

Discussion of the Disseminated-Gold-Ore-Occurrence Model

By Edwin W. Tooker

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INTRODUCTION

The ultimate objective of the 1982 workshop was, if possible, to develop an ore-occurrence model for the disseminated-gold-deposit type. Such a model should assure a common vocabulary and body of factual data that define the common classifiable deposit characteristics and lead to the systematic identification of favorable geologic environments of deposition. Several ore-occurrence models for other types of deposits at various qualitative and quantitative levels have been created to organize data systematically for meeting special-purpose needs (Erickson, 1982; Cox, 1983a, b), but the seeming diversity between sediment- and volcanic-hosted disseminated gold occurrences appeared, at the outset, to pose difficulties in arriving at a simple model. Options for framing a model were considered first, and the elements composing one followed.

Recently, two types of occurrence models have been developed, each of which provides an example of model technology. A genetic-geologic uranium model, for example, encompasses the widely ranging igneous,

sedimentary, and metamorphic environments in which uranium forms (Finch and others, 1980). The environment and processes of formation of deposits thought to have a common origin are considered in a time-process sequence. The matrix is intended to consider every event, condition, and process that influenced mineralization, and thus aid in evaluation of the resources. As an example of the second type of model, the computer program "Prospector" (Duda, 1980) was designed for the identification or recognition of specific types of deposits (for example, porphyry copper, massive sulfide) and links field and laboratory observable or inferred evidence with an inference network of plausible rules based on probabilistic reasoning. Such a model provides a systematic methodology for creating a useful resource model and may assist in evaluating geologic terranes and the discovery of unrecognized resources.

The consensus of the workshop was that a definitive or quantitative model, such as those described above, may be premature for disseminated gold deposits; however, documentation of the geologic attributes as well as of existing gaps in data is an important first step in establishing the status of knowledge.

Round Mountain mine, Nevada

[Data from J. V. Tingley, Nevada Bureau of Mines and Geology, and B. R. Berger. n.d., no data available]

A. Name/location -----	Round Mountain gold mine. West flank of the Toquima Range, mining area located in portions of secs. 19, 20, 30, and 31, T. 10 N., R. 44 E., Mount Diablo Baseline Meridian, Nye County, Nev.														
B. Deposit type -----	Volcanic-hosted; veins, sheeted zones, breccia, blanket dissemination.														
C. Other examples -----	Similar to occurrences at Hasbrouck Mountain, Divide district, Esmeralda County, Nev., and generally to the Delamar mine, Owyhee County, Idaho. Except for variations in host-rock type and slightly different positions within the hydrothermal systems, the occurrence also is similar to the deposits at Creede, Colo.														
D. Regional attributes															
1. Presence of gold -----	Located within a known gold province--central Nevada. It is a known type; there may be some districtwide zoning, especially if the nearby Jefferson-district mineralization can be correlated with Round Mountain. The other metal occurrences within the Round Mountain district (W, Hg, Ag at Silver Point) are related to much earlier periods of mineralization and so cannot be used to establish mineral zoning within the district. Other precious metal districts in the region are as follows:														
	<table> <tr> <th>District</th><th>Type of deposit</th></tr> <tr> <td>Round Mountain -----</td><td>Placer.</td></tr> <tr> <td>Jefferson City -----</td><td>Ag-Au quartz veins; breccias.</td></tr> <tr> <td>Gold Hill -----</td><td>Au-Ag quartz veins; breccias.</td></tr> <tr> <td>Shale Pit-Silver Pit --</td><td>Disseminated Au; Ag/base-metal veins.</td></tr> <tr> <td>Manhattan -----</td><td>Ag-Au quartz veins; disseminated Au.</td></tr> <tr> <td>Northumberland -----</td><td>Disseminated Au.</td></tr> </table>	District	Type of deposit	Round Mountain -----	Placer.	Jefferson City -----	Ag-Au quartz veins; breccias.	Gold Hill -----	Au-Ag quartz veins; breccias.	Shale Pit-Silver Pit --	Disseminated Au; Ag/base-metal veins.	Manhattan -----	Ag-Au quartz veins; disseminated Au.	Northumberland -----	Disseminated Au.
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2. Terrane -----	The Round Mountain deposits formed in the ring-fracture zone of a late Oligocene caldera; the disseminated and veinlet ores formed in nonwelded intracaldera fill, and the lodes in densely welded intracaldera fill. The basement is continental crust, immediately beneath the ash flows are Paleozoic argillite, limestone, and quartzite, and Cretaceous granite.														
3. Basement -----	Continental crust.														
4. Igneous association -----	Igneous host rock (welded biotite quartz rhyolite ash-flow tuff); tuffite dikes are present. A plug of intrusive material is probably present beneath Round Mountain (rhyolite domes are exposed at Jefferson City and Gold Hill).														
5. Structural regime -----	Caldera. The inferred plug may have intruded at a point on the ring structure of a caldera. Important deeper structures appear to be north-southerly and northeasterly-trending features not exposed on the surface. Ores are mostly concentrated on northwest-trending high-angle fractures, also somewhat on northeast-trending fractures.														
6. Level of erosion -----	Shallow; deposit formed near the surface and has been eroded only a few tens of meters.														
E. District attributes															
1. Host rocks -----	(a) Silicified nonwelded tuff (upper part of flow) was fractured and thus was favorable for the formation of narrow high-grade gold veins. (b) Welded tuff (middle portion of flow sheet) was fractured, but wider zones developed, filled with quartz veins to form sheeted zones. These wider areas are being mined in the present open-pit operation. (c) Soft nonwelded tuff (lower part of flow) was porous and permitted a blanketlike disseminated occurrence to form. This deposit forms the bulk of the new reserves at Round Mountain.														

