

TRACE ELEMENT ANALYSIS OF PLACER GOLD SAMPLES

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ABSTRACT

Trace element analysis of placer gold can be used as a valuable exploration tool in order to determine the original deposit source and locating lode gold deposits. Placer gold collected from multiple districts in New Mexico and Alaska, coupled with a broad database of previously analyzed placer gold samples indicate correlations between chemical signatures (especially gold, silver, and copper) and type of deposits (i.e., Au-rich copper porphyry deposits, Au porphyry deposits, and epithermal deposits). By completing a chemical analysis and determining the particle morphology of placer gold collected from these districts using an electron microprobe, patterns in the chemical signatures from each location can be used to examine chemical variability (1) within the individual placer gold particles, (2) within the same district and (3) among different districts.

INTRODUCTION

Although there are numerous past studies on the chemical composition of placer gold by Newberry et al. (1997), Melchiorre (2001, 2009), Townley et al. (2003), and McLemore et al. (2014), the gold analyzed tends to be collected from one or few specific districts. Rarely do those studies compare compositional results to additional districts, or elaborate on the correlation between the elemental composition of the placer gold and the original deposit source for the respective districts. This research analyzes the composition of placer gold from multiple districts and within the same district.

There are a number of elements, which can, in various quantities, be present in placer gold particles. Native gold can be in complete solid solution with native silver and contain additional elements including Cu, As, Pb, Fe, and S. The chemical signature of the gold is determined by the thermodynamic conditions of precipitation and transport as well as the total metal content of the system. As Townley et al. (2003) explains, "These thermodynamic conditions and metal budget differ from one type of hydrothermal deposit to another, and hence different deposit types will each have a characteristic gold compositional signature." Identifying this signature can be a highly valuable tool in exploring for gold, as it can not only be used to determine the original source deposit of the placer gold, but provide valuable insight as to the erosion level of the present deposit.

RESEARCH METHODOLOGY

Data for this research project was obtained through panning by the authors and selected trained associates. Additional gold compositional data was obtained from the literature.

Placer gold samples were collected by panning from the Piños Altos, Hillsboro, Jicarilla, and Orogrande mining districts of New Mexico (Fig. 1). Additional samples from Jack Wade and Deadwood Gulch districts in Alaska, collected by James G. McLemore, were also examined. GPS information was taken at every collection location within the different districts in order to note the exact location, elevation, and geology of the placer gold samples.

Following collection, the individual gold samples were separated by location, then the placer gold samples were individually photographed in order to measure the particle length, and classify each particle's flatness and sphericity.

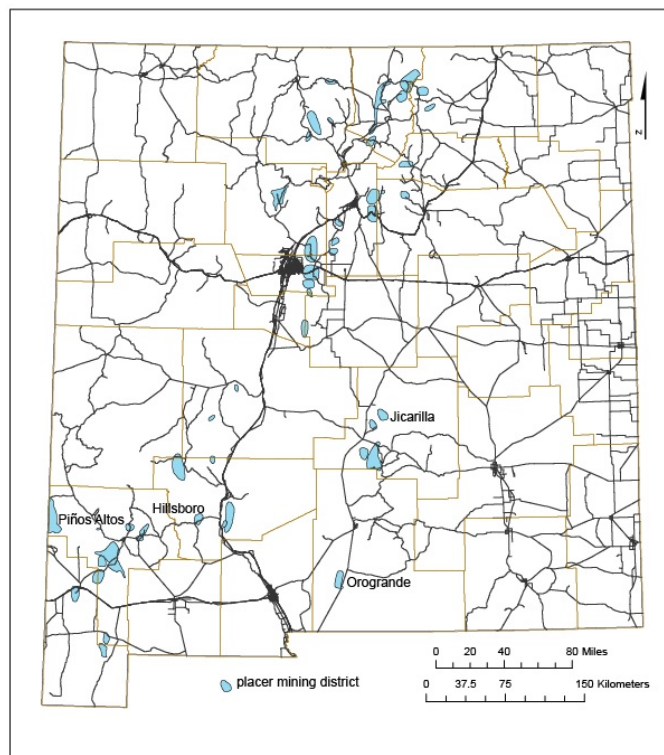


Figure 1. Placer mining districts of New Mexico.

