of these two mines is summarized in appendix F. Scattered miscellaneous occurrences are in other areas of the Forest.

Lone Star Mine

A complete description of the Lone Star Mine (plate 1, Fluor1) is given by Chatman (1994, p. 13-15); a summary is presented here. The mine is located in Middle Canyon in the eastern Whetstone Mountains Unit. At one time, it was one of the State's largest producers of metallurgical-grade fluorite, producing 20,000 st from 1946 to 1967. Fluorspar occurred in a northwest-striking, steeply northeast-dipping vein which averaged 2 ft in thickness. The vein was mined for at least 200 ft along strike from several drift levels; the deepest was the 300 ft level. Ore grade averaged 85% CaF_2, and contained 1.5 to 2.0% silica impurities. The mine was operated sporadically during its production years, and since 1975 there has been no production, reportedly due to depletion of the ore body. (See Elevatorski, 1971, p. 10; Keith, 1973, p. 91.)

When examined in 1980, an area of the mine site had subsided, probably due to collapse of stopes on the 60 ft level (Chatman, 1994, p. 15). In addition, the main shaft had been backfilled (McColly and Scott, 1982, p. 7). By 1992, however, the backfill material had apparently fallen further down the shaft, leaving it open to a depth of about 75 ft. The possibility of further subsidence presents a significant physical hazard.

Since the fluorspar vein was inaccessible during USBM investigation of the site, it was not possible to make resource estimates. Although the vein at the mine is reportedly depleted, there is a possibility that more fluorspar-bearing vein material exists at depth along strike outside the mine area. Surface drilling would be the most feasible way of determining fluorspar continuity. However, current domestic demand for fluorite is met through production from mines in Illinois and from foreign sources, all of which produce fluorspar at low cost from much larger deposits than that of the Lone Star Mine. The ore body at the Lone Star Mine is therefore probably not economic under current market conditions.

Other occurrences

The remaining fluorspar locations in the Forest were not investigated during USBM field examination. Information on the only other known producer was obtained from the literature and is presented here. Other locations are minor, and many are occurrences of fluorite as a gangue mineral; these are presented in appendix A.

An unnamed deposit in the Chiricahua-Pedregosa Mountains Unit about 2 mi northwest of Paradise, Arizona (plate 1, Fluor2) reportedly produced about 400 st of fluorspar (Elevatorski, 1971, p. 12). The fluorspar came from a series of 6- to 12-in. wide veinlets in granite. No other information is known.

Conclusions

There is little likelihood for development of fluorspar occurrences in the Forest. In recent years, the consumption of metallurgical-grade fluorspar by the steel industry has decreased dramatically, due to a decline in steel production and improved processes requiring little or no fluorine (Miller, 1992, p. 7). Current domestic demand for fluorite is met through other U.S. and foreign sources, all of which produce fluorspar at low cost from much larger deposits than could reasonably be expected to occur in the Forest. The ore body at the Lone Star Mine, the most significant of the locations in the Forest, may be entirely depleted, or, if fluorspar does occur at depth, it is probably not economic under current market conditions. The limited information available from other fluorspar locations documented in the Forest indicates that there is little possibility of development there either.

Sand and gravel

Sand and gravel production has occurred in numerous locations in the Forest. Operations are often portable and operate on a temporary or sporadic basis at a given site. Currently (1994), the Bear Wallow area of the Santa Catalina-Rincon Mountains Unit (plate 1) is a source of fill material which is being used for road improvement of the Mt. Lemmon highway. This source will be depleted by the construction project (William Lewis, U.S. Forest Service Coronado National Forest, Tucson, Arizona; oral comm., 1994). An area of Happy Valley, on the east flank of the Rincon Mountains in the Santa Catalina-Rincon Mountains Unit (plate 1), is a source of sand, gravel, and borrow pit material for Pima County government use. The Clarke Pit is a small private sand and gravel operation in Calabasas Canyon in the southeastern Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit (plate 1). Aggregate, screened sand, and crushed rock for septic leach fields are produced. Production is 21,500 yd^3/yr, with two year's worth of reserves (as of December, 1993). The market for this material is in Nogales and Rio Rico, Arizona (USBM, in press, b). The Arizona Department of Transportation has periodically operated sand and gravel pits in the Nicksville area near the eastern edge of the Huachuca Mountains Unit (plate 1).

Undeveloped occurrences of sand and gravel are widespread in the Forest. The USBM (in press, a, plate 2; in press, b, figure 43) outlined areas of possible sand and gravel resources in the Santa Catalina-Rincon Mountains Unit and the

Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit (plate 1). Other resources are likely to be found in geologic settings similar to these elsewhere in the Forest. Two basic types of sand and gravel occurrences are likely to occur. Large areas of residual and talus sand and gravel deposits are relatively poor sources because of poor sorting. Higher quality sources of sand and gravel are those that have been formed by the transport and reworking of detritus by stream action; such deposits include valley fill, stream terraces, active stream channels, and alluvial fans. These are abundant in the Forest, and may represent significant future resources (Keith, 1969b, p. 429).

It should be noted that specifications for various uses of sand and gravel can vary widely; a particular source may require extensive field checking and laboratory testing before a resource can be defined for a particular application. A drawback commonly found in the types of deposits occurring in the Forest is that sand tends to occur in greater abundance than gravel, except in areas of preserved gravel bars and lenses; factors such as this and others may increase the expense of producing adequate materials for some uses (Keith, 1969b, p. 440).

