

PARAGENESIS OF THE BLANCHARD DEPOSIT

BINGHAM, HANSONBURG

SOCORRO, NEW MEXICO

BY

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CONTENTS

	Page
Acknowledgements	1
Abstract	2
Introduction	3
Location	4
General Characteristics of the Deposit	4
Mineral Descriptions	6
Primary Minerals	6
Secondary Minerals	9
Fluid Inclusion Studies in the Areas surrounding the Hansonburg District	16
General Knowledge of Fluid Inclusions	16
Method and Instruments Used for Thermometry	17
Preparation of Sample and Procedure of Determination of Homogenization Temperature of Fluid Inclusions	19
Previous Homogenization Temperature Measurements in New Mexico	19
New Studies of Homogenization Temperature of Fluid Inclusions in Fluorite from Areas around the Hansonburg District	20
Measurements of Fluid Inclusions in Calcite from Manganese Mine in Socorro County	22
Geologic Setting and Mineralogy of the Investigated Fluorite Deposits	23
Discussion	27
Paragenesis	28
Conclusion	38
References	39

Plates

	Page
1. Map of Socorro County showing location of mining districts	5
2. Photomicrograph showing aggregates of acicular crystals of aurichalcite	14
3. Photomicrograph showing trigonal crystals of spangolite	14
4. Photomicrograph showing needlelike crystals of plattnerite	15
5. Photomicrograph showing cubic crystals of murdochite	15
6. Instruments for measuring homogenization temperature of fluid inclusion	18
7. Map showing location of fluorite deposits in areas surrounding the Hansonburg District	21
8. Roedder et al's paragenesis tables	29
9. Paragenesis tables of the Blanchard Deposit	32
10. Table I Supergene Enrichment and Oxidation	34
11. Table II Oxidation of Residual Ions	36
12. Table III Oxidation of Transported Ions	37

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ABSTRACT

The Blanchard deposit is located 1.5 miles south of the Mex-Tex group of workings in Bingham mining area, Hansonburg District, southeast Socorro County, New Mexico. It is a series of mesothermal veins of the cavity filling and replacement type following faults, breccia zones and pre-existing fractures in Pennsylvanian shale and limestones.

The main ore minerals are barite, fluorite and galena. Various species of secondary supergene minerals of lead, copper and zinc, make the deposit unusual in its total mineral assemblage.

The homogenization temperatures of fluid inclusions in fluorite from areas surrounding the Hansonburg District are in the range of 200°C the same as those from the Hansonburg District.

The paragenesis of secondary supergene minerals is controlled by a supergene enrichment process as well as the Eh-pH and solubility of the solutions that dissolved the earlier sulfide minerals, sphalerite, pyrite, galena, chalcopryrite, covellite, and also redistributed calcium carbonate and quartz.

INTRODUCTION

This paper reports the results of a study of paragenesis and mineralogy of the Blanchard deposit in the Hansonburg District, Socorro County, New Mexico, including measurements of homogenization temperatures of fluid inclusions in fluorites from areas surrounding the Hansonburg District. The minerals are identified by microchemical test, X-ray diffraction method and polished section, which aid in the determination of paragenesis from handspecimens. The microchemical tests and polished section work follows Chamot & Mason (1946) and Short (1968). X-ray diffraction is performed by the Debye-Scherrer Method, (Azaroff et al 1958 and Nuffield 1966).

The measurements of homogenization temperatures of fluid inclusions in fluorites from other areas in central New Mexico were done, in order to compare with the homogenization temperatures of fluid inclusions in fluorite from the Hansonburg District and to investigate similarities and differences in these areas.

LOCATION

The Blanchard deposit is situated on the northwestern front of the Oscura Mountains, 1.5 miles south of the Royal Flush and Mex-Tex Mines in Bingham mining area, Hansonburg District, southeast Socorro County, New Mexico. The area is located in Sec. 1, T.5 S., R.5 E. on the U.S. Geological Survey Bingham Quadrangle topographic map.

GENERAL CHARACTERISTICS OF THE DEPOSIT

The Blanchard deposit lies along a westward facing fault scarp of the Oscura Mountains in cliff-forming limestones, shales, and sandstones of the Magdalena Group of Pennsylvanian and Permian ages (Roedder et al, 1968). It is a series of thin mesothermal cavity filling fissure veins feeding lenticular and blanketlike bedded replacement bodies along the faults, fractures, breccia and sheet zones in Pennsylvanian limestone and shale. The direction of faults and fractures is nearly north-south (Kopicki, 1962).

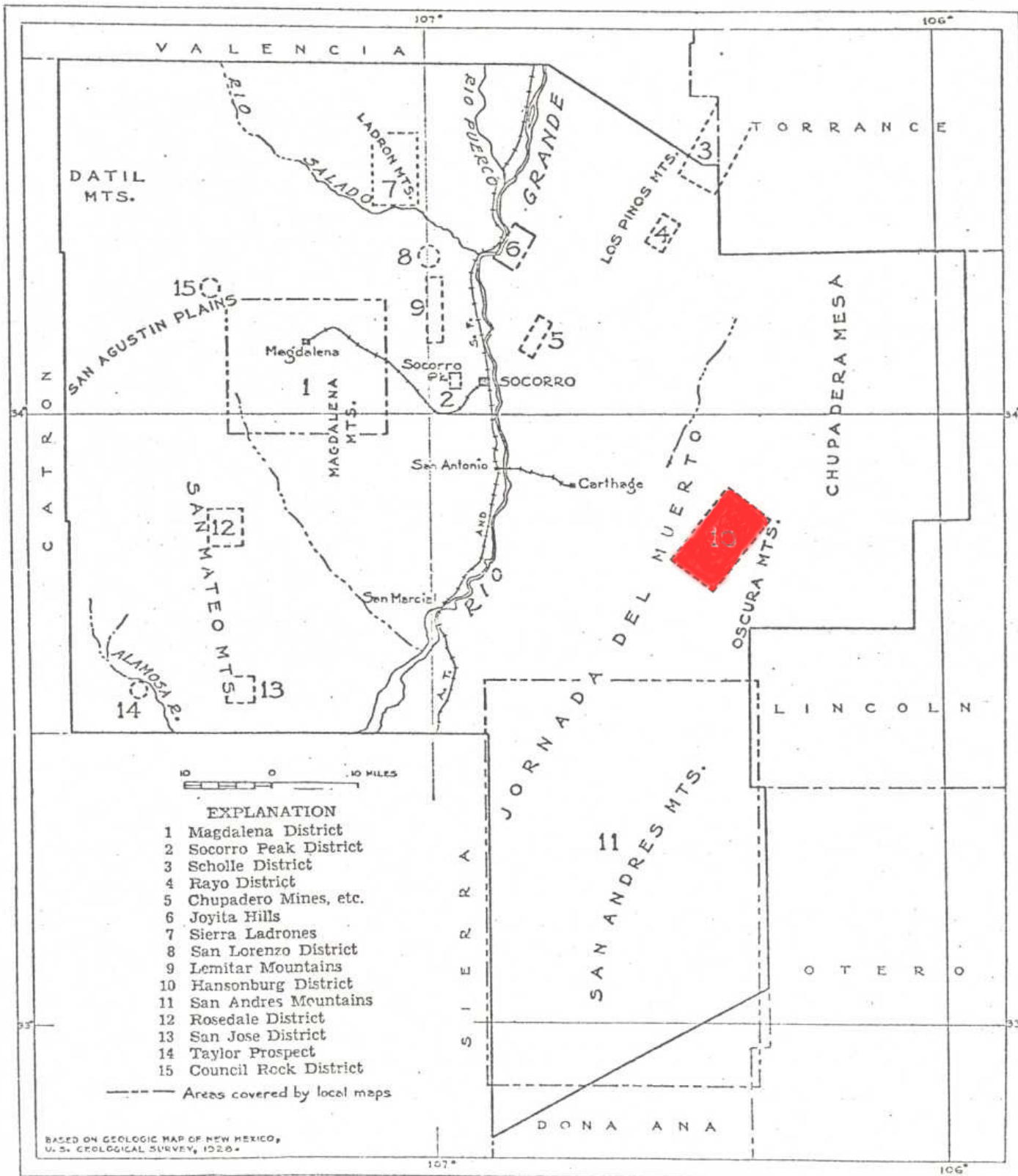
The blankets extending laterally outward from the faults in massive limestone consist of bands and tabular vugs of quartz, barite and fluorite associated with galena and other sulfides (Roedder et al, 1968).