Once photographed, the panned samples were examined using a Cameca SX-100 electron microprobe located at New Mexico Institute of Mining and Technology, in order to determine the chemical composition of individual placer gold particles. The analysis began with backscattered electron (BSE) imaging of a gold grain to determine if chemical zonation, if any, had occurred within individual gold particles. After BSE imaging, qualitative scans were conducted in order to determine the compositional makeup of the gold particles. For each gold particle, Au, Ag, Cu, As, Pb, Fe, and S were analyzed. Since Au and Ag are present at high abundances, a 20 nA probe current was used with 10 and 20 second count times, respectively. Low abundance elements like Cu, As, Pb, Fe, and S were analyzed with a 200 nA probe current, with count times between 60 and 120 seconds.

Past research conducted by Townley et al. (2003) analyzed samples from the Guanaco and Pimenton mines, located in north and central Chile, respectively, and samples from south-central Bolivia. By recording how the chemical composition of these placer gold samples relate to the original deposit types, Townley et al. (2003) identified patterns in specific chemical signatures of three different deposit types; Au-rich copper porphyry deposits, epithermal deposits, and Au porphyry deposits. Their study showed that gold particles from Au-rich copper porphyry deposits had a high copper content with variable silver contents. Gold particles from epithermal environments had a low copper content and tend to be silver rich, while gold particles from Au

porphyry deposits were low in copper and richer in silver contents compared with epithermal environments, exhibiting a pattern of higher copper contents with high gold contents. Using these preliminary results, data from this current research was compared in order to verify their initial findings. Our study will test these observations.

GEOLOGIC DESCRIPTION OF AREAS SAMPLED

Piños Altos, New Mexico

The Piños Altos mining district is located in the Piños Altos Mountains approximately 8 mi northeast of Silver City, New Mexico (Fig. 1). Placer gold was discovered in the area in 1860. The lode mineral deposits in the district consist of Laramide polymetallic veins in intrusive rocks and lead-zinc skarns with a lesser amount of copper skarns in the limestones. Replacement and skarn deposits in Magdalena Group limestones were responsible for most of the district's past production. The geology and mineral production of the district is described in more detail by Lindgren et al. (1910), Johnson (1972), McKnight and Fellows (1978) and McLemore et al. (1996).

Hillsboro, New Mexico

The Hillsboro mining district is in the Animas Mountains in central New Mexico, west of T or C (Fig. 1). The Copper Flat Quartz Monzonite Porphyry Stock (CFQM) hosts porphyry copper mineralization. Polymetallic veins are associated with latite/quartz latite dikes and both radiate outwards from the CFQM, and are flanked by distal carbonate-hosted Pb-Zn and Ag-Mn replacement deposits to the south and north. Miocene-Holocene placer gold deposits occur in arroyos draining the CFQM and vein deposits (McLemore et al., 2000). The placer gold deposits were discovered in 1877. Numerous studies have described the Hillsboro mining district (Lindgren et al., 1910; Johnson, 1972; McLemore et al., 1999, 2000, Geedipally, et al., 2012).

Jicarilla, New Mexico

The Jicarilla mining district is located approximately 30 mi northeast of White Oaks, New Mexico (Fig. 1). Although Spanish and Mexican miners likely began mining of the placer gold deposits in the Jicarilla district two to three hundred years ago and certainly by 1850, it wasn't until 1880 that gold production was reported (McLemore et al., 1991). There are two types of lode deposits found in the Jicarilla district; gold veins and iron skarn/replacement deposits. The geology and mineral deposits of the Jicarilla mining district have been described in several reports (Lindgren et al., 1910; Ryberg, 1968; Johnson, 1972; Seagerstrom and Ryberg, 1974; McLemore et al., 1992).

Orogrande, New Mexico

The Orogrande mining district, also known as Jarilla, Brice, and Silver Hill, is in the Jarilla Mountains, south of Alamogordo (Fig. 1). *Orogrande* is Spanish for *big gold*. Types of deposits found in the Orogrande district include (1) placer gold, (2) skarn and replacement deposits, (3) veins, (4) porphyry copper deposits, and (5) turquoise deposits. Turquoise was probably first mined from the district by Native Americans before the 1880s (McLemore et al., 2014). Placer gold was discovered in the district about 1865. The geology of the Orogrande district is described in more detail by Lindgren et al. (1910), Schmidt and Craddock (1964), North (1982) and McLemore et al. (2014).

