



# Comparison of contrasting gold mine processing residues in a temperate rain forest, New Zealand



Kirstine R. Malloch\*, Dave Craw

Geology Department, University of Otago, Dunedin, New Zealand

## ARTICLE INFO

### Article history:

Received 30 January 2017

Received in revised form

15 May 2017

Accepted 31 May 2017

Available online 3 June 2017

Handling Editor: Dr. R. Seal

### Keywords:

Arsenic

Mercury

Lead

Zinc

Amalgamation

Gold roasting

Alexander mine

Golden Lead mine

## ABSTRACT

Processing residues high in metallic elements are the legacy of historic gold processing sites, concentrating naturally occurring metalloids in the ore (As, Sb) as well as chemicals and metals added during processing to recover the gold (Zn, Pb, Hg). This study uses electron microscopy to investigate the link between variations in processing residue mineralogy and the processing technique used to extract the gold. Semi-cemented amorphous ferric arsenate and As-bearing iron oxyhydroxides attenuating As, Zn and Pb are the products of the simplest processing technique of crushing, sulphide concentration and gold recovery through Hg-amalgamation. Zinc, Pb and Ca added during cyanidation form Zn-rich carbonate and Zn oxide mineralogy. Ore roasting concentrates As to elevated levels (>35 wt%) as well as concentrating Sb from the ore, and Hg from the amalgamation process. Roasting rapidly oxidises sulphide concentrates producing toxic and highly mobile arsenolite ( $\text{As}_2\text{O}_3$  ( $\text{As}^{3+}$ )). Roaster tailings processed by all of these techniques, crushing, roasting and cyanidation, are largely comprised of As-hematite and quartz.

Mine residue weathering causes localised acidification and leaching of metallic elements, along with the high rainfall on these site remobilising elements. Lime added during processing and the carbonate-host rock neutralises this acidification. The formation of secondary  $\text{Fe}^{3+}$  oxyhydroxide minerals formed during residue weathering and oxidation sequesters As, Zn and Pb. Redox conditions and the pH of a site will control the stability of these secondary minerals. The toxicity of a site/processing residue can be correlated to the processing technique used, with characterisation of processing residue mineralogy having important implications for site remediation and management.

© 2017 Elsevier Ltd. All rights reserved.

## 1. Introduction

Processing of orogenic gold deposits can concentrate naturally occurring elements (As and Sb; Salzsauler et al., 2005; Jamieson, 2014; Craw et al., 2015) as well as metals and chemicals added during processing (Pb, Zn and Hg; de Lacerda and Salomons, 1998). Processing residues are complex matrixes undergoing constant change over time. Changes in environmental conditions, such as pH, Eh and hydrology, will affect the attenuation and distribution of the metals (Krause and Ettel, 1989; Martínez and Motto, 2000; Smedley and Kinniburgh, 2002; Giménez et al., 2007; Courtin-Nomade et al., 2016). Historic processing sites are acknowledged as being places of significant toxicity, and tailings were either dumped into rivers or left on site with no rehabilitation after mine closure (Ashley et al., 2003; DeSisto et al., 2011; Jamieson, 2014).

Modern rehabilitation and management of a processing site requires knowledge of the mineralogy and chemistry of the mine residues on site, the mineral weathering trajectory, and the mobility of elements in the prevailing climatic regime.

This study examines the localised enrichment of various metallic elements that remain after a variety of different processing techniques were used for gold extraction prior to the 1950s. The methods of processing used depended on the mineralogy of the deposit and the technologies that were available at the time of the operation (Park, 1904; Marsden and House, 1993; Lottermoser, 2010). Five chemically and mineralogically distinct types of processing residues were identified and have remained at the three study sites for more than 80 years under temperate rain forest conditions. Physical and chemical weathering of the residues have resulted in changes in mineralogy and geochemistry. The objectives of this study are to identify variations in residues from different processing techniques, and the subsequent processes of weathering and metal (loid) attenuation. By understanding the mineralogy, and therefore the stability and mobility of each of the residue types, the

\* Corresponding author.

E-mail address: [malki495@student.otago.ac.nz](mailto:malki495@student.otago.ac.nz) (K.R. Malloch).

on-going environmental issues at these sites can be identified. This study has wider implications for historic processing sites, whereby understanding the connection between processing techniques, mineral weathering trajectories and secondary mineral phase formation and stability has important implications in site management and the prioritising and designing of remediation works.