Generally, all the minerals sampled are in the zones of oxidation and supergene enrichment. The supergene suite of copper-lead-zinc minerals are much more widespread and varied than the main very coarsely crystalline hypogene minerals: barite, fluorite, quartz, and galena. Intrusive igneous rocks cropping out in the Oscura Mountains to the east and south are quartz monzonite and diorite of middle Tertiary age. (Roedder et al, 1968).

From Lasky, Samuel G. 1932.

NEW MEXICO SCHOOL OF MINES
STATE BUREAU OF MINES AND MINERAL RESOURCES

BULLETIN 8
PLATE I



MAP OF SOCORRO COUNTY
Showing location of mining districts

MINERAL DESCRIPTIONS

The primary minerals consist of barite, quartz, fluorite, galena, chalcopyrite, pyrite, covellite and sphalerite.

The secondary minerals can be classified into 6 groups on the basis of chemical composition:

1. Oxide group consisting of goethite, murdochite and plattnerite.
2. Sulphate group consisting of anglesite, jarosite, plumbojarosite, spangolite, brochantite, linarite and gypsum.
3. Carbonate group consisting of calcite, rosasite, aurichalcite, azurite, cerussite and malachite.
4. Silicate group consisting of hemimorphite, dickite and chrysocolla.
5. Molybdate group represented only by wulfenite.
6. Fluoride group represented only by fluorite.

Primary Minerals

1. Barite (BaSO_4) - Identified by refractive index and x-ray diffraction.

Barite is the most abundant ore mineral in the area. It occurs in many varieties of form and in three colors: colorless, white and brown. Generally it occurs in tabular and bladed crystals, with individual crystals very large, up to 150 mm. in one or more dimensions. Colorless barite crystals are about 75 mm. wide and 2 mm. thick; some crystals contain chalcopyrite crystals as inclusion. Another form of barite

occurs in very small colorless, thin vitreous crystals about 4 mm. wide and .02 mm. thick. It is associated with brochantite and some barite crystals are coated by small crystals of quartz.

2. Quartz (SiO_2) - Identified by hardness and crystal form.

Quartz occurs as:

- a) silicification of limestone,
 - b) euhedral to anhedral crystals, sometimes coated by goethite, jarosite, or plumbojarosite,
 - c) minute clear colorless crystals coating barite, fluorite and galena. This quartz is a second generation of quartz.
3. Fluorite (CaF_2) - Identified by microchemical test and crystal form.

Fluorite occurs mainly as cubic crystals of various sizes from 1 mm. to 30 mm. on a side in many colors: Pale green, blue, purple, white and colorless. A second generation of fluorite occurs as small clear colorless cubic crystals; their size is from microscopic to .05 mm. on a side.

4. Galena (PbS) - Identified by microchemical test and crystal form.

Galena occurs as individual cubes or cube groups on silicified limestone mainly associated with quartz, fluorite and barite. Some cubic crystals of galena altered to form anglèsite, cerussite, linarite and brochantite layers.

Alteration layers of anglesite and cerussite sometimes alternate on the cube surface but the core of an altered galena cube contains only anglesite in concentric layers of vitreous gray and earthy white. Some altered galena cubes are filled with chrysocolla in the center of the cube. Relatively small amounts of unaltered galena cubes are also found in the area. Goethite and dickite coat some galena cubes.

5. Chalcopyrite (CuFeS_2) - Identified by microchemical test and polished section.

Chalcopyrite occurs as inclusions in barite crystals. Weathered crystals are usually replaced by goethite.

6. Pyrite (FeS_2) - Identified by microchemical test and hardness.

Pyrite occurs in small quantities in massive gypsum.

7. Covellite (CuS) - (The sample is in the museum of the New Mexico State Bureau of Mines and Mineral Resources.)

Covellite is very rare in the area. It occurs as an indigo blue overgrowth on sphalerite in massive gypsum.

8. Sphalerite (ZnFeS) - (The sample is in the museum of the New Mexico State Bureau of Mines and Mineral Resources.)

Minor amounts of sphalerite were deposited early in the sequence of deposition. (Roedder et al, 1968).

Secondary Minerals

A. Oxide Group

9. Goethite, $\text{FeO}(\text{OH})$ - Identified by microchemical test and x-ray diffraction.

Goethite is found as yellow, brown and blackish stains coating quartz, barite, galena, fluorite and scalenohedral crystals of calcite. It also shows a fluffy habit. Goethite is sometimes associated with wulfenite, plattnerite and murdochite. Exposed chalcopyrite is replaced by goethite.

10. Murdochite, $\text{PbCu}_6(\text{O}, \text{Cl}, \text{Br})_8$ - Identified by microchemical test and x-ray diffraction.

Murdochite occurs as shiny black iridescent cubic crystals or a combination of cubic and octahedral faces. The size of the average murdochite crystal is about 1 mm. on a side. It is associated with plattnerite, wulfenite, cerussite and goethite.

11. Plattnerite (PbO_2) - Identified by microchemical test and x-ray diffraction.

Plattnerite occurs as shiny black needlelike crystals associated with murdochite. Some black needles of plattnerite are on tabular crystals of hemimorphite.

B. Sulphate Group

12. Anglesite (PbSO_4) - Identified by microchemical test.

Anglesite is a vitreous gray alteration product of galena (Keith 1972), and also comprises the white concentric layers that replaced the cores of galena

cubes (Kopicki 1962). The compact earthy white anglesite in some cores of galena cubes develops a hole that is filled with chrysocolla. Anglesite also occurs as vitreous prismatic crystals on the surface of galena cubes commonly overlain by cerussite and sometimes is associated with linarite and brochantite.

13. Jarosite, $\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$ - Identified by micro-chemical test.

Jarosite occurs as a yellow-brown earthy incrustation on quartz crystals. It is associated with plumbojarosite.

14. Plumbojarosite, $\text{PbFe}_6^{+3}(\text{SO}_4)_4(\text{OH})_{12}$ - Identified by x-ray diffraction and micro-chemical test.

Plumbojarosite occurs as a greenish yellow earthy incrustation on travertine. Paperspar (calcite) is found on the plumbojarosite.

15. Spangolite, $\text{Cu}_6\text{Al}(\text{SO}_4)(\text{OH})_{12}\text{Cl}\cdot 3\text{H}_2\text{O}$ - Identified by x-ray diffraction and micro-chemical test.

Spangolite occurs as dark green vitreous trigonal crystals with striations. It is associated with brochantite and linarite. It crystallizes on the surface of quartz crystals or barite.

