1911

Evidence pertaining to the origin and deposition of ore deposits

James Edward McGoughran

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DEPOSITS'  
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by  
James Edward McCoughran.  

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submitted to the faculty of the  
SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI  
in partial fulfillment of the work required for the  
DEGREE OF  
BACHELOR OF SCIENCE IN GENERAL SCIENCE  
Rolla, Mo.  
1911.  

Approved by  
Assistant Professor of Geology and Mineralogy.
EVIDENCES PERTAINING

To the

ORIGIN AND DEPOSITION

Of

ORE DEPOSITS.
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INTRODUCTION

The relation existing between the origin of an ore deposit, and the method best suited for its exploration and exploitation is so intimate that a definite idea of the origin of a deposit is of the greatest importance. Intelligent and systematic work on a deposit, whether in the earlier stages of exploration or in later development, will be almost wholly dependent upon the ability of the management to draw correct conclusions regarding the origin of the deposit. For this reason the collecting and relating of evidence which may assist in arriving at a correct conclusion as to the origin of the deposit, is of prime importance.

All ore deposits are generally conceded to be the result of one of two processes, namely; deposition from solution, which includes solutions of both meteoric and magmatic origin, and segregation from an igneous magma. Deposition from solution may be accomplished in any one, or a combination of two or more, of the following agencies: (1) downward moving, cold, meteoric solutions; (2) upward moving, hot, meteoric solutions; (3) upward moving, cold, meteoric solutions;
and (4) upward moving, hot, magmatic solutions. Upward moving, cold, magmatic solutions may also be active in some cases in forming deposits, but, as cooling of solutions is probably one of the greatest factors in causing precipitation from hot solutions, the natural conclusion is that the cooled solution would probably have little matter left to precipitate. Under each of the agencies proposed have been grouped certain criteria which are regarded as evidence in support of the activity of such agent. The endeavor has been to arrange the criteria in the order of their importance, but there is considerable difficulty in fixing the relative importance of many of them. Under each of the criteria is placed as evidence for its support the deposits where the given conditions prevail.

In comparing the evidence for the different theories or origin, some confusion may arise from the fact that some deposits are listed under heads which appear to be contradictory; for example, where secondary enrichment has occurred, as at Bisbee, the Bisbee district is given as evidence under several of the sub-heads under deposition by cold meteoric solutions, when in fact all of the evidence obtainable strongly indi-
cate that this deposit is the result of deposition from hot ascending solutions. An attempt has been made to indicate evidence of this kind by marking it with an asterisk, "*".

REFERENCES

In collecting the evidence tabulated herein reference has been made to the following publications:


Lord, Elliot, Comstock mining and miners: Monograph U. S. Geol. Survey No.4, 1903.


Spurr, J. E. Geology of the Tonapah mining district, Nevada; Prof. Paper U. S. Geol. Survey No.42.


An index to the contact minerals found in the various deposits is added. The minerals being designated by letters and numbers.

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<tr>
<td>Lead:</td>
</tr>
<tr>
<td>Southeastern Missouri Dis.</td>
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<td><strong>California</strong></td>
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<tr>
<td>Copper:</td>
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<tr>
<td>Copperopolis District</td>
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<td>Bully Hill</td>
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<td>Gold:</td>
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<td>Mother Lode &quot;</td>
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</tbody>
</table>
Colorado

Lead & Silver:
  Leadville District
Silver & Gold:
  Silverton District
  Rico "
  Ten Mile "
  Telluride "
Gold:
  Cripple Creek District

Idaho

Lead & Silver:
  Coeur d'Alene Dis.
  Willow Creek "

Nevada

Gold:
  Tonopah District
Gold & Silver:
  Comstock Lode Dis.
  Silver Peak "

South Dakota

Gold:
  Black Hills District

Arizona

Copper:
  Globe District
  Clifton-Morenci Dis.
  Bisbee District
TABULATION OF EVIDENCES PERTAINING TO THE ORIGIN AND DEPOSITION OF THE DEPOSITS.

1. Deposited from Solution:
   (a) Downward moving cold
   (b) Upward moving cold
   (c) Upward moving hot
   (d) Upward moving not

2. Deposited by Segregation from an igneous magma.

DEPOSITION FROM SOLUTION

Evidences of, and Districts.