Average costs for all types of sand and gravel in the study area are $4.25/st (Dupree and Coggin, 1994, p. 14). Transportation costs, per st, are typically $1.50 for the first mile, and $0.15/mi for each additional mile (Ray Krohn, Arizona Department of Transportation, oral comm., 1994).

Gemstones

Semi-precious gemstones have been produced from a number of areas in the Forest. All of the sites have been small operations, operated on a sporadic basis, and all have produced collector's and lapidary specimens rather than minerals for industrial applications. Very little information is available on most of the sites; three of the better-known locations with recent activity were visited during USBM field investigation of the Forest.

Semi-precious blue opal is produced by Arizona Blue Fire Opal from the Scorpio claims (plate 1, Gem1) about 2 mi northwest of Ruby in the Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit. The opal is used for jewelry (USBM, in press, b).

Turquoise occurs in the southern Pinaleno-Greasewood Mountains Unit, about 15 mi north of Willcox (plate 1, Gem2). An unnamed exploration shaft exposes a 3/8-in.-thick seam of turquoise in a shear zone. Production, if any, has been small, and was apparently not of gem quality (Brown, 1993a, p. 9, 50).

Fire agate and chalcedony are produced from two claim groups in the Deer Creek drainage in the eastern Galiuro Mountains Unit: the Vernice claims and the One-Track claims (plate 1, Gem3 and Gem4, respectively). The amount of production is unknown, but the area has produced lapidary quality gemstone sporadically for several years. The value of fire agate is presently in the $5 to $40/ct range (Brown, 1993c, p. 30).

The nature of gem occurrences is such that large-scale exploration or predictions of foreseeable development are inappropriate, but the discovery and small-scale exploitation of gemstone deposits will undoubtedly continue in the Forest.

CONCLUSIONS

For most of the industrial mineral occurrences documented in the Coronado National Forest, feasibility for development will always be highly variable, given changing demands, low unit value of most of the commodities, costs associated with transportation, and small profit margins for producers. However, some general conclusions regarding reasonably foreseeable development of industrial minerals in the Forest can be made as follows:

- Increasing construction, particularly in the Tucson metropolitan area, but also in mid-sized market areas such as Sierra Vista, Nogales, and Douglas, will create more demand for raw materials. This is especially true for sand and gravel, but also applies to other commodities, including crushed marble for roofing granules and decorative chips, dimension marble and limestone, and crushed carbonate rocks for wallboard manufacture.

- A resurgence in the copper smelting industry in southern Arizona could cause an increased demand for silica flux, making development of some of the occurrences of these commodities in the Forest feasible.

- Production of carbonate rocks in the Santa Rita Mountains will continue for the foreseeable future. This is due to a large resource of high-quality rock and a wide range of products, which create an unusually stable economic base for an industrial mineral product. Other carbonate rock occurrences in the Forest are unlikely to compete with the Santa Rita Quarry or the other operations nearby but outside the Forest.

- Demand for some commodities is impossible to predict and may appear or disappear for capricious reasons, such as fashion. Examples include most types of decorative stone, some semiprecious gemstones, and marble chips for terrazzo manufacture.

- Environmental restrictions on development of natural resources will probably continue to increase. The effects of regulation may either increase or decrease the possibility for exploitation of industrial minerals in the Forest. When applied to public lands, strict regulations could abolish development outright, or increase production expense to a prohibitive level. Restrictions directed toward mineral development in populated areas such as Tucson, however, could result in making remote occurrences such as those in the Forest more economically viable in the future.

REFERENCES

Note: "USBM" is the U.S. Bureau of Mines

Arizona Department of Mines and Mineral Resources, no date: Unpublished report in Southern Belle Mine file, available in Phoenix, Arizona, 2 p.

Armstrong, R. C., 1993, Mineral appraisal of Coronado National Forest, part 4, Peloncillo Mountains Unit, Cochise County, Arizona, Hidalgo County, New Mexico: U.S. Bureau of Mines Open File Report MLA 18-93, 30 p.

Armstrong, R. C., and Brown, S. D., 1993, Mineral appraisal of Coronado National Forest, part 3, Winchester Mountains Unit, Cochise County, Arizona: U.S. Bureau of Mines Open File Report MLA 10-93, 21 p.

Bates, R. L., and Jackson, J. A. (eds.), 1980, Glossary of Geology: American Geological Institute, Falls Church, Virginia, 749 p.

Braun, E. R., 1969, Geology and ore deposits of the Marble Peak area, Santa Catalina mountains, Pima County, Arizona: Unpublished M.S. thesis, University of Arizona, Tucson, page count unknown.

Brown, S. D., 1993a, Mineral appraisal of the Coronado National Forest, part 1, Pinaleno-Greasewood Mountains Unit, Graham County, Arizona: U.S. Bureau of Mines Open File Report MLA 8-93, 82 p.

Brown, S. D., 1993b, Mineral appraisal of the Coronado National Forest, part 2, Chiricahua-Pedregosa Mountains Unit, Cochise County, Arizona: U.S. Bureau of Mines Open File Report MLA 12-93, 188 p.

Brown, S. D., 1993c, Mineral appraisal of the Coronado National Forest, part 9, Galiuro Mountains Unit, Graham County, Arizona: U.S. Bureau of Mines Open File Report MLA 21-93, 41 p.

Brown, S. D., 1993d, Mineral appraisal of the Coronado National Forest, part 10, Santa Teresa Mountains Unit, Graham County, Arizona: U.S. Bureau of Mines Open File Report MLA 26-93, 53 p.