2. Traps -----

(a) The upper nonwelded, middle welded, lower nonwelded "stratigraphy" of the host ash-flow tuff served as a stratigraphic as well as a structural trap. (b) Classic structural traps appear to have controlled formation of ore shoots within the major veins mined during the life of the old underground-mining operation. High-grade shoots occurred at multiple vein intersections, vein breccia intersections, and so on.

3. Preparation -----

Not apparent and not considered important. Alteration was not a prerequisite for ore formation.

4. Size -----

The original Round Mountain gold district is relatively small, it extends only about 2 1/2 km east-west by about 1 1/2 km north-south. Numerous adjoining mining operations were consolidated at an early date at Round Mountain into one operating company, which mined what is essentially a single ore occurrence. Gold and silver are (and have been) the only metals recovered at Round Mountain. Production of lode mines and related gold placers during 1907-68 was about \$12,000,000. Reserves announced by the present operators, the Smoky Valley Mining Co., total more than 200 million tons (181.4 million t) averaging nearly 0.05 oz Au/ton (1.7 g Au/t) which is 8-10 million oz Au (248.8 million g Au) and more than 15 million oz Ag (466.5 million g Ag). Older mining produced 800,000-900,000 oz Au (24.9-28 million g Au), mainly from placers. Many early mines were eventually consolidated into the Sunnyside and Fairview as only important producers. The only significant product is Au-Ag bullion. Elsewhere in area is minor tungsten production from quartz-huebnerite veins, silver from quartz veins (Silver Pit), and gold from Paleozoic sedimentary rocks (Shale Pit).

5. Extensions -----

Possibilities are good for the discovery of extensions; Smoky Valley continues to develop ore as they continue to drill. Other, similar ore bodies could exist in the Round Mountain area, possibly related to Mount Jefferson caldera or to the inferred other caldera at Round Mountain.

F. Deposit attributes

1. Host rocks -----

Volcanic (welded tuff). Some ore is localized in hydrothermal breccia; disseminated ores are stratabound (in nonwelded-tuff horizons), breccia ores are pods or veinlike. Ores occur (a) in quartz-feldspar veins and veinlets, (b) in silica-cemented breccia, (c) in association with disseminated pyrite, and (d) replacing pumice fragments.