1. Presence of metal in mine waters.
   Chemical analysis of mine waters shows metals to be present in all of them.

2. Secondary enrichments.
   Butte District, Bisbee, Morenci, Globe, Wisconsin, Southeast Missouri, Couer d'Alene, Leadville, Silverton, Rico, Bully Hill.
3. Deposition along water channels.

Joplin, Wisconsin, Southeast Missouri, Coeur-d'Alene, Leadville, Michigan Cu, Bisbee, Clifton, Globe, Silverton, Rico, Black Hills, Treadwell, Bully Hill.

4. Association with minerals known to have been deposited by solution.


Meteoric Solutions: - Evidences of, and Districts.

Downward moving, cold, meteoric solutions.

1. Presence of oxides, carbonates and hydrates.

2. Katamorphism of wall-rock, forming clay with hematite, or limonite, etc.

3. Located in drainage courses.

4. Similarity of gangue to country rock.
   (local gangue).
   Joplin, Wisconsin, Southeast Missouri, Leadville*, L.S. Cu Mch.*, Franklin Furnace*.

5. Presence of ores in the unaltered country rock (especially sedimentaries).
   Joplin, Wisconsin, Southeast Missouri, Black Hills*.

   (*Evidence that may confuse. See Introduction).
Upward moving cold meteoric solutions.

1. Artesian conditions present.
   Joplin, Wisconsin, Southeast Missouri, Comstock Lode*, Clifton-Morenci*.

2. Absence of minerals deposited only by hot solutions.
   Joplin, Wisconsin, Southeast Missouri.

Upward moving hot meteoric solutions:


   (*Evidence that may confuse. See Introduction.)
2. Alteration of wall rock to sericite, chlorite with pyrite, and the absence of kaolinization.

Couer d'Alene, Butte, L. S. (Mich) Cu, Tonopah, Pilbara, Clifton-Morenci, Bingham, Willow Creek, Cripple Creek, Franklin Furnace, Nevada City, Ten Mile, Telluride, Tintic, Silverton, Black Hills, Bully Hill.

3. Introduction of SiO₂, K, and Fe₂S₂ into wall rock.

Couer d'Alene, Leadville, Franklin Furnace, Bisbee, Globe, Clifton, Tonopah, Pilbara, Bingham, Willow Creek, Cripple Creek, Nevada City, Ten Mile, Telluride, Tintic, Silverton, Copperopolis, Black Hills, Treadwell, Bully Hill.

4. Association with contact minerals, as garnet, andalucite, etc.

Couer d'Alene, ll, i, s, k; p, 12; Franklin Furnace q, j, p, y, x, s, c, b, w, n, k, c, d, v, z, ll, 12, 13, 5; L S. Mich. Cu, j, s, n, l;
Clifton-Morenci x, d, 9, p, n, j; Bisbee x, p, j, d, y; Ten Mile, j, 9, x, 2, 13, 14; Nevada City c; Telluride x, k, g, f, 15, j, 11, 13, m, 16, 14, 4, n, l, d, p, w; Tintic l, 14, j, m, o, k, i, x, r, 4; Silverton x, 1, 14, j, m, 13, 17, 16, 2, 4, n, l, i, k, o, 9; Rico x, 9, k, 15, l, 13, e, j, 16, 14, l, p, y, n; Copperopolis x, n, 1, k; Black Hills 16, l, x, p, j, f, d; Bully Hill, 14, 4, x, 17; Franklin Furnace d, y, w; Tonopah l, w, y, 4, 9, o; Clifton p, n, g, o, 4; Bisbee p, n, 5, o, j, 18; Mother Lode l, x, 9, o; Comstock Lode l, HgS; Cripple Creek 9, o, x, t; Treadwell, l, j, x.

5. Loss of Al₂O₃, in wall rock also

 loss of Na₂O, CaO, MgO, FeO, Fe₂O₃.

Coeur d'Alene, Franklin Furnace, Clifton-Morenci, Tonopah, Pilbara, Bingham, Willow Creek, Cripple Creek, Ten Mile, Telluride, Tintic, Silverton, Rico, Copperopolis, Butte, Mother Lode, Comstock Lode, Tonopah.

6. Excessive temperature of mine waters.

 Comstock Lode, Cripple Creek.
7. Absence of minerals formed only under surface conditions.
   Couer d'Alene, Leadville, Franklin Furnace, Butte, Ten Mile, Telluride, Tintic, Silverton, Rico, Treadwell, Black Hills, Michigan Copper, Bingham, Mother Lode, Comstock Lode, Silver Peak, Tonopah, Cripple Creek, Sudbury.