Budden, R. T., 1975, The Tortolita-Santa Catalina Mountain complex: Unpublished M.S. thesis, University of Arizona, Tucson, 133 p.

Chatman, M. L., 1993, Mineral appraisal of Coronado National Forest, part 6, Dragoon Mountains Unit, Cochise County, Arizona: U.S. Bureau of Mines Open File Report MLA 30-93, 326 p.

Chatman, M. L., 1994, Mineral appraisal of Coronado National Forest, part 11, Whetstone Mountains Unit, Cochise and Pima Counties, Arizona: U.S. Bureau of Mines Open File Report MLA 2-94, 81 p.

Chatman, M. L., Mineral appraisal of Coronado National Forest, part 7, Patagonia Mountains-Canelo Hills Unit, Cochise and Santa Cruz Counties, Arizona: U.S. Bureau of Mines Open File Report, in press.

Creasey, S. C., 1967, General geology of the Mammoth quadrangle, Pinal County, Arizona: U.S. Geological Survey Bulletin 1218, 94 p.

Drewes, H. D., 1981, Tectonics of southeastern Arizona: U.S. Geological Survey Professional Paper 1144, 96 p.

Dupree, J. A., and Coggin, H. M., 1994, Arizona annual report: U.S. Bureau of Mines Mineral Yearbook, 20 p.

Elevatorski, E. A., 1971, Arizona Fluorspar: Arizona Department of Mines and Mineral Resources report, 51 p.

Graybeal, F. T., 1962, The geology and gypsum deposits of the southern Whetstone Mountains, Cochise County, Arizona: Unpublished M.S. thesis, University of Arizona, Tucson, 80 p.

Greeley, M. N., 1988, notes on field visits to Nature's Pride claim: available at Arizona Department of Mines and Mineral Resources, Phoenix, Arizona, 1 p.

Johnson, A. L., 1959, Field engineers report on Corbett Marble Quarry: available at Arizona Department of Mines and Mineral Resources, Phoenix, Arizona, 1 p.

Keith, S. B., 1969a, Gypsum and anhydrite, in Mineral and water resources of Arizona, report prepared by the U.S. Geological Survey, the Arizona Bureau of Mines, and the U.S. Bureau of Reclamation: Committee on Interior and Insular Affairs, U.S. Senate, 90th Congress, 2nd Session, U.S. Government Printing Office, Washington, D.C., p. 371-382.

Keith, S. B., 1969b, Sand and gravel, in Mineral and water resources of Arizona, report prepared by the U.S. Geological Survey, the Arizona Bureau of Mines, and the U.S. Bureau of Reclamation: Committee on Interior and Insular Affairs, U.S. Senate, 90th Congress, 2nd Session, U.S. Government Printing Office, Washington, D.C., p. 424-441.

Keith, S. B., 1973, Index of mining properties in Cochise County, Arizona: Arizona Bureau of Mines Bulletin 187, 98 p.

McColly, R. A., and Scott, D. C., 1982, Mineral investigation of the Whetstone roadless area, Cochise and Pima Counties, Arizona: U.S. Bureau of Mines Open File Report MLA 129-82, 22 p.

McDonnell, J. R., Jr., Mineral appraisal of Coronado National Forest, part 12, Santa Rita Mountains Unit, Pima and Santa Cruz Counties, Arizona: U.S. Bureau of Mines Open File Report, in press

Miller, M.M., 1992, Fluorspar annual report: U.S. Bureau of Mines annual commodity report series, 16 p.

Paige, Sidney, 1909, Marble prospects in the Chiricahua Mountains, Arizona, in Hayes, C. W. and Lindgren, Waldemar, Contributions to economic geology 1908, Part I, metals and non-metals except fuels: U.S. Geological Survey Bulletin 380, 406 p.

Phillips, K. A., 1987, Arizona industrial minerals, 2nd edition: Arizona Department of Mines and Mineral Resources, 185 p.

Phillips, K. A., Niemuth, N. J., Bain, D. R., 1994, Directory of active mines in Arizona: Arizona Department of Mines and Mineral Resources, Directory 42, 24 p. and map.

Simons, F. S., 1964, Geology of the Klondyke quadrangle, Graham and Pinal Counties, Arizona: U.S. Geological Survey Professional Paper 461, 173 p.

Tsuji, K. S., 1984, Silver mineralization of the El Tigre Mine and volcanic resurgence in the Chiricahua Mountains, Cochise County, Arizona: Unpublished M.S. thesis, University of Arizona, Tucson, 140 p.

Tuftin, S. E., and Armstrong, R. C., 1994, Mineral appraisal of Coronado National Forest, part 8, Huachuca Mountains Unit, Cochise and Santa Cruz Counties, Arizona: U.S. Bureau of Mines Open File Report MLA 1-94, 192 p.

USBM, Mineral appraisal of Coronado National Forest, part 5, Santa Catalina-Rincon Mountains Unit, Pima and Pinal Counties, Arizona: U.S. Bureau of Mines Open File Report, in press, a

USBM, Mineral appraisal of Coronado National Forest, part 13, Atascosa-Pajarito-San Luis-Tumacacori Mountains Unit, Pima and Santa Cruz Counties, Arizona: U.S. Bureau of Mines Open File Report, in press, b

Wrucke, C. T., McColly, R. A., Werschky, R. S., Scott, D. C., Bankey, V. L., Kleinkopf, M. D., Staatz, M. H., and Armstrong, A. K., 1983, Mineral resources of the Whetstone Mountains roadless area, Cochise and Pima Counties, Arizona: U.S. Geological Survey Miscellaneous Field Studies MF-1614-A, 1:48,000 scale map and 10 p. pamphlet.

