UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# GEOLOGIC CHARACTERISTICS OF CARBONATE-HOSTED GOLD DEPOSITS ASSOCIATED WITH TERTIARY IGNEOUS ROCKS, WEST-CENTRAL, UTAH

by

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## INTRODUCTION

This report is a written version of an oral presentation given at the Geological Society of America's Annual Meeting at Phoenix in October, 1987. Data for this work was acquired under the USGS's Conterminous United States Mineral Assessment Program in the Delta, Utah two-degree quadrangle. Field work for the Delta project began in 1986, and the ideas and interpretations presented here are preliminary and are likely to be revised and improved as the project continues.

The Delta two-degree quadrangle is located in west-central Utah, in the eastern Basin and Range physiographic province but near the intersection of the Basin and Range, Rocky Mountain, and Colorado Plateau provinces (fig. 1). Trace-element geochemical data presented here includes information from approximately 600 heavy-mineral-concentrate and 2,000 rock sample sites from throughout the Delta quadrangle.

Important quantities of gold, silver, lead, zinc, copper, cadmium, bismuth, arsenic, antimony, manganese, beryllium, tungsten, barium, fluorite, and uranium have been mined from the Tintic-Deep Creek mineral belt. In addition, geochemically anomalous amounts of tin, molybdenum, boron, tellurium, mercury, cobalt, and vanadium occur in rocks associated with the ore deposits.

## GENERAL GEOLOGY

A variety of sedimentary rocks and extrusive and intrusive igneous rocks, ranging in age from Proterozoic to Recent, occur in the quadrangle. The Proterozoic rocks generally consist of tillite, quartzite, and argillite. Paleozoic rocks are typical of the miosynclinal deposits that are widespread in the Basin and Range province. Limestone and dolomite constitute considerably more than half of these rocks, quartzite and sandstone are next in abundance, and shale is least abundant (Morris and Mogensen, 1978). The igneous rocks are chiefly Tertiary intrusive bodies and extrusive lavas and tuffs. Intrusive igneous rocks include one of the largest bodies in Utah, the Ibapah stock in the Deep Creek Mountains, and many smaller stocks, plugs, dikes, and sills. Extrusive rocks include large volumes of topaz rhyolite in the Thomas Range and scattered flows and outflows ranging in composition from basaltic to rhyolitic. Post volcanic deposits consist of thick accumulations of valley fill and lacustrine sediments in the intermontane basins and relatively thin accumulations of talus, colluvium, alluvium, and similar materials in upland areas.

## MINERAL DEPOSITS

Metallic mineral deposits in the Delta quadrangle include precious-, base-, and lithophile-metal replacement bodies, vein deposits, minor contact metasomatic deposits, low-grade porphyry deposits, and placer deposits. The mineral deposits, with the exception of skarns and placers in the Notch Peak area, are generally confined to the Tintic-Deep Creek mineral belt, anapproximately east-west trending belt which traverses the northern part of the Delta quadrangle. Hydrothermal mineralization is present in every mountain range across the mineral belt.