16. Brochantite, $\text{Cu}_4(\text{SO}_4)(\text{OH})_6$ - Identified by x-ray diffraction and micro-chemical test.

Brochantite occurs as emerald green silky mats or slender prismatic acicular crystal aggregates

with vertically striated faces. It may occur on oxidized surfaces of galena cubes associated with linarite. Brochantite is commonly found coating barite associated with linarite.

17. Linarite, $\text{PbCu}(\text{SO}_4)(\text{OH})_2$ - Identified by micro-chemical test.

Linarite is characterized by a deep azure-blue color, subadamantine to vitreous luster with a crystalline surface forming as crusts of elongated or tabular blades (Kopicki 1962), on barite, quartz and blue fluorite. Linarite occurs as a direct result of oxidation on the surface of galena cubes. It is associated with anglesite, brochantite, cerussite and barite.

18. Gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ - Identified by microchemical test.

Gypsum occurs as small vitreous colorless aggregates of crystal laths. Some crystals of malachite are enclosed in the crystal aggregates of gypsum.

C. Carbonate Group

19. Calcite (CaCO_3) - Identified by microchemical test and x-ray diffraction.

Calcite occurs in four forms: clear colorless rhombohedral crystals, paperspar (calcite), travertine, and brown scalenohedral crystals.

20. Rosasite, $(\text{Cu}, \text{Zn})_2(\text{CO}_3)(\text{OH})_2$ - Identified by x-ray diffraction and microchemical test.

Rosasite occurs as light blue-green globules or mammillary spherules on tabular crystals of

hemimorphite; some crystals of hemimorphite also grow on rosasite globules.

21. Aurichalcite $(\text{Zn, Cu})_5(\text{CO}_3)_2(\text{OH})_6$ - Identified by x-ray diffraction and microchemical test.

Aurichalcite is characterized by sky-blue aggregates of acicular crystals. It occurs associated with hemimorphite and brochantite. Some tiny clear vitreous cubic crystals of fluorite grow on the surface of prismatic acicular crystals of aurichalcite.

22. Azurite, $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$ - (The sample is in the museum of the New Mexico State Bureau of Mines and Mineral Resources.)

Azurite is an azure-blue mineral associated with brochantite.

23. Cerussite (PbCO_3) - Identified by microchemical test.

Cerussite is a stable phase of galena alteration. It occurs generally as white earthy compact powder and also colorless to translucent granular crystalline aggregates; some samples show pseudo-hexagonal crystals. A vitreous thin layer of cerussite coats other secondary minerals and goethite that in turn coat quartz. Colorless to shining vitreous granular crystal groups of cerussite grow on the surface of galena cubes associated with anglesite, linarite, brochantite and hemimorphite.

24. Malachite, $\text{Cu}_2(\text{CO}_3)(\text{OH})_2$ - Identified by microchemical test.

Malachite is a bright to dull green granular,

radiating and fibrous aggregate. It crystallizes on dickite that coats a fluorite cube; sometimes malachite is coated by dickite. Chrysocolla is found in the area as pseudomorphs after malachite.

D. Silicate Group

25. Hemimorphite, $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Hemimorphite occurs as colorless vitreous tiny tabular crystal aggregates. It is associated with plattnerite, aurichalcite, rosasite and brochantite; chrysocolla may be pseudomorphic after hemimorphite.

26. Dickite, $Al_2Si_2O_5(OH)_4$ - Identified by x-ray diffraction.

Dickite occurs as a white earthy compact powder or incrustation on fluorite and galena.

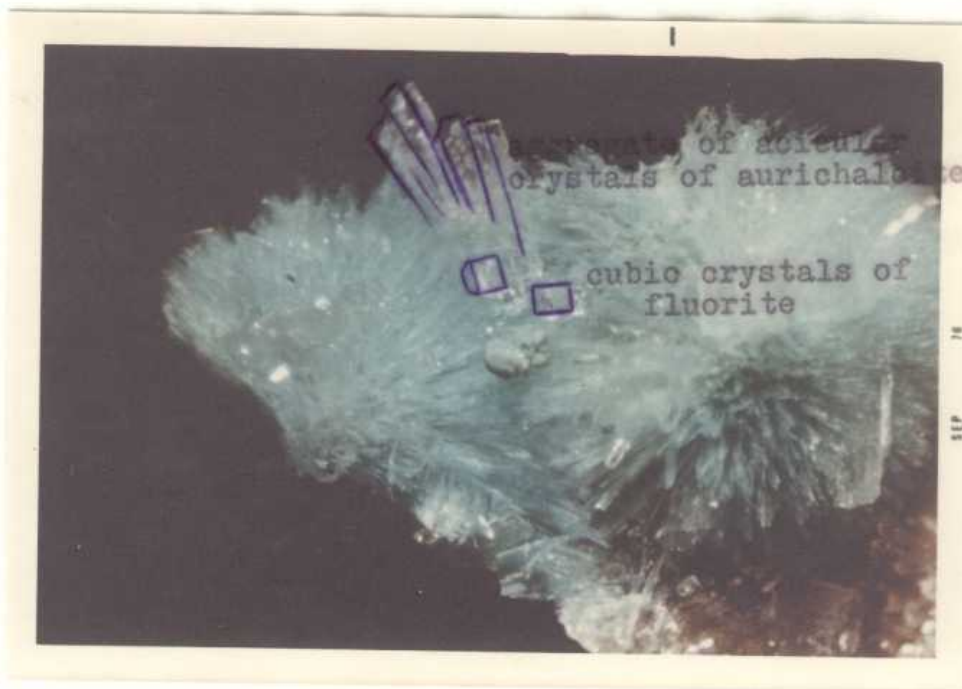
27. Chrysocolla, $(Cu, Al)_2 H_2Si_2O_5(OH)_4 \cdot nH_2O$ - Identified by x-ray diffraction and micro-chemical test.

Chrysocolla is characterized by blue, cracked, jelly-like, or blue, fibrous aggregates. It is the most abundant oxidized copper mineral. It occurs as pseudomorphs after malachite, hemimorphite, brochantite and spangolite.