Appendix A--Miscellaneous mineral occurrences in or near the Coronado National Forest.

[Locations in or near the Forest, mentioned in the literature as locations of industrial minerals. Field examination and/or more thorough literature research indicates that these are occurrences only. Reasons for reaching these conclusions are given in the Comments column.]

Name	Location	Plate 1 Location Identifier	Commodity	Comments
3 R copper porphyry area[1]	T. 23 S., R. 16 E., Sec. 6	Al1	alunite	Occurs in phyllic alteration of deep copper porphyry/breccia bodies. Potential source of alumina, but not likely to compete with domestic and imported bauxite.
Red Mountain copper porphyry area[2]	T. 22 S., R. 16 E., Sec. 19 and 20	Al2	do.	do.
Alamo Springs Mine[3]	T. 13 S., R. 14 E., Sec. 3, 4	Gyp9	gypsum	Mine probably had past production of gypsum, but is now in a residential area; area is outside Forest.
Helvetia Mine[4]	T. 18 S., R. 15 E., Sec. 13, 14	Gyp10	do.	Gypsum beds in Permian Epitaph Fm.; area is outside Forest.
Pague prospect[5]	T. 16 S., R. 30 E., SE. 1/4 Sec. 17	Fluor3	fluorspar	Green and purple coarsely crystalline fluorite in a 4-ft-wide vein. The vein reportedly has a high silica content.
Grand Reef Mine[6]	T. 6 S., R. 20 E., NE. 1/4 Sec. 29	Fluor4	do.	Occurs as a gangue mineral associated with base and precious metals.
Dogwater Mine[7]	T. 6 S., R. 20 E., NW. 1/4 Sec. 33	Fluor5	do.	Purple to white fluorite occurs as a gangue mineral associated with base metals.
Junction prospect[8]	T. 6 S., R. 20 E., NW. 1/4 Sec. 33	Fluor6	do.	Occurs as a gangue mineral associated with base metals.
Landsman Group[9]	T. 5 S., R. 20 E., W. 1/2 Sec. 29	Fluor7	do.	Purple fluorite occurs as a gangue mineral associated with base and precious metals.
Driscoll Mtn. prospect[10]	T. 14 S., R. 18 E., Sec. 24	Fluor8	do.	Coarsely crystalline green fluorite in 3- to 4-ft-wide veins in Devonian or Mississippian limestone. Grade reported at 70% CaF_2.
Annie Laurie claims[11]	T. 23 S., R. 16 E., SW. 1/4 Sec. 8	Fluor9	do.	Occurs as a gangue mineral associated with uranium and base metals.
Alta Mine[11]	T. 23 S., R. 16 E., C. W. 1/2 Sec. 4	Fluor10	do.	Occurs as a gangue mineral associated with base and precious metals.
Snowrock claims[12]	T. 8 S., R. 22 E., C. Sec. 10	Mica1	mica	Muscovite and biotite in pegmatite and mica schist.
Lost Goat[13]	T. 8 S., R. 25 E., Sec. 33	Mica2	do.	do.

Appendix A--Miscellaneous mineral occurrences in or near the Coronado National Forest-Source Notes.

[1] Chatman, in press
[2] Chatman, in press
[3] Phillips, 1987, p. 109
[4] Phillips, 1987, p. 110
[5] Elevatorski, 1971, p. 12
[6] Simons, 1964, p. 146-147
[7] Simons, 1964, p. 147
[8] Simons, 1964, p. 148
[9] Elevatorski, 1971, p. 19
[10] Elevatorski, 1971, p. 33
[11] USBM, in press, b
[12] Chatman, in press
[13] Phillips, 1987, p. 126

Appendix B--Production and resources of silica as copper smelter flux from the Coronado National Forest.

Name	Location	Plate 1 Location Identifier	Production (st)/Year(s)		Resources (st)/Class		Grade gold (oz/st)	Grade silver (oz/st)	Grade copper (per cent)
Gold Hill[1]	T. 10 S., R. 15 E., NW. 1/4 Sec. 14	Sil1	60,000	Uncertain	5,000,000	Inferred	--	0.5	--
Southern Belle[2]	T. 10 S., R. 16 E., Sec. 19, 20.	Sil2	18,000 mined for metals content)	1885-1888	618,000	Inferred	0.2 to 0.5	--	--
			Unknown tonnage of gold-bearing silica flux	Unknown					
"Ledge East of Austerlitz"[3]	T. 22 S., R. 11 E., SW. 1/4 Sec. 31.	Sil3	Unknown; probably small	--	155,000	Inferred, sub-economic	0.2	1.9	--
Ricketts Mine[4]	T. 18 S., R. 19 E., Sec. 24	Sil4	300,000	1950's	300,000	indicated	--	--	--
Unmined area W. of Ricketts Mine[4]	T. 18 S., R. 19 E., Sec. 24	Sil5	--	--	15,000,000	indicated	--	--	--
Copper Plate Mine[5]	T. 19 S., R. 18 E., C. Sec 24	Sil6	1,600	1957-1958	2,000 to 4,000	inferred, sub-economic	--	0.6 to 1.0	1.2 to 1.6
Tungsten Reef[6]	T. 23 S., R. 20 E., SW. 1/4 Sec. 14 and E. 1/2 Sec. 15	Sil7	None	--	Not estimated	--	--	--	--
Tako #9[7]	T. 24 S., R. 20 E., SE. 1/4 Sec. 3 and NE. 14 Sec. 10	Sil8	unknown	--	20,000	indicated, marginally economic	0.18	0.95	0.19
El Tigre[8]	T. 17 S., R. 30 E., SE. 1/4 Sec. 20	Sil9	732	1973	157,850	Indicated or Inferred	0.005	0.52	--
			700 to 800	1974					
Southeast end of El Tigre vein[8]	T. 17 S., R. 30 E., S. 1/2 Sec. 27	Sil10	None	--	571,458	Indicated or Inferred	0.005	0.18	--