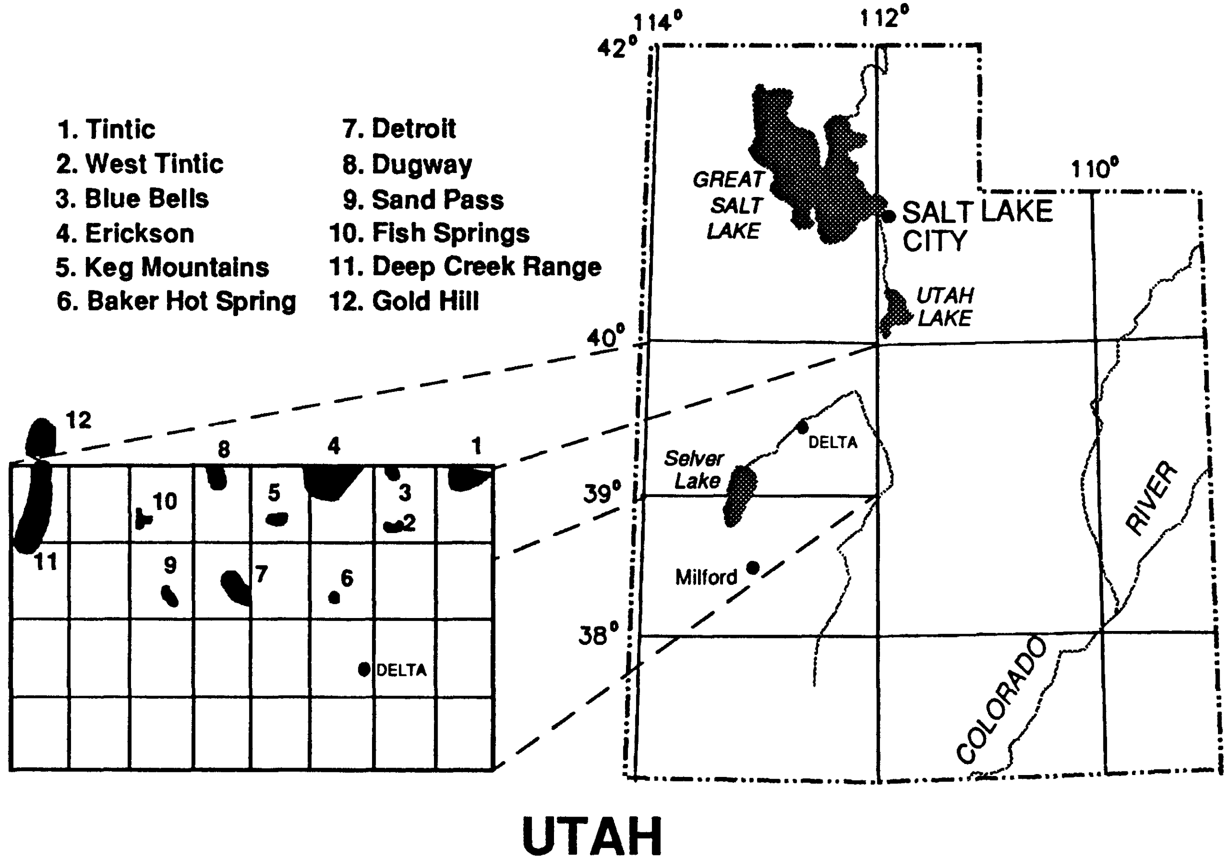



Figure 1.--Map of the Delta, Utah 1° x 2° quadrangle, showing mining districts and prospect areas.

## PURPOSE OF PAPER

The purpose of this paper is to present data that suggests to us that gold-bearing carbonate-hosted replacement deposits in the Tintic-Deep Creek mineral belt are related to porphyritic igneous rocks. These replacement deposits include masses that were replaced dominantly by silica (jasperoids) and masses that were replaced by fluids which resulted in an argillite-quartz-hematite-pyrite mineral assemblage. The Drum mine, located in the Drum Mountains, is the largest deposit known to date of this type from within the mineral belt. In contrast to typical Carlin-type gold deposits (i.e., Bagby and Berger, 1985), the Tintic-Deep Creek carbonate-hosted gold deposits are parts of zoned mineralized systems. These systems can be generalized to consist of, from the center to the peripheries, copper and/or molybdenum porphyry bodies, gold- and copper-bearing veins, lead- and silver-bearing replacement bodies, and zinc- and manganese-bearing replacement bodies (fig. 2). Where present, the gold-bearing carbonate-hosted replacement deposits generally occur in close proximity to zones of lead, zinc, silver, and/or manganese replacement deposits.

## GEOCHEMICAL CHARACTERISTICS OF MINERALIZATION

Individual base- and precious-metal ore deposits in the mineral belt are typically zoned, consistent with alteration and mineralization patterns described by many authors in classic studies of porphyry mineralization (e.g., Lowell and Guilbert, 1970; Sillitoe, 1973). The zoning of ore elements is generalized as follows: copper and/or molybdenum disseminated in porphyry bodies; copper and gold in veins closest to the porphyry stocks; lead, zinc, and silver from replacement deposits an intermediate distance from the stocks; and zinc, lead, and /or manganese in replacement deposits farthest from the stocks. Our geochemical data from rock samples collected at individual areas of mineralization in the Tintic-Deep Creek mineral belt are characteristically zoned with respect to geochemically anomalous elements as follows: an innermost zone containing tungsten, tin, beryllium, bismuth, iron, and silver, with less common occurrences of gold, lead, zinc, cadmium, and manganese; an intermediate zone containing silver, molybdenum, and lead, with less common occurrences of zinc, arsenic, antimony, tungsten, manganese, and vanadium; a zone still farther from the stock containing arsenic, antimony, cadmium, and manganese, and less common occurrences of gold, copper, molybdenum, tin, beryllium, and bismuth; and an outer zone containing gold, barium, beryllium, antimony, tungsten, and arsenic (table 1). While these geochemical suites appear in one form or another throughout the mineral belt, suites in any particular area of mineralization are more complicated, including the telescoping or absence of individual elements within zones (table 2).

Detailed geologic and geochemical studies of gold-bearing replacement bodies in the mineral belt show that the bodies are always associated with other types of mineralization (especially base-metal replacement mineralization, but also including low-grade porphyry mineralization) and that the areas of replacement are anomalous in many trace elements. These two general characteristics of the gold-bearing replacement bodies, their consistent association with (a) other types of mineralization, and (b) a large number of anomalous trace elements, suggest to us that the gold-bearing replacement deposits are a part of the porphyry-type mineralization.

