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## *Notes on the mineral deposits of the Gallinas Mountains, New Mexico*

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# NOTES ON THE MINERAL DEPOSITS OF THE GALLINAS MOUNTAINS, NEW MEXICO

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## INTRODUCTION

Many small mineral deposits occur in the eastern part of the Gallinas Mountains in the Red Cloud district. The deposits may be divided into two types — iron deposits and fluorite-copper deposits. Inasmuch as the iron ores occur only in limestone at an intrusive contact, they are geologically distinct from the other mineral occurrences. The fluorite and copper deposits, however, are not distinctly different from one another; they differ only in the tenor of fluorite and copper minerals. The small amounts of gold, silver, lead, and bastnaesite that were mined were recovered from the fluorite-copper deposits.

Although the presence of mineral deposits in the Gallinas Mountains was known as early as 1885, it was the increased mineral demand during World War II that spurred prospecting which resulted in the discovery of most of the deposits. About 10,000 tons of iron were mined in 1942 and 1943, and nearly 4,000 tons of copper ores were produced up to 1949. Between 1942 and 1955, fluorite was shipped from at least three mines in the district. And one mine, the Red Cloud fluorite mine, yielded bastnaesite between 1953 and 1955. Total fluor-spar production probably was less than 2,000 tons, from which about 60 tons of bastnaesite concentrate were recovered (Griswold, 1959). Altogether 29 mines and prospects are located in the district. Except for assessment work, all are now idle.

The general geology of the Gallinas Mountains is discussed in another paper in this guidebook. Details of the bastnaesite mineralization are given in a previously published paper (Perhac and Heinrich, 1964).

## FLUORITE-COPPER DEPOSITS

Except for two minor occurrences, all fluorite-copper deposits are in Yeso (Permian) sandstones and siltstones overlying a trachyte laccolith. During intrusion of the laccolith, the overlying sedimentary rocks were domed and extensively faulted (high-angle normal faults). Because of the brittle nature of the Yeso, brecciation is common along the faults. Individual breccia zones may be as much as 30 feet wide and range in length from a few feet to over 1,500 feet. It is along the faults and in the breccia zones that the epigenetic mineralization occurred. The large amount of open space and the many cross fractures (commonly joints) served as excellent channelways for the mineralizing fluids. As the ore fluid rose, it precipitated minerals in the open spaces associated with the faulting and accompanying brecciation.

Ore minerals occur not only in breccia zones paralleling faults, but also in pipe-like shattered zones at the intersection of two or more major faults.

Open-space filling is, by far, the common mode of occurrence for the mineralization. Only in a few areas of intense mineralization has the sandstone actually been replaced. Typical ore specimens thus consist of either a highly brecciated rock criss-crossed by small veinlets or a porous mass of fluorite and copper minerals from the breccia zone. True fissure veins, without associated wall-rock brecciation, are relatively rare.

The mineralogy of the deposits is summarized in table 1. Fluorite is the most abundant mineral, even in those deposits worked primarily for copper. Barite or quartz are generally the next most abundant minerals. Pyrite, although minor, is ubiquitous. Every deposit contains these four primary minerals. In addition the cerium fluo-carbonate, bastnaesite, was identified in all but three deposits. Some deposits are mineralogically simple, containing virtually only four hypogene minerals: fluorite, quartz, barite, and pyrite. In contrast, the Rio Tinto deposit contains at least nine hypogene minerals plus a variety of supergene species. Many deposits contain at least traces of the copper sulfides bornite and chalcocite. At some, oxidation was so complete that no trace of the sulfide is apparent, the presence of copper being shown by azurite, malachite, and particularly chrysocolla. Galena and its alteration products (cerussite, anglesite, and pyromorphite) occur in some deposits.

Most of the fluorite-copper deposits show evidence of at least two periods of hypogene mineralization. During the first period mineralizing fluids deposited quartz, barite, sulfide minerals, fluorite, bastnaesite, and perhaps calcite. They probably were deposited in this general order as indicated by such features as quartz-lined fractures, fluorite deposits on etched barite crystals, and bastnaesite crystals along fluorite cleavage and fracture planes. Following the initial phase of mineralization, the deposits were refractured as shown by the number of early-formed minerals that are fractured and bent or microfaulted. During the second phase, mainly barite, fluorite, and locally abundant calcite were precipitated. In addition, at a few deposits, minor late silica occurs as chalcedony lining tiny cavities in the ore. Supergene alteration was the final step in the formation of the deposits.

Several facts indicate that these are low temperature mineral deposits. Fracture filling was the main type of deposition. Abundant open spaces, comb structure, crustification, and the presence of many short and irregular veinlets all attest to low temperature and pressure. (The sedimentary cover probably did not exceed 1,500 feet at the time of mineralization.) The lack of wallrock altera-

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Table 1: Mineralogy of the Fluorite-Copper Deposits in the Red Cloud District, New Mexico