Jack Wade and Deadwood Gulch districts, Alaska

The Deadwood Gulch and Jack Wade mining districts are both located in east-central Alaska near the Canadian border. The Deadwood Gulch district was described by Yeend (1991) as "one of the most productive" deposits of the area. By 1896 there were 47 claims, 8 of which produced approximately 5,000 oz of gold that year. Jack Wade Creek, also known as Wade Creek, is a northern tributary of the Walker Fork of the Fortymile River. Placers on Jack Wade Creek were first discovered in 1895 by Jack Anderson and Wade Nelson, and gold has been mined almost continuously since its discovery (http://mrddata.usgs.gov/ardf/show-ardf.php?ardf_num=EA144; accessed 10/23/15)

RESULTS OF ELECRON MICROPROBE ANALYSIS

Distinct patterns found through BSE imaging of placer gold particles from different districts, and within the same district, are

apparent. There is a reoccurring pattern of silver depletion along the rim of the gold grains, which is observed in placer particles from New Mexico, Alaska, Arizona, and others nationwide (Fig. 2). However, the BSE image of an individual gold particle taken directly from the source before erosion and transportation, show that no depletion can usually be found (Fig. 3).

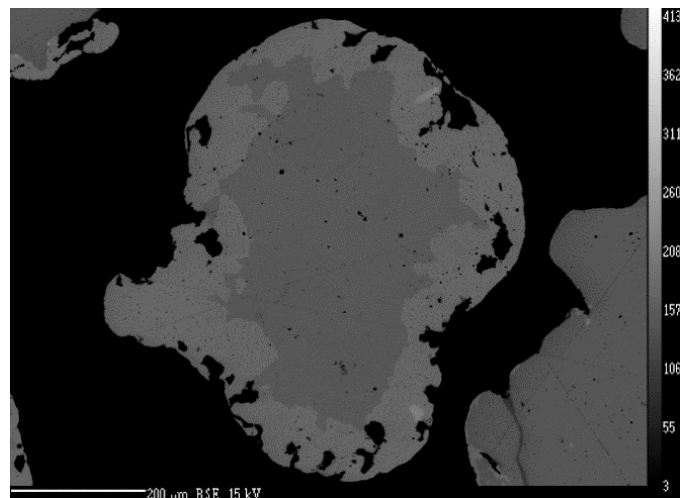


Figure 2. Image of gold placer particle from the Hillsboro district exhibiting silver depletion along the rim of the grain.

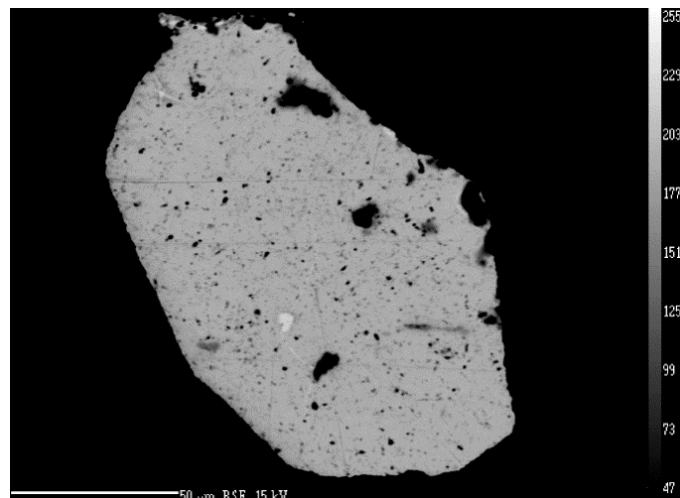


Figure 3. Image of a gold particle from the Sally vein in the Jicarilla district exhibiting no silver depletion along the rim of the grain.

Based on the data produced from the qualitative scans, the elements Au, Ag, and Cu were determined to be the most useful discrimination elements. It can be concluded that specific chemical signatures of placer gold particles directly correlate with original source deposits such as Au-rich copper porphyry deposits, Au porphyry deposits, and epithermal vein deposits (Fig 4).

Trace element analysis on placer gold from the Piños Altos district (Table 1), indicate higher copper and silver content compared to the epithermal and underlying Au-rich copper porphyry sources. Analysis on placer gold from the Jicarilla district (Table 2) show little copper content, but very high silver content. This high silver content is due to the underlying Au-rich porphyry deposit. Analysis on placer gold from the Orogrande district (Table 3) also shows little copper content with moderate silver content, however the detected silver was less significant than the silver contents found in the Orogrande district. This difference is because, although, gold from epithermal deposits have high silver content, there will be more silver detected in environments where a Au-rich porphyry deposit is present. These results all correspond to the research conducted by Townley et al. (2003),

verifying their initial conclusions about relating the composition of placer gold to certain source deposits.