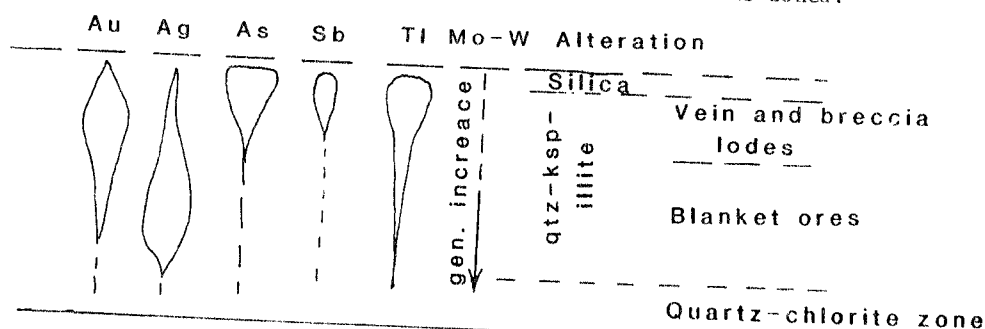
2. Size/shape -----

Deposits are generally elongate and vertical along the primary controlling structures, ranging from narrow veins in the tightest rock to flat wide blanket forms in the porous tuff. Three general forms can be described: (a) Narrow, quartz-adularia veins in silicified nonwelded tuff (the "silica cap"). These veins were very narrow, 0.6 to 2.5 cm thick, but several closely spaced veins and the silicified rock nearby were commonly mined in stopes as much as 1 1/2 m wide several meters feet along strike, and from the surface down to about 120 m. No records exist on this (early) period of mining, but tonnage was small and the ore quite probably good. (b) Wide zones in the welded part of the tuff. The rock was not so silicified and fractured in a less brittle fashion. Wide sheeted zones occurred along vertical structures, a system of parallel flat structures, related to centers of hydrothermal brecciation. Tonnage of this material mined underground until about 1930 totaled about 500,000 ton (453,500 t) grading from \$4 to \$50 per ton (in the approximate range of 0.11-1.4 oz Au/ton (3.4-43.5 g Au/t)). The present open-pit operation is mining one of the widest of the vertical sheeted zones. Announced tonnages of this part of the deposit were 12 million ton (10.9 million t) at 0.055 oz Au/ton (1.7 g Au/t). (c) Blanketlike zone, formed at the intersection of the wide sheeted zone with the lower, nonwelded tuff. The top of this zone is reported to be about 120 m below the level of the present pit; values

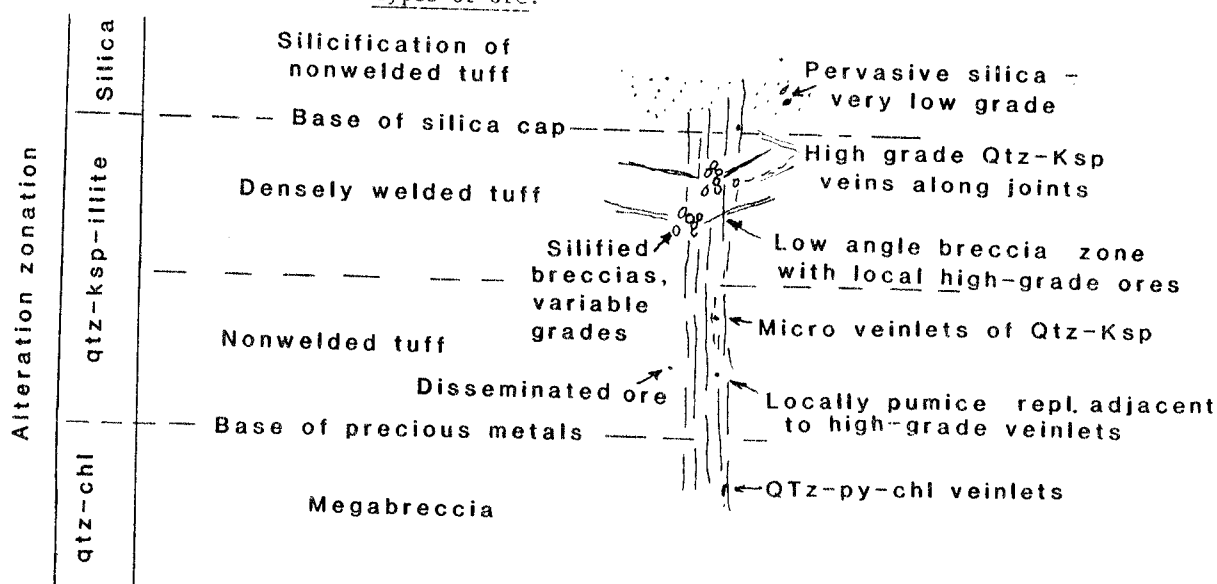
(mineralization) have been reported to 360 m in some holes. The zone is several hundred meters wide and is elongate along the controlling N.40°-50° W.-trending sheeted zone. Exploration of this zone has resulted in defining more than 195 million ton (177 million t) of ore averaging just under 0.05 oz Au/ton (1.6 Au/t). Exploration is still in progress.