**Table 1. Generalized distribution of ore and anomalous elements within chemical zones distributed around intrusive igneous rock bodies in the Tintic-Deep Creek mineral belt, Utah.**

| ORE ELEMENTS | | ASSOCIATED ANOMALOUS ELEMENTS |
|---|---|---|
| Innermost Zone | Cu, Mo | W, Sn, Mo, Be, Bi, Ag, Fe +/- (Au, Pb, Zn, Cd, Mn) |
| Intermediate Zone I | Cu, Au | Ag, Mo, Pb +/- (Zn, As, Sb, W, Mn, V) |
| Intermediate Zone II | Pb, Zn,Ag | As, Sb, Cd, Mn +/- (Au, Cu, Mo, Sn, Bi, Be) |
| Outermost Zone | Zn, Mn, Pb | Au, Ba, Be, Sb, W, As |

**Table 2. Preliminary geochemical associations for mineralized rock samples from the Tintic-Deep Creek mineral belt.**

| AREA | GENERALIZED GEOCHEMICAL SUITES IN ROCK SAMPLES |
|---|---|
| Tintic mining district (Morris and Mogensen, 1978) | innermost= Cu-Au<br>intermediate= Pb-Ag<br>outermost= Zn |
| West Tintic mining district | inner= W-Sn-Mo-Cu-Bi-Zn-Mn-Ag +/- (Au-Cd-Pb)<br>outer= Pb-Zn-Ag-Cd-As-Sb |
| Sheeprock Mountains | inner= Sn-Pb-Zn<br>outer= Pb-Zn-Ag-Cu-Bi-Cd |
| Simpson Mountains | inner= Sn-Mn-Be<br>outer= Pb-Zn-Mn-Ag-Cd-Mo |
| Baker Hot Spring | Mn-Ba-Be-Sb-W |
| Keg Mountains | Pb-Ag-Cu-Mo +/- (Zn-V-Sb) |
| Drum Mountains | inner= Cu-Sn-Bi-Ag-Sb<br>outer= As-Mn-Be-Pb-Sb-V-W |
| Fish Springs mining district | inner= Au-Ag-As-Mo-Pb-Sb-W-Zn<br>outer= Pb-Zn-Ag-As-Sb-Cd-Cu |
| Sand Pass | As-Be-Sb-W-Ba-Mo |
| Deep Creek Range | Au-Ag-As-Sb-Bi-Cd-Cu-Mo-Pb-Zn-Sn |

## GEOPHYSICAL CHARACTERISTICS OF MINERALIZATION

Aeromagnetic and radiometric maps of the Delta quadrangle show a series of highs extending from the Tintic mining district to the Deep Creek Range. These highs reflect high-magnetic-susceptibility, high-radioelement Tertiary and Quaternary extrusive and intrusive rocks, and outline the positions of several postulated caldera structures.

Aeromagnetic highs occur very close to mineralized rock in the East and West Tintic, Sheeprock, Desert, Keg, Thomas, Drum, Fish Springs, Swasey, and Deep Creek Mountains, and in the vicinity of Baker Hot Spring, near Fumarole Butte. Some of these highs correlate with extrusive igneous rocks, but many are thought to reflect specific intrusive bodies, some of which are related to nearby mineral deposits. These aeromagnetic highs make a good geophysical guide for locating possible areas of base- and precious-metal mineralization.

## COMMON GEOLOGIC CHARACTERISTICS FOR BASE- AND PRECIOUS-METAL DEPOSITS

The common geologic, geochemical, and geophysical characteristics of the different base- and precious-metal mineral deposits throughout the Tintic-Deep Creek mineral belt suggest a similar origin. Some of these characteristics are shown schematically in figure 2 and include:

a). The emplacement of near-surface intrusive igneous rocks. Evidence for this includes the presence of porphyry intrusive bodies, highly altered dikes, pebble dikes, brecciated igneous and sedimentary rocks, and/or geochemical and geophysical signatures suggestive of such rocks.