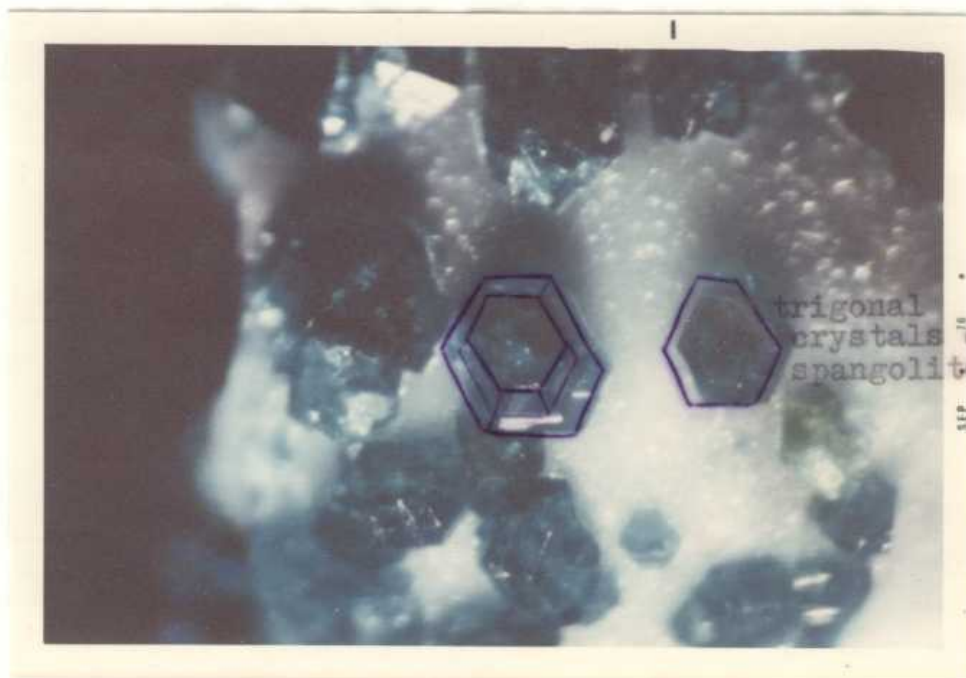
E. Molybdate Group

28. Wulfenite, $PbMoO_4$ - Identified by microchemical test.

Wulfenite is characterized by yellow to orange tetragonal dipyramidal crystals. The size of individual crystals is about 2 mm. long and 1 mm. wide. It is associated with cerussite, goethite, plattnerite, murdochite and brochantite.



Photomicrograph showing sky blue aggregates of acicular crystals of aurichalcite. Some tiny clear vitreous cubic crystals of fluorite grow on top of the prismatic acicular crystals of aurichalcite. (picture taken by J. Taggart)



Photomicrograph showing dark green vitreous trigonal crystals of spangolite on quartz crystals. (picture taken by J. Taggart)



Photomicrograph showing shiny black needlelike crystals of plattnerite on goethite staining quartz. Tetragonal twinned crystals of plattnerite are also shown in the picture. (picture taken by J. Taggart)



Photomicrograph showing shiny black iridescent cubic crystals of murdochite on goethite staining quartz. (picture taken by J. Taggart)

FLUID INCLUSION STUDIES IN THE AREAS SURROUNDING THE
HANSONBURG DISTRICT.

General Knowledge of Fluid Inclusion.

When crystals grow or crystallize in any kind of fluid medium, a small portion of the fluid will be trapped as a bubble in a solid crystal or as groups of droplets and these groups accumulate irregularly. These fluid inclusions give evidence of the nearly general presence of a fluid phase during the geological events yielding these host minerals. (Roedder, 1960).

Fluid inclusions consist mostly of two phases, a low-viscosity liquid and a gas or vapor bubble. The liquid is an aqueous salt solution with large concentrations of Na^+ , K^+ , Ca^{+2} , Mg^{+2} , Cl^- , and SO_4^{-2} ions. Carbon dioxide occurs both as liquid and gas. The bubble may consist only of water vapor. Three phase-inclusions contain liquid, gas bubble and salt crystals as a solid phase. Solid phases in inclusions are universally so small that they can be identified certainly only by optical methods. (Roedder, 1960).

The size of fluid inclusions mostly are less than .01 mm. Sizes larger than 0.1 mm. are not common. (Roedder, 1960).

"The inclusions in any given sample are seldom of only one generation. Commonly the primary inclusions are sparsely distributed and large, but the secondary inclusions in the same sample are small and very numerous." (Roedder, 1960).

Primary inclusions are those that were trapped during

the growth of the surrounding crystals. This type of fluid inclusion formed in euhedral crystals of negative crystal shape at higher temperatures than secondary inclusions.

Secondary inclusions are those that formed by any process after complete crystallization of the host. This type of fluid inclusions forms in groups along a plane and does not have crystal form.

Pseudo-secondary or Primary-secondary are the fluid inclusions that formed in the zone of overlap between primary inclusions and secondary fluid inclusions. These types of inclusions form if a crystal cracks during its growth, allowing the medium in which it is growing to enter the crystal, and be trapped in the core. (Roedder 1960)

Fluid inclusion are useful for studying:

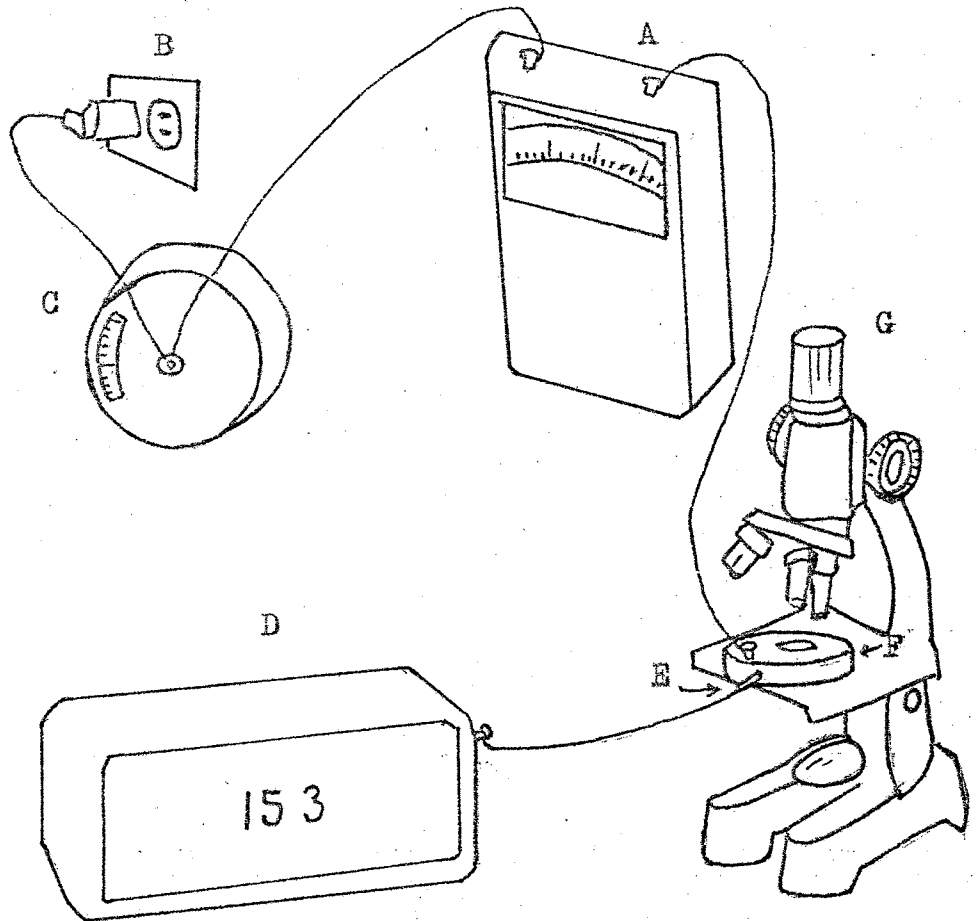
1. homogenization temperatures of phases to provide minimum temperatures of crystallization.
2. the pH, composition and salinity of solution that forms the enclosing minerals.
3. Some characteristics of mineralizing solutions.

Method and instruments used for thermometry.

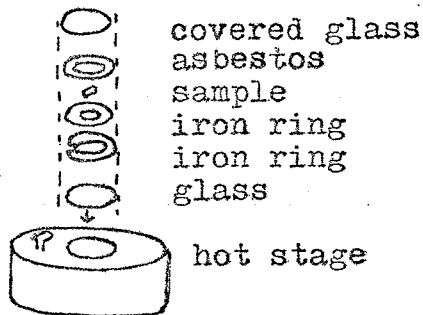
The most accurate and universally accepted method of temperature determination is to heat the fluid inclusions under the microscope while observing the inclusion.

