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Technical note

Mineralogical and metallurgical study of supergene ores of the Mike Cu—Au (—Zn) deposit, Carlin trend, Nevada

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ABSTRACT

The undeveloped Mike Cu—Au(—Zn) deposit on the Carlin trend of Nevada, USA, currently held by Newmont Mining, hosts an unusual suite of oxide Cu and Au minerals. This study evaluates the possibilities for economic recovery by 1) comparing the Cu and Au extraction achieved from the supergene ores by six different lixiviants, and 2) identifying which minerals cause low recovery for each lixiviant and why. Gold is present as auricupride and electrum and copper exists as conichalcite (Ca—Cu arsenate), native Cu, cuprite, chrysocolla, and minor malachite, with locally significant copper in jarosite, hematite, and goethite. The reagents tested were sulfuric, sulfurous, and methanesulfonic acids to recover Cu, cyanide and thiourea to recover Au, and glycine to recover both. No reagent recovered both Cu and Au effectively, although sulfuric and methanesulfonic acids recovered most of the Cu and cyanide and thiourea recovered most of the Au. Glycine recovered nearly all of the Au and > 50% of the Cu from the cuprite- and native-Cu-dominated ore type, but did not recover much Cu or Au from any of the other ore types. This supports the hypothesis that Cu^{2+} catalyzes Au dissolution in glycine, and thus effective Au leaching by glycine from oxide Cu—Au ores may be contingent upon the solubility of the Cu minerals in glycine.

Post-leaching QEMSCAN analysis indicates that conichalcite and Cu-bearing Fe oxides failed to dissolve completely in all reagents and were the principal causes of low recovery. In addition, native Cu dissolved only partly in thiourea, and chrysocolla dissolved only partly in thiourea, glycine, or cyanide. Other observed mineralogical changes include the total loss of dolomite and partial loss of alunite and iron oxide from all samples, with apparent gains in alunite and jarosite.

1. Introduction to the problem

Oxidized copper-gold ores are problematic to leach. The sulfuric acid used to leach Cu oxides does not dissolve Au, and the cyanide used to leach Au is consumed by Cu minerals. In the case of the supergene ores at the Mike deposit, a large and currently undeveloped Cu—Au(—Zn) resource on the Carlin Trend, the situation is further complicated by the occurrence of Cu mainly as conichalcite ($CaCuAsO_4OH$), a largely unstudied ore mineral. The objective of this work is 1) to evaluate the potential for hydrometallurgical recovery of Cu and Au from the Mike supergene ore suite, and 2) to establish which minerals resist dissolution in which lixiviants.

2. Geological and mining background

2.1. Location of the deposit and regional geologic context

The Mike prospect, held by Newmont, is a buried Cu—Au(—Zn) deposit in the Maggie Creek district in Nevada's Carlin trend (Fig. 1). The Carlin trend is a series of Au districts and deposits strung out along a 60-km-long northwesterly structural zone in the Basin and Range province of northern Nevada. Host rocks are Paleozoic carbonates and shales, heavily altered with argillization of silicate minerals, dissolution of carbonate minerals, and formation of jasperoid by deposition of silica (Hofstra et al., 1999; Cline et al., 2005). In the hypogene zones of Carlin deposits the Au occurs as auriferous pyrite and arsenopyrite and their marcasite equivalents, which are oxidized to varieties of native Au in the supergene zone (Teal and Jackson, 2002). The gold minerals in Carlin deposits are commonly accompanied by orpiment, realgar, cinnabar, stibnite, and sulfosalts (Cline et al., 2005). Copper and other base metals may be present, but typically in grades of < 0.01% (Arehart, 1996).

Mike was discovered in the Maggie Creek district in 1989, and its resource – eventually calculated at > 8.5 M oz. Au, 1027 M lbs. Cu, and 809 M lbs. Zn – makes it one of the largest single resources on the Carlin