Appendix B--Production of silica as copper smelter flux from the Coronado National Forest-Source Notes.

[1] Budden, 1975, plate 3; David McGee, Silica Mines, Inc. President, Oracle, Arizona; oral comm., 1990 to 1993
[2] USBM, in press, a
[3] USBM, in press, b
[4] Chatman, 1994, p. 15-16
[5] Chatman, 1994, p. 10-11
[6] Tuftin and Armstrong, 1994, p. 24
[7] Tuftin and Armstrong, 1994, p. 18-19
[8] Brown, 1993c, p. 101; Tsuji, 1984, p. 130

Appendix C--Production and resources of marble from the Coronado National Forest.

Site Name	Location	Plate 1 Location Identifier	Production (st)	Resources (st)/Class		Color	Possible Uses
Marble Peak[1]	T. 11 S., R. 16 E., Sec. 17, 18, 19, 20	Marb1	None	Not estimated	--	White, slight green tint	Dimension stone, Filler material.
Santa Rita Quarry[2]	T. 18 S., R. 15 E., Sec. 11, 14.	Marb2	100,000 (approx. annual production)	7,500,000	Measured and/or Indicated	White	Wide range of marble/limestone products.
Unmined area S. of Santa Rita Quarry[2]	T. 18 S., R. 15 E., Sec. 36.	Marb3	None	Unknown	Indicated and/or Inferred	White	do.
Corbett Marble Quarry[3]	T. 23 S., R. 21 E., Sec. 32	Marb4	Unknown	Not estimated	--	White	Roofing granules.
Breche Saguaro[4]	T. 16 S., R. 23 E., C. N. 1/2 Sec. 35.	Marb5	1,300 mined; includes 130 remaining on site	22,500	Indicated	Varied: Brown, white, yellow, gray	Landscape chip, Landscape boulder, Dimension stone.
Green Chip[5]	T. 16 S., R. 23 E., NE. 1/4 NW. 1/4 Sec. 33.	Marb6	6,800 mined; includes 1,000 remaining on site	46,500	Indicated	Green and white mixture	Landscape chip.
				150,000	Inferred		
White quarries (northernmost and central pit)[5]	T. 16 S., R. 23 E., C. Sec. 33.	Marb7	2,300 N. most pit; 15,600 central pit	180,000	Indicated	White	Roofing granules.
White quarries (southernmost pit)[5]	T. 16 S., R. 23 E., C. S. 1/2 Sec. 33.	Marb7	34,300 mined; includes: 1,600 stockpiled on site	950,000	Indicated	White	Roofing granules.
Paul claim[5]	T. 16 S., R 23 E., NE. 1/4 SE. 1/4 Sec. 33.	Marb7	None	1,300,000	Indicated	White	Roofing granules.
Red Marble Quarry[5]	T. 16 S., R. 23 E., NE 1/4 Sec. 27.	Marb8	7,500 mined; includes 2,300 remaining on site	7,000	Indicated	Red and pink	Landscaping chips, Landscaping boulders.
Unnamed quarry[5]	T. 16 S., R. 23 E., NW. 1/4 NE. 1/4 Sec. 27.	Marb9	600	11,300	Indicated	Red and pink	Landscaping chips, Landscaping boulders.

Appendix C--Production and resources of marble from the Coronado National Forest, Continued

Site Name	Location	Plate 1 Location Identifier	Production (st)	Resources (st)/Class		Color	Possible Uses
Unmined area E. of Red Marble Quarry[5]	T. 16 S., R. 23 E., W. 1/2 Sec. 26.	Mar10	None	30,000	Indicated	Red and pink	Landscaping chips, Landscaping boulders.
Unmined area S. of Red Marble Quarry[5]	T. 16 S., R. 23 E., NW. 1/4 SE. 1/4 Sec. 27.	Marb11	None	3,800	Indicated	Red and pink	Landscaping chips, Landscaping boulders.
Apache Yellow Marble Quarries[6]	T. 16 S., R. 23 E., NE. 1/4 NW. 1/4 Sec. 33.	Marb12	700 (North pit); 500 (South pit)	Not estimated	--	Yellow-white (North pit); Yellow/brown (South pit)	Dimension stone (North pit); Crushed chip (South pit).
Cochise White Marble claim[7]	T. 16 S., R. 30 E., Sec. 21, 28	Marb13	None	Not estimated	--	White	Dimension stone, filler material.

[1] USBM (in press, a)
[2] McDonnell (in press)
[3] Johnson, 1959, p. 1
[4] USBM field measurements, 1991
[5] Chatman, 1993, p. 12
[6] Chatman, 1993, p. D19-20
[7] Paige, 1909, p. 310

Appendix D--Production of limestone and dolomite from the Coronado National Forest.