The instruments are a high magnification microscope with adequate lighting, a hot stage which consists of an iron cylinder containing a piece of circular glass for placing sample, two metal rings, asbestos and a second

piece of round glass covering the unit. Asbestos is used for an insulator, the cover glass is used for preventing fog. A thermocouple is inserted through the hole at iron cylinder past the metal ring nearly in contact with sample. A temperature indicator is connected with thermocouple. The electrical power is connected with the ammeter and the hot stage, can be controlled by the thermostat, as shown in the sketch.



- | | |
|-------------------|--------------------------|
| A: ammeter | D: temperature indicator |
| B: electric power | E: thermocouple |
| C: thermostat | F: hot stage |
| | G: microscope |



HOMOGENIZATION TEMPERATURE

MEASURING INSTRUMENTS

Preparation of sample and procedure for determination of homogenization temperature of fluid inclusions.

Split the fluorite sample into small pieces of thin flat cleavage flakes about 2-5 mm in diameter and 1-2 mm thick. Look for the primary fluid inclusions in these small pieces of sample under the microscope. Then place the flake that contains the primary inclusions in the heating stage, put two metal rings around the sample then put the asbestos ring on metal ring, finally cover with the round glass. Set the hot stage under the microscope. Insert the thermocouple through the iron cylinder almost in contact with sample. Heat the sample by switching on and control the amperage with thermostat until it reach 3.2 amperes at start, then add amperes slowly until the bubble disappears. Read the temperature immediately.

Previous homogenization temperature measurements in New Mexico

The homogenization temperature of fluid inclusions in fluorite from the Greenleaf #1 prospect, Fluorite Ridge, Luna County, New Mexico were measured by Twenhofel (1947). These fluid inclusions gave temperatures from 150°C for a later pale violet, cubic stage to a maximum of 202°C for an early green octahedral stage. (Roedder et al, 1968).

Roedder et al (1968) measured the homogenization temperature of fluid inclusions in fluorite from the Hansonburg District and reported temperatures in the range

of 177^o-187^oC for the early rounded green fluorite I and in the range of 176^o-192^oC for the later sharp green and greenish white fluorite II and III. Then the temperature dropped 50^oC before the start of crystallization of fluorite IV. They concluded that fluid inclusions from the first three substages of fluorite were essentially constant in temperature at 186^o-205^oC, and the succeeding two substages yielded gradually decreasing temperature to about 140^oC.

Dr. Richard E. Beane of New Mexico Institute of Mining & Technology has studied homogenization temperatures, salinity, and composition of fluid inclusions in fluorite from various part of New Mexico. He is going to publish his research very soon.

New studies of homogenization temperature of fluid inclusions in fluorite from areas around the Hansonburg District.

The homogenization temperatures of fluid inclusions in fluorite from many areas surrounding the Hansonburg District were measured and yielded the following results as:

1. Gonzales Prospect

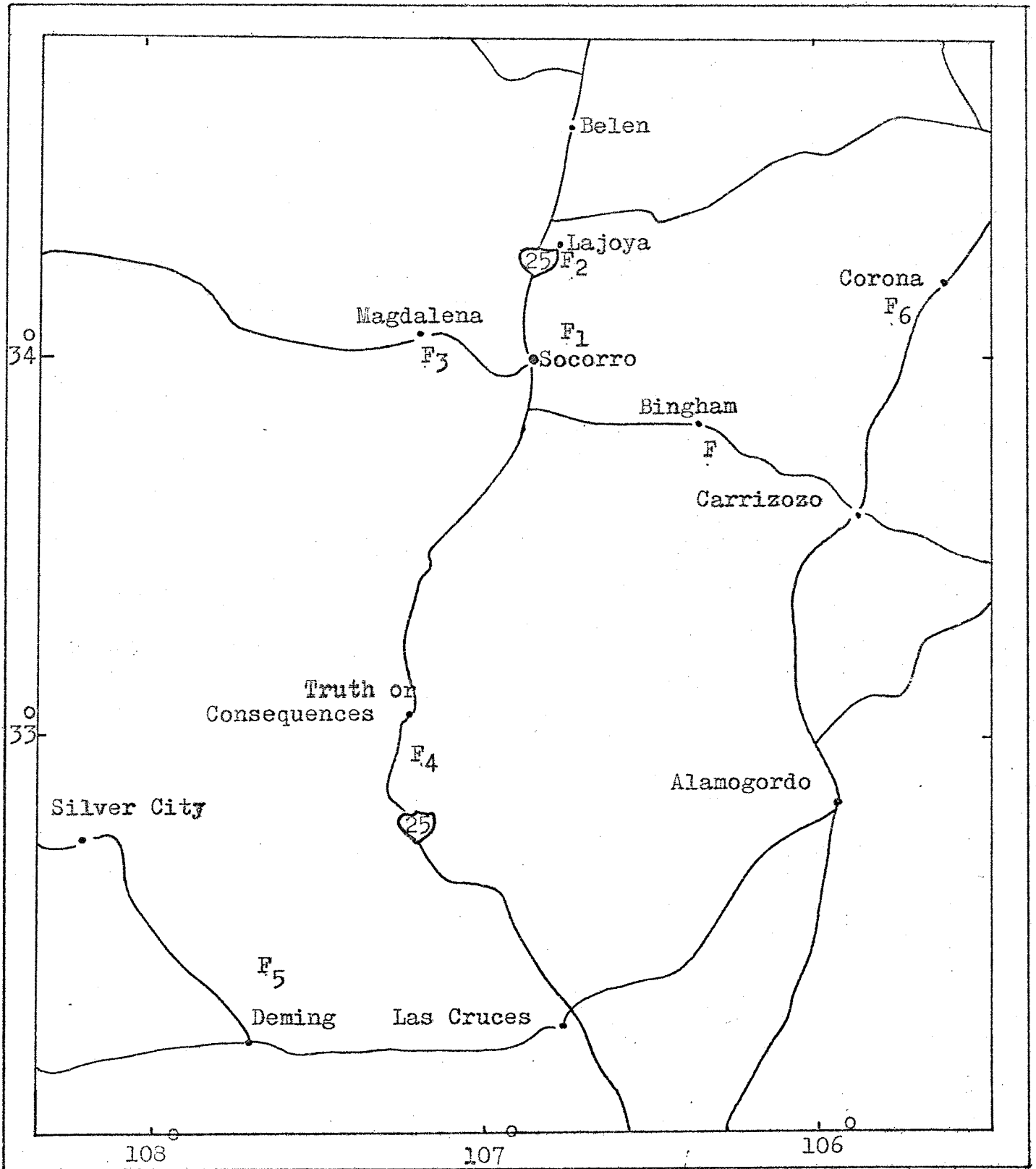
Colorless, pure fluorite gave temperatures
in the range of 190^o-196^oC.











Pale green, pure fluorite gave temperatures
in the range of 180^o-190^oC.

2. Joyita Hills

White to pale green, dense siliceous fluorite
gave temperatures in the range of 200^o-215^oC.