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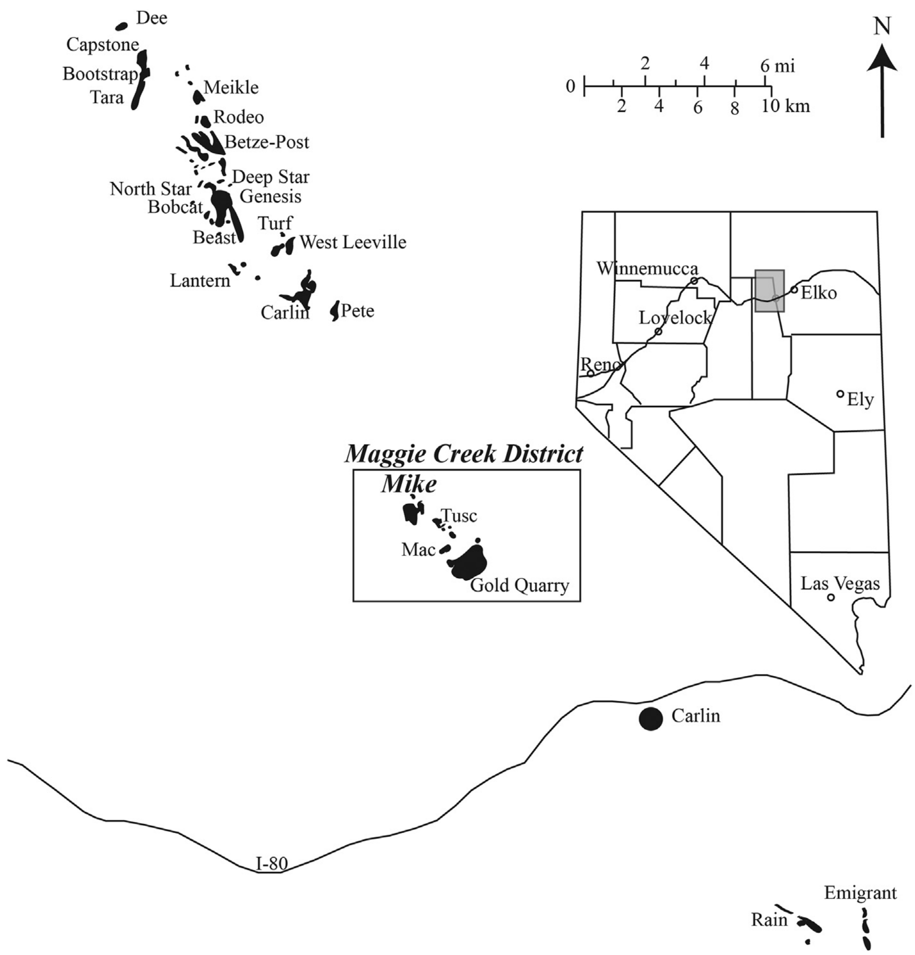

Fig. 1. Location map of the Carlin trend, showing Mike in the Maggie Creek district.
Modified from Norby and Orobona (2002).

Trend (Norby and Orobona, 2002; Harlan et al., 2002). Occurring where the Soap Creek and Good Hope faults intersect (Fig. 2), the deposit consists of the Main Mike mineralization in the hanging wall, and the West Mike mineralization in the footwall, of the Good Hope fault. Each of these contains two main ore zones, a lower hypogene Cu-Au-Zn orebody and an upper supergene Cu–Au zone with anomalous but subeconomic Zn (Fig. 3). The mineralized volume has been partly delineated by drilling but remains open to the northwest.

Mike deviates from the conventional Carlin deposit model in exhibiting widespread high-temperature alteration in the ore-hosting rocks and in having high Cu and Zn grades (averaging 0.34% and 2.13% respectively) (Teal and Branham, 1997; Bawden, 2002; Norby and Orobona, 2002). These and other anomalous features have been variously explained as the overprinting of a Cu–Zn deposit by a Carlin-type Au mineralization episode (Teal and Branham, 1997; Norby and Orobona, 2002) and as the overprinting of a Carlin-type Au deposit by a later Cu–Zn mineralization episode (Bawden, 2002; Bawden et al., 2003; Parrish, 2014). Whatever the respective timing of Cu–Zn and Au mineralization, the ores precipitated in both episodes were subsequently oxidized by meteoric waters. The resulting supergene mineralization consists of conichalcite-dominated Cu oxides (sensu lato) and native Cu with varieties of native Au. The two metals occur together throughout the supergene zone and contribute roughly equal proportions to its value, so any metallurgical method used must be able to recover both Cu and Au from the same material.

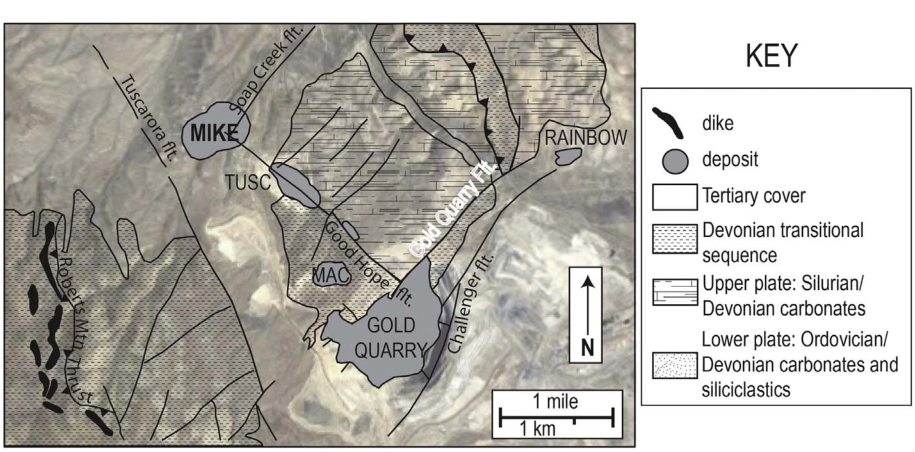

Fig. 2. Simplified geologic map of the Maggie Creek district. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
Modified from Teal and Branham (1997)