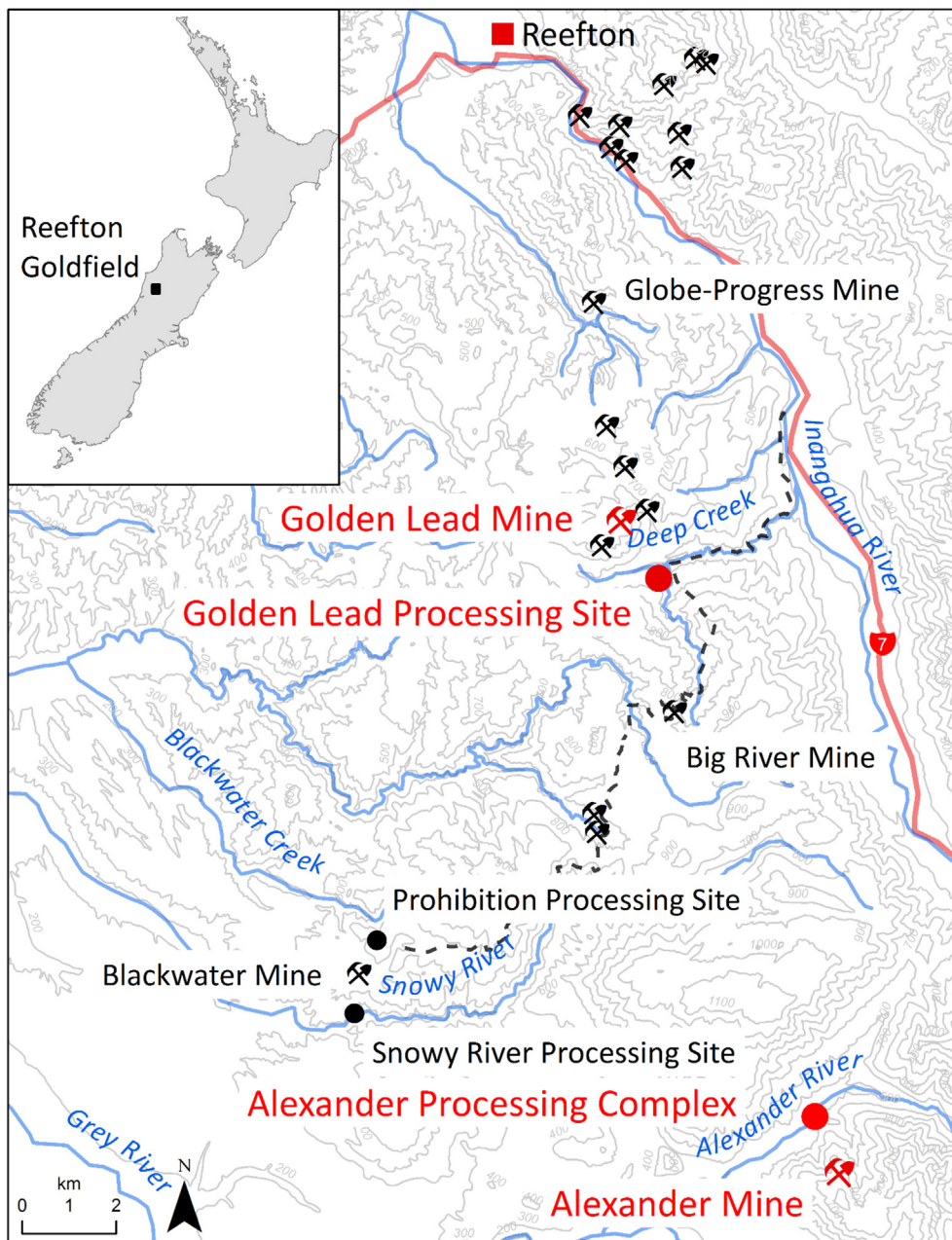
## 2. General context of study

### 2.1. Mine processing sites

This study examines and compares processing sites at two different orogenic gold deposits, Golden Lead and Alexander (Fig. 1), in the Reefton goldfield of southern New Zealand (Gage,

1948; Christie and Brathwaite, 2003). These deposits are hosted by carbonate-bearing argillite and greywacke turbidites of the Cambrian to Early Ordovician Greenland Group (Laird and Shelley, 1974). The deposits consist of Paleozoic orogenic gold-bearing quartz veins in a belt of north-trending intense shearing and folding (Gage, 1948; Christie and Brathwaite, 2003).

The Golden Lead and Alexander mines (Fig. 1) were worked prior to the 1950s. The Golden Lead mine was developed in quartz vein stockwork within a shear zone, and operated as a series of hillside adits from 1890 to 1908. An aerial tramway transported the ore to the processing site located next to a creek below the workings (Fig. 1). The Alexander gold mine was developed in a quartz vein system, between 1921 and 1943, and was accessed by a series of adits driven into the side of the mountain. Ore was transported



**Fig. 1.** Location map showing the Alexander processing complex (consisting of the battery and roaster sites) and mine and the Golden Lead processing site and mine within the Reefton goldfield. Other historic processing sites where elevated concentrations of As and Sb have been identified are shown (Haffert and Craw, 2009; Druzbecka and Craw, 2015), as well as the recently closed Globe-Progress mine. Topographic contours, waterways and roads are from LINZ topographic maps.

Download English Version:

<https://daneshyari.com/en/article/5752513>

Download Persian Version:

<https://daneshyari.com/article/5752513>

[Daneshyari.com](https://daneshyari.com)