8. Presence of artesian flow, or conditions.
   Comstock Lode, Clifton-Morenci.

   Couer d'Alene, Leadville, Butte, L. S. Michigan Cu, Bisbee, Globe, Clifton, Bingham, Mother Lode, Comstock Lode, Tonopah, Cripple Creek, Willow Creek, Pilbara, Nevada City, Ten Mile, Telluride, Tintic, Silverton, Rico, Copperopolis, Black Hills, Treadwell, Bully Hill.
Upward moving, cold magmatic solutions:

Upward moving, cold magmatic solutions may form ore deposits in some cases, but, as cooling of solutions is probably one of the greatest factors in causing precipitation from hot solutions, that it is believed that they have little or no effect in forming ore deposits and are therefore not considered here.

Upward moving hot magmatic solutions:

1. Evidence of hot solutions.
   

2. Foreign gangue.
   
   Couer d'Alene, Nevada City, Butte, Ten Mile, Telluride, Tintic, Silverton, Rico, Bisbee, Globe.
Clifton-Morenci, Black Hills, Treadwell, Bully Hill, Comstock Lode, Tonopah, Cripple Creek, Copperopolis, Nevada City, Willow Creek.

3. Uniformity and continuity of deposits with depth.

4. Volcanic gases in mine waters CO₂, H₂S, F, Cl, etc.
   Comstock Lode, Tonopah, Mazarron (Spain), Cripple Creek.

5. Rare minerals in mine waters.
   Couer d'Alene, Leadville, Tonopah, Comstock Lode, Cripple Creek, Black Hills, Bully Hill.

7. Presence of ores in trunk channels.
   Couer d'Alene, Leadville, Ten Mile, Tintic, Rico, Black Hills, Treadwell, Butte, Lake Superior Copper, Mother Lode, Comstock Lode, Cripple Creek, Nevada City.
8. Introduction of F, FeS₂, and rare minerals

Franklin Furnace, Cripple Creek, Willow Creek, Pilbarra, Tonopah, Clifton-Lorenci, Bingham, Telluride, Tintic, Silverton, Copperopolis, Black Hills, Treadwell, Bully Hill.

DEPOSITION BY SEGREGATION FROM AN IGNEOUS MAGMA.

1. Association with igneous rocks, (co-extensive with and along contacts.)

Butte, Michigan, Franklin Furnace, Bisbee, Globe, Clifton, Couer d'Alene, Leadville, Mother Lode, Comstock Lode, Tonopah, Cripple Creek, Willow Creek, Pilbarra, Nevada City, Bingham, Ten Mile, Telluride, Tintic, Silverton, Rico, Copperopolis, Black Hills, Treadwell, Sudbury, Bully Hill, Silver Peak.

2. Gradation from igneous rock to gangue quartz-through Alaskite.

Silver Peak.
3. Relations of minerals and inclusions in gangue and associated igneous rocks.
   Bisbee, Globe, Clifton, Comstock Lode, Black Hills, Treadwell, Sudbury, Bully Hill, Cripple Creek, Butte.

4. Presence of ore in the intrusive.
   Butte, Bisbee, Globe, Clifton, Comstock Lode, Bingham, Black Hills, Treadwell, Bully Hill.

5. Volcanic gases in mine waters.
   $\text{H}_2\text{S}, \text{F}, \text{Cl}$, etc.
   Comstock Lode, Tonopah, Mazarron (Spain), Cripple Creek.

6. Occurrence of ores in lenses within these igneous rocks.
   Copperopolis.
## INDEX TO CONTACT (Secondary) MINERALS

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CONCLUSION.

In looking over the evidence grouped in the foregoing tables it is at once evident that by far the greater number of the ore deposits are associated with igneous rocks, and that they have resulted from deposition from hot solution. It appears that, relatively, deposition by segregation from an igneous magma is of much less importance than deposition from solution, in the formation of ore bodies. However, segregation is the only explanation possible in accounting for some very important deposits, but they are very few in number. In distinguishing between deposits resulting from hot ascending meteoric solutions and those resulting from hot ascending magmatic waters, no very sharp distinction can be drawn in most cases, and it is rarely safe to state conclusively to which class the solutions belong.