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fluorite	X	x	x	x	X	x	x	X	x	X	x	x	x	x	x	x	x
Quartz	M	tr	m	m	m	m	tr	m	M	m	m	tr	m	m	x	m	m
Barite	x	x	tr	m	M	M	M	M	m	M	m	m	m	m	m	M	m
Bastnaesite	m			tr	tr	tr	m	tr									
Calcite	tr	tr	tr	tr						tr	M	tr	m		m	tr	
Chalcedony													tr		tr		
Pyrite	tr	tr	tr	m	tr	tr	m	tr									
Galena		m	tr			tr						tr	m			m	
Bornite		tr	tr		tr								tr				
Chalcocite		m	M		tr							tr	tr				
Limonite	tr																
Hematite	tr																
Pyromorphite		tr	tr								tr		tr		tr		
Cerussite		?											m		tr		
Anglesite			tr										tr				tr
Chrysocolla		m	m		tr						tr	tr	tr		tr		
Malachite		tr	tr		tr						tr	tr	tr		tr		
Azurite		tr	tr								tr	tr	tr				

X = greater than 50%

x = 25 - 50%

M = 10 - 25%

m = 5 - 10%

tr = less than 5%

#### Prospects

1. Red Cloud Fluorite
2. Red Cloud Copper and Deadwood
3. Little Wonder
4. Last Chance
5. Eagle Nest
6. Bottleneck
7. Congress
8. Conqueror No. 4 and Hilltop
9. Summit

10. Hoosier Girl North
11. Hoosier Girl South
12. Eureka
13. Rio Tinto
14. All American
15. Sky High
16. Pride No. 2
17. M and E No. 13

tion and the presence of chalcedony also suggest a relatively low temperature for the ore-forming fluid. Finally, a fluid inclusion geothermometric study on bastnaesite indicates a formational temperature of 175 to 185°C. On the basis, therefore, of texture, structure, mineralogy, and temperature of formation, the Gallinas Mountains fluorite-copper deposits are considered epithermal.

### IRON DEPOSITS

Five iron deposits occur in the Gallinas Mountains. They are typical limestone replacement lodes and all are in Yeso limestone (or its metasomatized equivalent) that is in contact with the underlying trachyte laccolith. It is evident, from the irregular shape of the mineralized zones and the exclusion of all rock types except limestone (gypsum at one deposit) as a host, that the iron minerals

are replacement deposits. Fracture control, nevertheless, is evident, and the greatest ore concentrations typically are present along northwest or northeast fractures. In general, the ore fluids probably rose along the steep fractures and replaced limestone while migrating along bedding planes away from the fractures.

The mineralogy of the lodes is simple. Magnetite, hematite, and limonite are, for all practical purposes, the only minerals present. However, trace amounts of pyrite also were noted. The calcite that is commonly mixed with the iron minerals is undoubtedly derived from the host. This also applies to the gypsum mixed with the ore at the Red Cliff mine. Quartz is present in small amounts. Locally, tremolite and diopside, derived from a skarn, are dispersed throughout the mineralized rock.

The first step in the formation of the deposits was the introduction of SiO<sub>2</sub> from either minor silicification

of the Yeso sandstone near the ore zone, or crystallization of minor quartz in the limestone. At those deposits at which skarns occur some  $\text{SiO}_2$  was utilized in the formation of lime silicate minerals. Iron was introduced following the addition of  $\text{SiO}_2$ . At the skarn deposits, some iron was first used for the formation of tremolite-diopside; the presence of dolomite in parts of the Yeso prevented extensive magnesia metasomatism. The skarn stage preceded precipitation of ore minerals. After satisfying all possible requirements of the silicates, the remaining iron in the mineralizing fluids was deposited as magnetite and hematite. The final phase in the formation of the ore deposits was surficial alteration. This is indicated by hydration of the iron minerals to the ubiquitous limonite, and possibly some oxidation of magnetite to hematite.

The temperature at which the iron deposits formed is not easily determined because no critical minerals or assemblages have been found. A priori, one would suspect a relatively high temperature. Two features, however, suggest that the temperature may have been considerably lower than that at which many other contact metasomatic deposits formed. First, the lime silicate assemblage (calcite-tremolite-quartz-diopside) could form at 250-300°C. This assemblage may be characteristic of albite-epidote hornfels facies rather than the higher temperature hornblende hornfels facies. The lower temperature is based on such considerations as: 1) disequilibrium as indicated by four phases in a three component system, 2) low  $\text{CO}_2$  partial pressure, and 3) presence of chlorite-muscovite (critical for albite-epidote facies) matrix in sandstones near the deposits. Thus a temperature of 250-300°C (Turner, 1958) is possible for the metamorphism, hence a somewhat lower temperature for the

ore deposition. Second, the presence of unreplaced gypsum in the ore indicates that the ore fluid temperature was less than that at which gypsum dehydrates to anhydrite (about 200°C considering pressure coefficients of transformation). Admittedly, original gypsum may have changed during mineralization and then hydrated back during surficial alteration. However, the gypsum lacks relict anhydrite and also lacks textures indicating original dehydration plus later hydration (Goldman, 1952). Thus the iron minerals may have formed at about 200°C.

In suggesting a low temperature for mineralization, certain assumptions are made: 1) temperatures assigned to the albite-epidote facies approach the correct order of magnitude, 2) an open system prevailed, 3) sufficient permeability existed to allow escape of  $\text{CO}_2$  thereby resulting in low  $\text{CO}_2$  pressure, and 4) gypsum was not dehydrated. If these conditions were met, then the Gallinas iron deposits probably formed in the temperature range of 200-250°C.

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