MAP
 SHOWING LOCATION OF FLUORITE DEPOSITS IN AREAS SURROUNDING
 THE HANSONBURG DISTRICT



- | | | | |
|---|--|---|----------------------------|
| Legend:
 Interstate high way
 U.S. high way
 City
 Fluorite dep. at Bingham
 Fluorite dep. at Gonzales | | scale: | miles : 20
inches : 1 2 |
| | |  Fluorite dep. at Lajoya Hills
 Fluorite dep. at Magdalena Mtns
 Fluorite dep. at Sierra Caballo
 Fluorite dep. at Fluorite Ridge
 Fluorite dep. at Canada Ocho | |

- 3a. Magdalena Mountains (from the foot of the mountain)
Clear colorless fluorite associated with
barite, quartz and chrysocolla gave
temperatures in the range of 230° - 236° C.
- 3b. Magdalena Mountains (from the crest of the mountain)
Colorless fluorite associated with quartz
and galena gave temperatures
in the range of 225° - 229° C.
4. Sierra Caballo Mountains
Pale green fluorite associated with quartz
gave temperatures in the range of 185° - 205° C.
5. Fluorite Ridge
Pale green fluorite associated with quartz
gave temperatures in the range of 210° - 215° C.
6. Canada Ocho
Colorless fluorite associated with barite
and galena gave temperatures
in the range of 160° - 165° C.

Measurements of homogenization temperature of fluid inclusions in calcite from manganese mine in Socorro County.

A manganese mine in Chupadera Mountains, near Luis Lopez about 11 miles south west of Socorro is the deposit where the hypogene manganese oxides occur in sheeted and breccia zones in rhyolite. Manganese minerals coat individual fragments of rhyolite and fill fissures associated with quartz and calcite. (Dorr II, 1965).

Clear colorless calcite from a vug gave homogenization temperatures in the range of 237° - 240° C.

Geologic setting and mineralogy of the investigated fluorite deposits.

Gonzalez Prospect

Location. The deposit is located in NE $\frac{1}{4}$ sec. 2, T3S, R1E, in a State land section in the low-lying hills about 5 miles east of Socorro across the Rio Grande River.

(Williams 1966; Rothrock et al 1946)

Geologic setting of the deposit. Fluorite is deposited in a fault along the west flank of an anticline. The fault is nearly parallel to the major axis of the anticline which strikes N 15° to 20° W; the fault dips 70° - 80° W. Pink coarse-grained Precambrian granite is exposed on the upthrown (east) side of the fault and the foot wall of the vein. The country rocks near the deposit include shale, sandstone and limestone of Pennsylvanian age. (Rothrock 1964).

Mineralogy. Colorless and pale green fluorite are intergrown with barite. Microcrystalline quartz is commonly found near the footwall. The percentages of minerals are as follows: CaF_2 15-65.7%, SiO_2 9.2-50.2%; and BaSO_4 9.9-39.5%. Galena and sphalerite are found as scattered crystals. (Rothrock et al 1946).

Joyita Hills

Location. Fluorite deposits in the Joyita Hills are on the east side of the Rio Grande River about 15 miles north of Socorro. They are in T1N & T1S, R1E in the central

part of Socorro County, nearly 40 miles north of the Blanchard deposit. (Johnston 1928 & Rothrock et al 1946).

Geologic setting of the deposit. Fluorite occurs in breccia along fault planes and in massive vein material. Fluorite also occurs along a brecciated fault between rhyolite and granite. The Joyita Hills are a ridge of Precambrian granites and schists, which are overthrust against westward dipping Pennsylvanian limestones on the west. The east side of the granite area is faulted against a series of rhyolite and ash beds of Tertiary age. (Johnston 1928).

Mineralogy. White to pale green fluorite is associated with microcrystalline quartz, iron oxide and calcite. The percentages of minerals showed CaF_2 60.89%, SiO_2 29.16%, CaCO_3 2%, and Fe_2O_3 7.96% (Johnston 1928). It is a very dense siliceous fluorite, and therefore extremely difficult to find fluid inclusions.

Magdalena Mountains

Location. At the foot of Magdalena mountains near Kelly Mine in T3S, R4W and at the crest of Magdalena mountains in T3S, R3W, east of Socorro.

Geologic setting of the deposit. The core of the Magdalena mountains is composed of Precambrian granite and argillite overlain by sedimentary rocks of Mississippian, Pennsylvanian and Permian ages. Precambrian rocks predominate east of the crest. Sedimentary rocks are overlain by lava flows in the south. To the north, several large stocks

and dikes of Tertiary monzonite and related rocks occur. The main structure in the area is faults. The major mineralization is confined to contact zones between sedimentary rocks and a monzonite stock.

Mineralogy. Colorless fluorite occurs as a gangue mineral associated with other gangue minerals such as quartz, calcite, aragonite, barite, iron and manganese oxides. The main ore minerals include native gold and copper, sulfides, carbonates, and sulfates of copper, lead and zinc. (Lasky 1932).

Sierra Caballo Mountains

Location. Fluorite deposits are below the crest along the west flank of the northern part of the Sierra Caballo mountains in Sierra County.

Geologic setting of the deposit. Rocks in the vicinity of deposits are Precambrian granite and Paleozoic limestones dolomites, sandstones and shales. Fluorite mainly deposits in faults and folds on the west flank. The major structures are an anticline in the east front and a syncline to the west of the mountain. (Rothrock 1946).

Mineralogy. Pale green fluorite occurs intergrown with quartz in fluorite-quartz veins.

Fluorite Ridge

Location. Fluorite Ridge is $3\frac{1}{4}$ miles southwest of the southern end of the Cooks Range, about ten miles north of Deming. The deposits are reached by an access road that leaves paved State Highway 26 about $6\frac{1}{4}$ miles northeast of Deming.

Geologic setting of the deposit. Fluorite Ridge is composed of a stock of Tertiary monzonite porphyry intruded into Paleozoic sedimentary rocks resting on Precambrian granite and overlain by Lower Cretaceous sandstone. Basalt is the youngest igneous rock forming dikes cutting conglomerate and the older rocks. The deposits generally are fissure veins along faults and fractures, in volcanic rocks. A few deposits are fillings of solution cavities in limestone. (Rothrock 1946).

Mineralogy. Fluorite is white to pale green, dense to coarsely crystalline and is intergrown with crystalline quartz. (Williams 1966).

Canada Ocho

Location. Fluorite deposits are in the eastern part of Gallinas Mountains, 42 miles northwest of Carrizozo and 9 miles south of Corona. (Rothrock 1946).

Geologic setting of the deposit. Precambrian granite is directly overlain by the Abo sandstone of Permian age. The Abo sandstone is overlain by the Yeso formation. Some of the ridges and crests are capped by the Permian San Andres formation. Tertiary fine-grained to aphanitic syenite porphyry intrudes the Paleozoic and Precambrian rocks as laccoliths, sills and dikes. Monzonite breccia is the youngest intrusive rock in the area. Fluorite occurs along fractures, brecciated zones, bedding planes, formational contacts and as disseminated deposits, in quartzitic sandstones, siltstones and limestones of the Yeso Formation.

(Rothrock 1946)

Mineralogy. Fluorite is fine grained cementing material for breccia fragments in brecciated zones. It is associated with barite, quartz and galena, or may be associated with zinc, copper, silver, gold and rare earth minerals, locally. (Williams 1966)

Discussion

Roedder et al (1968) studied fluid inclusions in fluorites from the Hansonburg District including the Blanchard deposit. They got homogenization temperatures in the range of 187^o-205^oC.