Site Name	Location	Plate 1 Location Identifier	Production (st)	Possible Uses
Nugget Canyon[1]	T. 10 S., R. 16 E., Sec. 33	LS1	None	Crushed rock for fill or aggregate.
Stump Canyon prospect[2]	T. 23 S., R. 21 E., NW. 1/4 Sec. 31	LS2	275	Decorative crushed rock, Crushed rock for fill or aggregate.
Unnamed quarries[3]	T. 16 S., R. 23 E., NW. 1/4 NE. 1/4 Sec. 27.	LS3	1,300	Decorative crushed rock, Crushed rock for fill or aggregate.

[1] USBM, in press, a

[2] Unpublished USBM field notes, available in Denver, Colorado

[3] Chatman, 1993, p. D13-14, D16

Appendix E--Locations and resources of gypsum near the Coronado National Forest.

Name	Location	Plate 1 Location identifier	Resources (st)	Relation to areas in Forest
Southern Whetstone Mtns. Gypsum, central location[1]	T. 20 S., R. 19 E., Sec. 4, 9	Gyp5	7.2 million measured 3.7 million indicated or inferred, 80.2% avg. grade	Geologically similar to, and probably related to, locations Gyp1-Gyp3. Would be more economical to mine than Gyp1.
Southern Whetstone Mtns. Gypsum, northern location[1]	T. 19 S., R. 19 E., Sec. 32, 33; T. 20 S., R. 19 E., Sec. 4, 5	Gyp6	8.8 million indicated, 80.2% avg. grade	do.
Unnamed mineral location[2]	T. 18 S., R. 18 E., Sec. 10 and 15	Gyp7	200,000 measured 470,000 inferred	Does not extend into Forest; would likely be more economical to mine than Gyp1.
Unnamed mineral location[2]	T. 18 S., R. 18 E., Sec. 15	Gyp8	5,800 measured 12,000 inferred	do.

[1] Graybeal, 1962, p. 65-66
[2] Chatman, 1994, p. 30-31

Appendix F--Production of fluorspar from the Coronado National Forest.

Name	Location	Plate 1 Location Identifier	Production (st)/Year		Resources (st)
Lone Star Mine[1]	T. 18 S., R 19 E, Sec. 26.	Fluor1	5,400	1946-1950	Not estimated; mine reserves reportedly depleted.
			1,200	1950-1951	
			Unknown	1952-1953	
			34	1963	
			Unknown	1967	
Unnamed prospect[2]	T. 17 S., R. 30 E., Sec. 12	Fluor2	400 (approx.)	unknown	Not estimated.