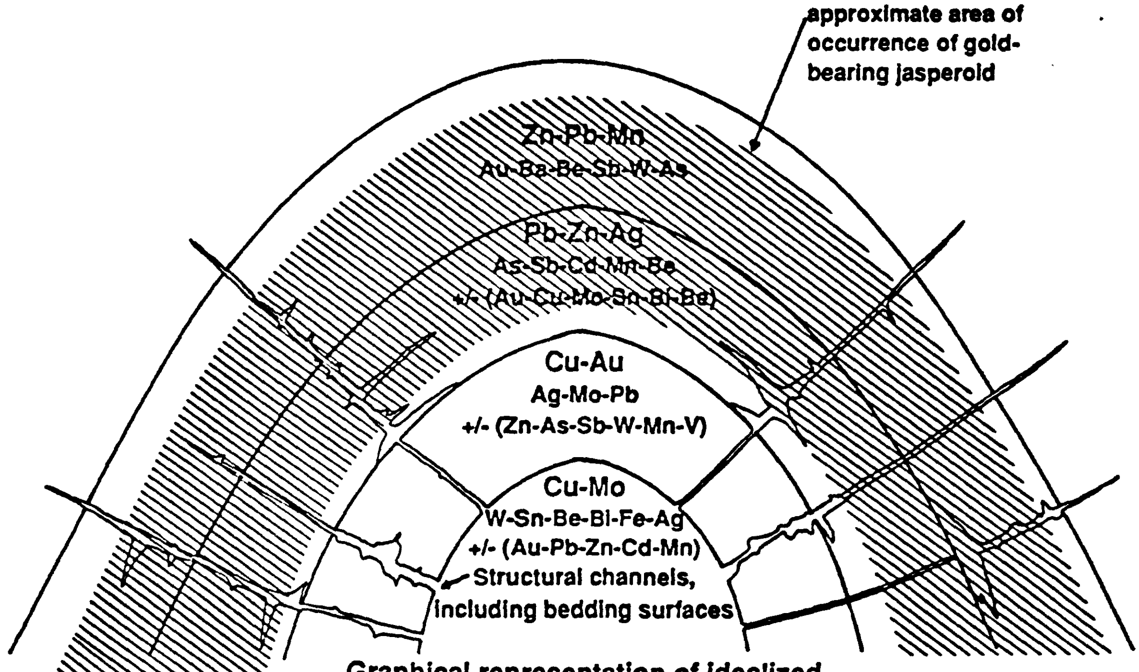
b). The development of concentric alteration and textural zones centered around the intrusive igneous bodies, as well as along zones of structural weakness.

c). The localization of alteration and mineralization along zones of structural weakness,including many east-west trends, parallel to the mineral belt. Significantly, the localization of deposits along this trend is almost perpendicular to the currently dominant structural trend, north-south, throughout the basin-and-range.

This fact, along with sporadic age data on igneous rocks from within the mineral districts, suggests that most of the base- and precious-metal mineralization occurred before the onset of basin-and-range tectonism.

This set of occurrences is essentially the same as those described for porphyry-type mineral deposits (i.e., Lowell and Guilbert, 1970; Sillitoe, 1973). However, we want to emphasize the occurrence and characteristics of gold-bearing carbonate-hosted replacement deposits with porphyry systems in the Tintic-Deep Creek mineral belt, something which was not included in many classic descriptions of porphyry deposits.

## GENERALIZED MODEL FOR BASE- AND PRECIOUS-METAL MINERALIZATION, TINTIC-DEEP CREEK MINERAL BELT, UTAH




Graphical representation of idealized chemical zones. Zones actually overlap.

Figure 2.
Idealized plan view of concentrically zoned ore and anomalous element suites centered on near-surface intrusive igneous rocks in the Tintic-Deep Creek mineral belt, Utah. Approximate location of occurrences of gold-bearing jasperoid in shade.

NOTE: (1) Intrusive igneous rocks may be represented at the surface by either porphyry stocks, dikes, or pipe-like breccia bodies.

(2) Scale of chemical zoning along individual structures is quite variable.

Figure 2.--Idealized plan view of concentrically zoned ore and anomalous element suites centered on near-surface intrusive igneous rocks in the Tintic-Deep Creek mineral belt, Utah.

## SIGNIFICANCE OF GEOLOGIC CHARACTERISTICS

When one considers the complete mineralized systems in the Tintic-Deep Creek mineral belt several areas appear to have relatively higher probabilities for the occurrence of carbonate-hosted gold-bearing replacement deposits related to igneous rocks. A few of these areas include much of the Tintic mining district, including areas overlain by volcanic rock, the West Tintic mining district, including areas covered by Proterozoic rock emplaced by thrust faults, much of the Drum Mountains, an area immediately south of Sand Pass, and the northwest part of the Fish Springs Range.

## SUMMARY

Geologic, geochemical, and geophysical data from the Delta two-degree quadrangle suggest that the majority of base- and precious-metal mineral occurrences, including gold-bearing carbonate-hosted replacement bodies, in the Tintic-Deep Creek mineral belt are related to centrally located near-surface intrusive igneous bodies. The mineral belt can be expected to contain additional undiscovered mineral deposits, especially ones similar to the relatively low-tonnage, low-grade carbonate-replacement gold deposit in the Drum Mountains and lead, zinc, and silver replacement deposits such as those in the Tintic mining district. The most reasonable places to prospect for these occurrences are in or near areas of known mineralization where regional-scale aeromagnetic highs and district-scale geochemical patterns suggest the presence of near-surface intrusive igneous bodies, including areas where the igneous body may be down-dropped by younger (basin-and-range) faulting.

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