Therefore, measurements of the homogenization temperatures of fluid inclusions in fluorites from many places surrounding the Hansonburg District were done, in order to compare them with the district. The results were mostly in the same range of temperatures as the Hansonburg District, except those fluorites from Canada Ocho gave lower temperatures than the general average while the fluorites from the Magdalena mountains were higher temperature. The reasons for these phenomena are due to the size of igneous bodies that relate to the deposits and the distance between the igneous bodies and the deposits. Fluorite in Canada Ocho, occurs in sedimentary rocks and far from the igneous bodies, which formed as laccoliths, sills and dikes. However, fluorite in Magdalena mountains deposits in contact zones between sedimentary rocks and large igneous stock. Calcite from the Chupadera mountains contains fluid inclusions that

gave homogenization temperatures in the same range as the inclusions in fluorite from Magdalena mountains. The calcite also is closely related to large Tertiary intrusives. However, generally the homogenization temperatures of fluid inclusions in fluorites from the surrounding areas are in the same 200°C range as from the Hansonburg District. It implies that most of the fluorites formed from fluids in temperatures around 200°C, which verifies the interpretation that the deposits in the Hansonburg District are mesothermal. (Park et al 1975).

PARAGENESIS

After scattered sills and dikes of middle Tertiary quartz monzonite and diorite had intruded Pennsylvanian limestone and shale (Roedder et al, 1968), hot (200°C) aqueous solutions migrated upward along preexisting fractures, faults and breccia zones, reacted with and replaced the original rocks. Hypogene minerals, sphalerite, pyrite, galena, chalcopryrite, covellite, fluorite, quartz and barite were formed. Then the water table dropped, leaving the hypogene sulfide minerals exposed to oxidation by air and ground water to form various species of secondary minerals by supergene enrichment processes. (Keith, 1972).

Previous paragenesis studies of the hypogene minerals in the Blanchard Claim and the Mex-Tex Group of Mines have been done by Roedder, Heyl and Creel (1968). They classified the main stages of hypogene mineralization into:

1. sphalerite, pyrite, galena and chalcopryrite,

2. five substages of fluorite with intermittent quartz and barite, and
3. late calcite.

They stated that barite, fluorite, quartz and galena are the main minerals in the deposit. Fluorite and quartz were deposited during many periods with different crystal habits and colors. Roedder et al (1968) show the table of the paragenesis of the hypogene minerals as follows:

338

ROEDDER, HEYL, AND CREEL

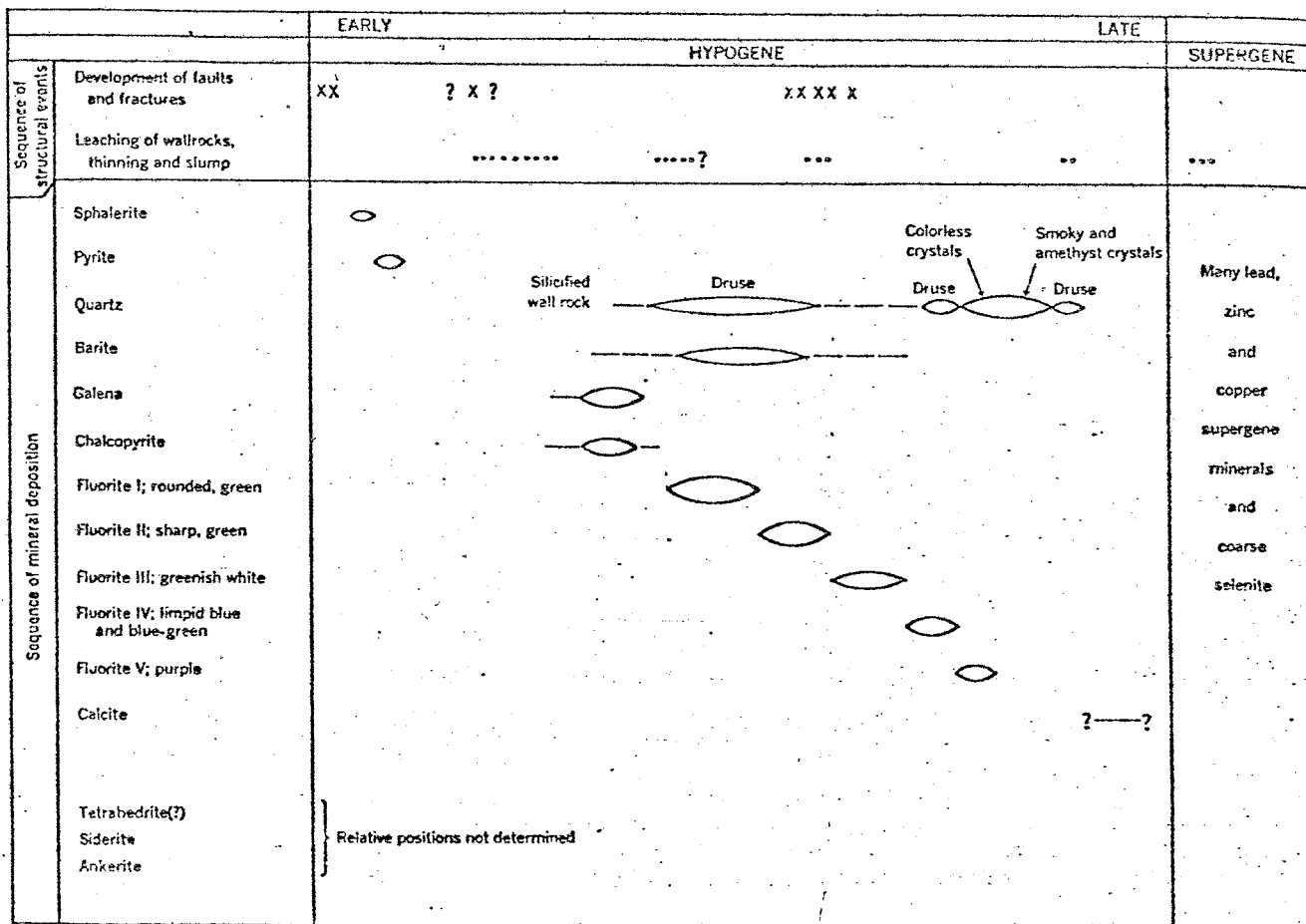


FIG. 3. Sequence of events during ore formation in the Hansonburg mining district, Socorro County, New Mexico.

From this table it is seen that small amounts of sphalerite and pyrite were deposited early in the deposition sequence, followed by minor chalcopyrite and galena. Then five substages of fluorite with intermittent quartz and barite took place. It is probable that calcite is the last hypogene mineral deposited.

Quartz occurred in several stages. The first stage consisted of massive silicification of the wall rocks, cementation of breccia and selective replacement of limestone. Later quartz occurred as thin druses of microscopic white quartz crystals coating the larger ones (Roedder et al, 1968).

The author agrees with most of the above paragenesis of the hypogene minerals in the area. But one thing they did not mention is covellite, which also exists in the Blanchard deposit. The later quartz occurring as thin druses of microscopic white crystals coated not only the larger crystals of quartz, but also barite, fluorite and galena. The author considers calcite as a supergene mineral instead of a hypogene mineral and calcite can be distinguished into four different forms: scalenohedron, travertine, paperspar calcite and the colorless rhombohedral crystal of calcite, deposited respectively.

The fact that the hypogene minerals of the deposit are commonly coarse crystals indicates that they were formed from a dilute solution under low pressures (Kopicki, 1962).