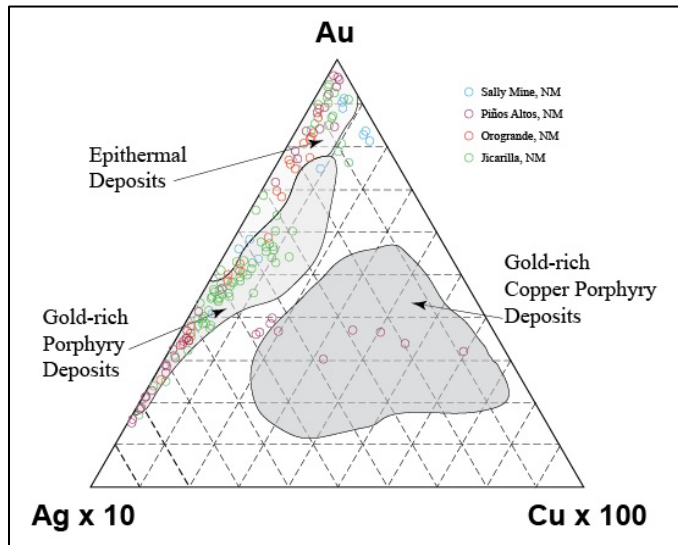


Figure 4. Au-(Ag x 10)-(Cu x 100) ternary diagram. Fields from Townley et al. (2003).

Table 1. Electron microprobe analysis of placer gold from the Piños Altos district (in weight percent).

	Ag	Au	Cu	As	Pb	Fe	S	Total
PA-02	10.87	86.59	0.92	0	0	0	0.01	98.39
PA-03	0.32	97.87	0.03	0	0	0	0.02	98.24
PA-04	11.67	86.35	0.37	0	0	0	0.01	98.4
PA-05	6.93	90.25	0.84	0	0	0	0.01	98.04
PA-06	11.31	86.28	0.38	0	0	0	0.01	97.97
PA-07	0.16	98.69	0.02	0	0	0	0.01	98.88
PA-08	9.54	88.23	0.37	0	0	0.01	0.01	98.15
PA-09	5.75	91.63	1.02	0	0	0	0.01	98.41

Table 2. Electron microprobe analysis of placer gold from the Jicarilla district (in weight percent).

	Ag	Au	Cu	As	Pb	Fe	S	Total
JG4-02	12.87	84.23	0.12	0.01	0.00	0.02	0.01	97.25
JG4-03	21.75	75.12	0.08	0.00	0.00	0.02	0.01	96.98
JG4-04	14.37	81.31	0.06	0.00	0.00	0.01	0.03	95.78
JG4-05	23.94	75.25	0.02	0.00	0.00	0.03	0.00	99.24

Table 3. Electron microprobe analysis of placer gold from the Orogrande district (in weight percent).

	Ag	Au	Cu	As	Pb	Fe	S	Total
OroGPEP1	8.56	89.96	0.05	0.00	0.00	0.00	0.02	98.60
OroGPEP1	2.60	92.58	0.05	0.00	0.00	0.01	0.04	95.28
OroGPEP1	3.75	94.95	0.04	0.00	0.00	0.00	0.03	98.78
OroGPEP1	9.46	88.83	0.06	0.00	0.00	0.00	0.03	98.37
OroGPEP1	3.72	93.41	0.06	0.00	0.00	0.00	0.05	97.24
OroGPEP1	7.92	90.30	0.08	0.00	0.00	0.01	0.02	98.32
OroGPEP1	5.34	90.73	0.10	0.00	0.00	0.01	0.05	96.24
OroGPEP1	21.82	75.77	0.04	0.00	0.00	0.00	0.03	97.68
OroGPEP1	2.03	93.23	0.07	0.00	0.00	0.00	0.04	95.37
OroGPEP1	13.59	84.88	0.03	0.00	0.00	0.00	0.02	98.53
OroGPEP1	2.64	94.44	0.02	0.00	0.00	0.02	0.02	97.14

CONCLUSIONS

In summary, trace element analysis of placer gold can be used as a valuable exploration tool in order to determine the original deposit source and locating lode gold deposits. Finding the unique chemical signature of patterns from each location can be used to examine chemical variability (1) within the individual placer gold particles, (2) within the same district and (3) among different districts. This research shows that certain source deposit types including Au-rich copper porphyry deposits, Au porphyry deposits, and epithermal vein deposit can be correlated with specific chemical compositions of placer gold samples.

Additional research will be necessary to increase the number of source deposit types, but these results offer a discrimination technique for the source deposit types mentioned, and can be useful for determining other types of hydrothermal deposits.

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