3. Physical characteristics -

Mineralogy--not well studied. Native Au, electrum, pyrite, and realgar. Mineralization is zoned:



Types of ore:



- Ore/gangue mineralogy -- Quartz and various iron oxides are the only common gangue minerals. Manganese oxides are common on some structures, and fluorite occurs in the breccias and in the main sheeted zones. Pyrite is a gangue mineral in the disseminated ores.
- Structures ----- Deposits in the upper part of the tuff occur as veins, vein-filled sheeted zones, and breccia. The deposit in the lower, nonwelded part of the ash flow is an open-space, dissemination, a blanketlike occurrence controlled by the intersection of a wide sheeted zone with the porous part of the tuff.
- Textures ----- Open-space filling, banded quartz and adularia, and tiny clear quartz crystals lining open cavities are commonly seen; some lamellar quartz after calcite also occurs.
- Host-rock type/age ----- Rhyolite welded tuff, dated at 26.1 ± 0.8 m.y. (biotite) and 25.7 ± 0.7 (sanidine). Mineralization has been dated at 25.2 ± 0.8 m.y. (adularia), 25.4 ± 0.8 (sericite), 25.1 ± 0.8 (altered dike).
- Paragenesis ----- n.d.

4. Chemical characteristics	
a. Solution chemistry	
(1) Inclusions -----	Abundant in quartz; very dilute solutions with essentially no depression of freezing point.
(2) Stability -----	n.d.
(3) Solubility -----	n.d.
(4) Isotopes -----	n.d.
(5) Cause of deposition	Evidence from fluid inclusions suggests boiling important mechanism
b. Temperature -----	From fluid inclusions: variation 170°C to 270°C; average, approximately 230°C.
c. Associated anomalies ---	Arsenic, thallium, molybdenum, tungsten, antimony, mercury
d. Alteration/zonation ---	Essentially all the ash-flow tuff at Round Mountain displays propylitic alteration. The major veins display alteration envelopes which grade outward from each vein-filled fracture, ranging from a thin clay selvage next to the vein which immediately grades out to propylitically altered rock, to large areas of argillic alteration associated with the hydrothermal-breccia centers. Areas of alunitic alteration coincide with the small centers of hydrothermal brecciation and are mappable by the presence of alunite veinlets, with some disseminated jarosite. Silicification is physically within a larger zone of argillic alteration.
e. Oxidized or carbonaceous materials.	No carbonaceous materials within ore deposit.
f. Chemical evolution -----	n.d.
5. Source of elements -----	n.d.
6. Geophysical signatures	
a. Gravity -----	Gravity has been used to map the major structures at Round Mountain by the use of indirect methods. Therefore, ore zones have been defined with some (reported) success.
b. Magnetic -----	n.d.
c. Induced polarization ---	n.d.
d. Seismic -----	The internal stratigraphy of the tuff unit (welded-nonwelded boundary) is apparently mappable by the use of seismic techniques.
e. Radiometric -----	n.d.
7. Summary of apparent depositional environment.	
	The Round Mountain deposit formed, probably very near the surface, in favorable horizons within an ash-flow tuff. Early silicification (formation of a "silica cap") caused portions of a hydrothermal system to "overpressure." The resultant fracturing, resealing, refracturing, and so on, caused the formation of podlike hydrothermal breccias and related quartz veins.
8. Byproduct metals -----	Gold is the principal metal, and silver the only byproduct.
G. Summary, features for resource evaluation.	
	The caldera setting is important. Localization of later, but related, plugs and (or) vent systems along the ring fractures have provided important mineralization controls. Host rocks could be any porous or brecciated rock. An impervious or less porous capping rock is important. Areas of widespread propylitic alteration occur with localized centers of argillic, advanced argillic; alunitic and locally pervasive silicification seems to be characteristic. At Round Mountain, the mineralogy appears to be simple: Free gold, silver, iron and manganese oxides containing gold and silver, and pyrite.