Several periods of leaching and replacement of the limestone wallrocks occurred during the general periods of

hypogene mineral deposition and at least two or three periods of faulting and renewed fracturing of the wallrocks near the faults (Roedder et al, 1968). The leaching solution which is rich in copper, lead and zinc migrated along the faults, fractures and breccia zones depending on the circulation of ground water. The introduced and resident ions reacted to form the complex and varied secondary minerals (Keith, 1972). The sequence roughly progressed from the deposition of sulfate to carbonate, to silicate, to molybdate, to oxide and to fluoride. Colorless cubic fluorite was the last mineral deposited in the area, shown in the following paragenesis table:

	Primary	Secondary			
Sphalerite	_____				
Pyrite	_____				
Galena	_____				c : quartz crystals
Chalcopyrite	_____				s : scalenohedral
Covellite	_____				t : travertine
Quartz	_____	c			p : paperspar
Fluorite	_____				r : rhombohedral
Barite	_____				
Anglesite	_____				
Calcite	_____	s	t	p	r
Goethite	_____				
Jarosite	_____				
Plumbojarosite	_____				
Hemimorphite	_____				
Rosasite	_____				
Aurichalcite	_____				
Spangolite	_____		?	?	
Brochantite	_____				
Linarite	_____				
Azurite	_____				?-?
Cerussite	_____				
Wulfenite	_____				
Murdochite	_____				
Plattnerite	_____				
Gypsum	_____				
Diakite	_____				
Malachite	_____				
Chrysocolla	_____				
Fluorite (Colorless)	_____				

Time →

47 1513

10 X 10 TO THE CENTIMETER 25 X 38 CM.
NEUFEL & ESSER CO. MADE IN U.S.A.



The above paragenesis table shows the relative sequence of the mineral deposition at the Blanchard Claim in the Hansonburg District. This generalized sequence has been determined on the basis of more than one hundred hand specimens. The solid lines in the table represent the most relative observed sequence. Question marks denote a possible sequence of deposition.

The paragenesis of supergene enrichment and oxidation progresses from sulfides through sulfates then carbonates and finally oxides in the following sequence:

Primary sulfide minerals

Anglesite	PbSO_4
Spangolite	$\text{Cu}_6\text{Al}(\text{SO}_4)(\text{OH})_{12}\text{Cl}\cdot 3\text{H}_2\text{O}$
Brochantite	$\text{Cu}_4(\text{SO}_4)(\text{OH})_6$
Linarite	$\text{PbCu}(\text{SO}_4)(\text{OH})_2$
Azurite	$\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$
Cerussite	PbCO_3
Murdochite	$\text{PbCu}_6(\text{OClBr})_8$
Plattnerite	PbO_2

TABLE 1
Supergene Enrichment and Oxidation

Mineral	Sulfide Deposition	Sulfate Deposition	Carbonate Deposition	Oxide Deposition
Anglesite	————	—		
Spangolite		?—?		
Brochantite			————	
Linarite			————	
Azurite			?—?—?	
Cerussite			————	
Murdochite				——
Plattnerite				——
Time	—————→ Present			

(adapted from Keith 1972)

The first supergene mineral is anglesite. Rankama and Sahama (1950) suggested that galena was directly converted into anglesite by oxidation, according to the equation:



Then the lead sulfate changed to lead carbonate which is more insoluble in a carbonate rich environment. (Kopicki, 1962).

By means of a physico-chemical relation, Kopicki (1962) pointed out that lead ion in the +2 state of linarite

was oxidized to lead ion +4 state of murdochite and plattnerite. But Keith (1972) explained that the oxidation took place in an aqueous medium which was indicated by the compositional fact that many species of secondary minerals occurring in the area have hydroxyl group or water incorporated in their structures. The oxidation starts from hypogene sulfides through supergene sulfates then progresses towards carbonates and oxides, which are more stable in oxidized environment. Keith (1972) also indicated that "in a limestone environment the decomposition of calcium carbonate will buffer the solution at a pH of 8.4, so a pronounced rise of pH across the mineral bands PbS: PbSO₄: PbCO₃, etc., will exist."

As sulfides continued to oxidize to sulfates in environment of strong neutralizing power, iron precipitated as an oxide to form goethite (which is the oxidation product of primary sulfide minerals mainly pyrite) or as an ion incorporated in the structure of some sulfate minerals such as jarosite and plumbojarosite. Because of individual solubility, more soluble zinc and copper sulfates migrated away, while lead sulfate remained in situ to form cerussite. (Keith, 1972). Then wulfenite formed at a short distance from galena and cerussite (Takahashi, 1960). The origin of molybdenum is not clear.

The following sequence indicates the progression:

Goethite	FeO(OH)
Jarosite	KFe ₃ (SO ₄) ₂ (OH) ₆
Plumbojarosite	PbFe ₆ (SO ₄) ₄ (OH) ₁₂

Cerussite	PbCO_3
Wulfenite	PbMoO_4

TABLE II
Oxidation of Residual Ions

Mineral	Chemistry	
Goethite	FeO(OH)	_____
Jarosite	$\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$	_____
Plumbojarosite	$\text{PbFe}_6(\text{SO}_4)_4(\text{OH})_{12}$	_____
Cerussite	PbCO_3	_____
Wulfenite	PbMoO_4	_____

Time $\xrightarrow{\hspace{15em}}$ Present

(adapted from Keith 1972)

The other sequence of deposition starts from carbonates to silicates as following:

Rosasite	$(\text{CuZn})_2(\text{CO}_3)(\text{OH})_2$
Aurichalcite	$(\text{ZnCu})_5(\text{CO}_3)_2(\text{OH})_6$
Malachite	$\text{Cu}_2(\text{CO}_3)(\text{OH})_2$
Chrysocolla	$(\text{CuAl})_2\text{H}_2\text{Si}_2\text{O}_5(\text{OH})_4 \cdot n\text{H}_2\text{O}$

TABLE III

Oxidation of Transported Ions

Mineral	Chemistry	
Rosasite	$(\text{CuZn})_2(\text{CO}_3)(\text{OH})_2$	—
Aurichalcite	$(\text{ZnCu})_5(\text{CO}_3)_2(\text{OH})_6$	—
Malachite	$\text{Cu}_2(\text{CO}_3)(\text{OH})_2$	—
Chrysocolla	$(\text{Cu, Al})_2\text{H}_2\text{Si}_2\text{O}_5(\text{OH})_4 \cdot n\text{H}_2\text{O}$	—

Time $\xrightarrow{\hspace{15em}}$ Present

(adapted from Keith 1972)

After the oxidation of sulfides to sulfates, copper and zinc in the form of sulfate solution migrated to react with the excess available carbonates at or near the contact with the wall rock to form rosasite and aurichalcite contemporaneously.

Malachite occurred sporadically in oxidizing zones. Chrysocolla is pseudomorphic after malachite.

Gypsum is a very late forming mineral that deposited in the area formed by the reaction of sulfate solution with the wall rock, limestone. While dickite formed by argillization of the original feldspar. (Deer, Howie & Zussman 1975) The second generation of fluorite formed as tiny clear crystals is the latest mineral that deposited in the area.

CONCLUSION

The paragenesis of the mineral deposition at the Blanchard Claim progresses from hypogene sulfides through supergene sulfates then carbonates and finally oxides or molybdate or silicates. The measurements of homogenization temperatures of fluid inclusions in fluorites from areas surrounding the Hansonburg District yielded an average value in the range of 200°C.; this figure agrees with the homogenization temperatures of fluid inclusions in fluorite from the Hansonburg District as well as the homogenization temperatures of fluid inclusions in calcite from manganese mine near Luis Lopez. The correspondence suggests the mineralizing fluids in areas surrounding the Hansonburg District, had similar physico-chemical controls.

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