[1] Chatman, 1994, p. 13-15
[2] Elevatorski, 1971, p. 12

OPEN FILE REPORT
MLA 10-94
PLATE 1

INDUSTRIAL MINERAL LOCATIONS IN THE CORONADO NATIONAL FOREST, ARIZONA

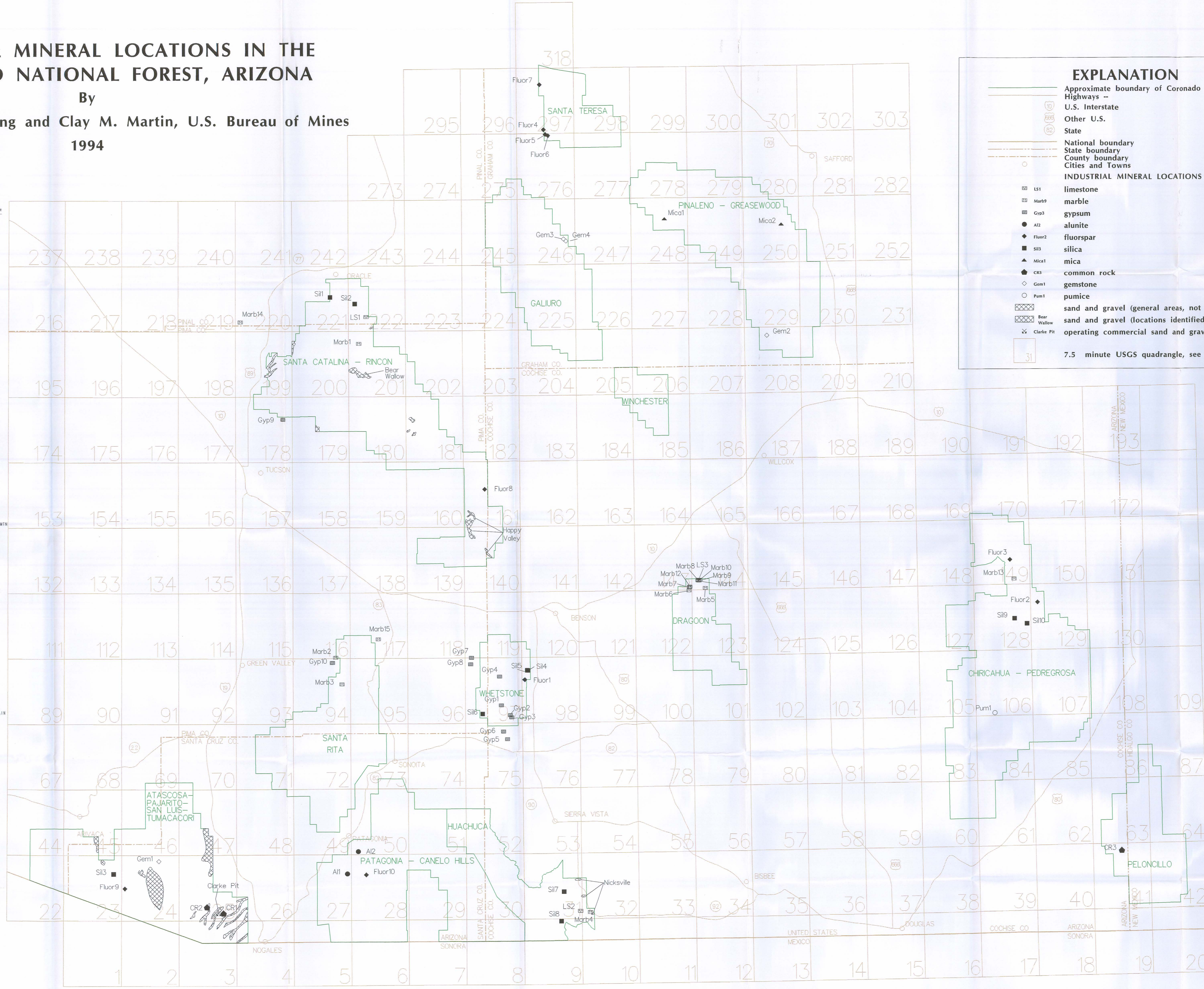
By

Robert C. Armstrong and Clay M. Martin, U.S. Bureau of Mines

1994

7.5 Minute USGS Quadrangle Index

TIC-ID	USGS Quadrangle name	TIC-ID	USGS Quadrangle name
2	ALAMO SPRING	136	TUCSON SW
3	PAJARITO PEAK	137	TUCSON SE
4	NOGALES	138	VAIL
5	KINO SPRINGS	139	RINCON PEAK
6	DUQUESNE	140	GALLETA FLAT WEST
7	LOCHIEL	141	GALLETA FLAT EAST
8	CAMPINI MESA	142	SAN PEDRO RANCH
9	MONTEZUMA PASS	143	DRAGOON
10	BOB THOMPSON PEAK	144	COCHISE
11	STARK	145	SULPHUR SPRING
12	NACO	146	DOS CABEZAS SW
13	BISBEE	147	PAT HILLS NORTH
14	PAUL SPUR	148	BOWIE MTN. SOUTH
15	DOUGLAS	149	COCHISE HEAD
16	EAST OF DOUGLAS	150	BLUE MOUNTAIN
17	SAN BERNARDINO RANCH	151	SAN SIMON CIENEGA
18	WEST OF GUADALUPE CANYON	153	LA TORTUGA BUTTE
19	GUADALUPE CANYON	154	COCORAQUE BUTTE
20	GUADALUPE PASS	155	BROWN MOUNTAIN
22	CUMERO MOUNTAIN	156	CAT MOUNTAIN
23	BARTLETT MOUNTAIN	157	TUCSON
24	RUBY	158	TUCSON WEST
25	PENA BLANCA LAKE	159	TANQUE VERDE PEAK
26	RIO RICO	160	MICA MOUNTAIN
27	CUMERO CANYON	161	HAPPY VALLEY
28	HARSHAW	162	WILDHORSE MOUNTAIN
29	CANELO PASS	163	DEEPWELL RANCH
30	HUACHUCA PEAK	164	STEELE HILLS
31	MILLER PEAK	165	RED BIRD HILLS
32	NICKSVILLE	166	WILLCOX SOUTH
33	HEREFORD	167	SIMMONS PEAK
34	BISBEE	168	DOS CABEZAS
35	BISBEE NE	169	BOWIE MTN NORTH
36	DOUBLE ADOBE	170	LITTLE WOOD CANYON
37	DOUGLAS NE	171	VANAR NW
38	COLLEGE PEAKS	172	VANAR
39	CINDER HILL	174	WATERMAN PEAK
40	LAZY J RANCH	175	WEST OF ARVA
41	GUADALUPE SPRING	176	ARVA
42	BLACK POINT	177	JAYNES
44	WILBUR CANYON	178	TUCSON NORTH
45	ARIVACA	179	SABINO CANYON
46	MURPHY PEAK	180	AGUA CALIENTE HILL
47	TUBAC	181	PIETY HILL
48	SAN CAYETANO MTNS	182	SOZA CANYON
49	PATAGONIA	183	SOZA MESA
50	MT. HUGHES	184	HOOKERS HOT SPRINGS
51	O'DONNELL CANYON	185	MUSKHOG MTN.
52	PYEATT RANCH	186	SQUARE MOUNTAIN
53	FORT HUACHUCA	187	WILLCOX NORTH
54	LEWIS SPRINGS	188	RAILROAD PASS
55	TOMBSTONE SE	189	LUZENA
56	POTTER MTN.	190	BOWIE
57	GLEESON SE	191	OLGA
58	MCNEAL	192	SAN SIMON
59	LESLIE CANYON	193	DOUBTFUL CANYON
60	PEDREGOSA MOUNTAINS WEST	195	SILVER BELL EAST
61	PEDREGOSA MOUNTAINS EAST	196	WEST OF MARANA
62	PARAMORE CRATER	197	MARANA
63	SKELETON CANYON	198	RUELAS CANYON
64	CLANTON DRAW	199	ORO VALLEY
67	LAS GUIJAS	200	MOUNT LEMMON
68	CERRO COLORADO	201	MOUNT BIGELOW
69	SAUCITO MOUNTAIN	202	BUEHMAN CANYON
70	AMADO	203	REDINGTON
71	MT. HOPKINS	204	CHERRY SPRING PEAK
72	MT. WRIGHTSON	205	THE MESAS
73	SONOITA	206	REILEY PEAK
74	ELGIN	207	WEST OF GREASEWOOD MTN
75	MUSTANG MOUNTAINS	208	GREASEWOOD MOUNTAIN
76	HUACHUCA CITY	209	MONK DRAW
77	FAIRBANK	210	FISHER HILLS
78	TOMBSTONE	216	SAMANIEGO HILLS
79	HAY MOUNTAIN	217	RED ROCK
80	OUTLAW MOUNTAIN	218	DESERT PEAK
81	ELFRIDO	219	TORTOLITA MOUNTAINS
82	SWISSHELM MTN.	220	ORACLE JUNCTION
83	BRUNO PEAK	221	ORACLE
84	SWEDE PEAK	222	CAMPO BONITO
85	APACHE	223	PEPPERSAUCE WASH
86	SKULL CANYON	224	KIELBERG CANYON
87	MOUNT BALDY	225	BASSETT PEAK
89	FRESNO WASH	226	HARRISON CANYON
90	PENITAS HILLS	227	SIERRA BONITA RANCH
91	BATAMOTE HILLS	228	FORT GRANT
92	ESPERANZA MILL	229	STOCKTON PASS
93	GREEN VALLEY	230	GILLESPIE MOUNTAIN
94	HELVETIA	231	TONQUE
95	EMPIRE RANCH	237	NEWMAN PEAK
96	SPRING WATER CANYON	238	PICACHO PASS
97	APACHE PEAK	239	DURHAM HILLS
98	MCGREW SPRING	240	CHIEF BUTTE
99	LAND	241	FORTIFIED PEAK
100	HABERSTOCK HILL	242	NORTH OF ORACLE
101	BLACK DIAMOND PEAK	243	MAMMOTH
102	TURQOISE MTN.	244	CLARK RANCH
103	SQUARETOP HILLS WEST	245	RHODES PEAK
104	SQUARETOP HILLS EAST	246	KENNEDY PEAK
105	STANFORD CANYON	247	EUREKA RANCH
106	CHIRICAHUA PEAK	248	BLUE JAY PEAK
107	PORTAL PEAK	249	WEBB PEAK
108	RODEO	250	MT. GRAHAM
111	PALO ALTO RANCH	251	ARTESIA
112	STEVENS MTN.	252	ARTESIA NE
113	SAMANIEGA PEAK	273	LOOKOUT MOUNTAIN
114	TWIN BUTTES	274	HOLY JOE PEAK
115	SAHUARITA	275	OAK GROVE CANYON
116	CORONA DE TUCSON	276	KLONDYKE
117	MOUNT FAGAN	277	BUFORD HILL
118	THE NARROWS	278	TRIPP CANYON
119	MESCAL	279	SHINGLE HILL MOUNTAIN
120	BENSON	280	THATCHER
121	SAINT DAVID	281	SAFFORD
122	KNOB HILL	282	SAN JOSE
123	COCHISE STRONGHOLD	295	BRANDENBURG MTN.
124	PEARCE	296	BOOGER CANYON
125	SULPHUR HILLS	297	COBRE GRANDE MTN.
126	PAT HILLS SOUTH	298	JACKSON MTN.
127	FIFE PEAK	299	TELEGRAPH WASH
128	RUSTLER PARK	300	EDEN
129	PORTAL	301	PIMA
130	PORTAL NE	302	WEBER PEAK
132	SAN PEDRO	303	LONE STAR MTN.
133	THREE POINTS	318	MOUNT TURNBULL
134	SAN XAVIER MISSION SW		
135	SAN XAVIER MISSION		



EXPLANATION

Approximate boundary of Coronado National Forest

Highways --

- U.S. Interstate
- Other U.S.
- State

National boundary

State boundary

County boundary

Cities and Towns

INDUSTRIAL MINERAL LOCATIONS -- showing location identifier

Identifier	Commodity
LS1	limestone
Marb9	marble
Gyp3	gypsum
Al2	alunite
Fluor2	fluorspar
Sil3	silica
Mica1	mica
CR3	common rock
Gem1	gemstone
Pum1	pumice
	sand and gravel (general areas, not specifically identified)
Bear Wallow	sand and gravel (locations identified in text)
Clarke Pit	operating commercial sand and gravel pit

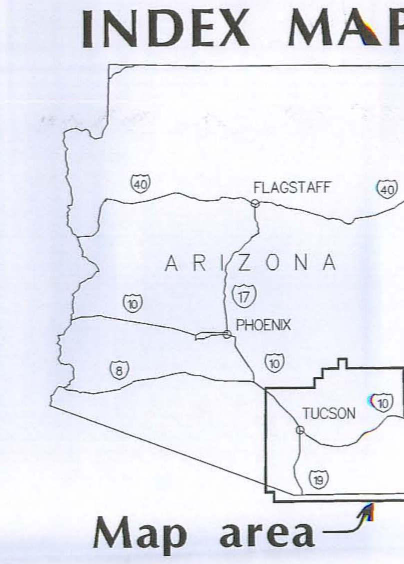
31 — 7.5 minute USGS quadrangle, see index at left

N

SCALE 1:250,000

2 0 2 4 6 8 10 mi

INDEX MAP



Map area

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF MINES