Evaluating Potential for Recovery of Te as a Byproduct of Au Extraction

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Tellurium: Energy Critical Element

Tellurium (Te) is an energy-critical element, found in limited supply in the earth's crust. Recent development of high efficiency CdTe-based thin-film photovoltaics has created unprecedented demand for Te, which is quickly outstripping production (Jaffe, 2009). Globally, almost all Te is produced as a byproduct of copper extraction. Although there are several high-grade Au-Ag telluride deposits in the western US, Te is discarded during processing. Recovering Te from Au-Ag mining is one potential way to meet increasing demand for Te.

Recent focus on Te as an energy critical element and large increases in price warrants revaluation of the economics of Te recovery. One untapped potential source of Te is to be recovered from Au-Ag mining processese. This project seeks to assess the potential for Te recovery through examination of Te behavior during extraction.

Research Goals

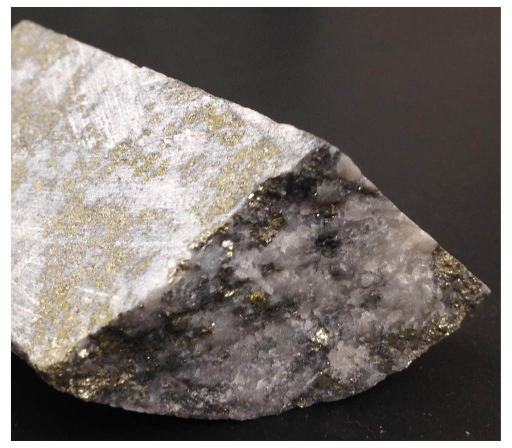
The overall goal of this project is to assess the viablility of tellurium recovery from the Golden Sunlight Mine, a modern Au/Ag mine near Whitehall, MT. Toward that goal, the following are specific research questions:

1. Optimize peroxide sinter method for sample dissolution and ICP-MS analysis of elemental composition.
2. Analyze elemental composition of samples from various stages in the extraction process at Golden Sunlight.
3. Perform mass balance calculation for Te using concentration and flux data, identifying potential points for Te extraction.

Golden Sunlight Mine

- Open pit mine, near Whitehall, MT
- Owned and operated by the Barrick Gold Corporation
- Proven and probable Au reserves of ~318,000 oz.
- Currently Te is not recovered, although the principal deposit is an Au-Ag telluride and has outstanding potential for Te recovery

"Since the Golden Sunlight mine commenced operation in the early 1980s there have been periodic episodes of poor gold recovery during cyanide treatment of the ore. Recoveries have fluctuated from 65%-85%" (Spry 2000)



Te-bearing ore from Golden Sunlight

Where's the Te?

"The response of different gold telluride materials to cyanide leaching is highly variable and generally not well understood" (Marsden 1992).

We initially hypothesized that Te may accumulate in the pyrite leach circuit, as previous studies report substitution of Te into sulfide minerals (i.e. pyrite).

- Golden Sunlight's principal mineralized deposit, the Mineral Hill Breccia Pipe, is up to 20% pyrite.

Te Speciation

Telluirum occurs naturally in a variety of forms:

- Native Te
- Au-Ag and other tellurides
- Te^{4+} & Te^{6+} oxyanion minerals
- Sulfosalts ($A_mB_nS_p$, A=metal, B=nonmetal, S=Sulfur/Te,Se)

Method Development

Ore and mill samples were collected from Golden Sunlight Mine during a site visit by S. Hayes in the summer of 2012.

Sodium Peroxide (Na_2O_2) Sinter

In order to analyze the elemental composition, it first is necessary to completely dissolve the samples. This was accomplished using a Na_2O_2 sinter method. Triplicate samples were placed in graphite crucibles with solid phase ground Na_2O_2, and heated for 0.5 hrs in a muffle furnace at 480°C. Excess Na_2O_2 was reacted with HNO_3 and HCl acids, and 18MΩ water was added to achieve a 1,000-fold dilution.

Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

ICP-MS is the favored analytical technique because of low detection limits and simultaneous multi-element detection. The Agilent 7500ce ICP-MS, housed in the Advanced Instrumentation Lab at UAF, utilizes Ar as the inert carrier gas to generate a 10,000 K plasma to supply ions to the MS detector. The detection system contains an octapole collision cell and quadropole mass spectrometer.

Standard Addition

Initial calibration data indication a rotational matrix effect, necessitating the use of standard addition calibration to obtain precise and accurate results when analyzing reference material (NIST- 2780). The standard addition method involves the addition of a spike solution and back-calculating to the actual Te signal (Thompson 2009).

ICP-MS Skimmer cone "clogging" effect

Cyanide Leach Cascade at Golden Sunlight Mine

www.reclaimmontanaheadwaters.org

Au Extraction Process

Crushing/Grinding – Usually the first step in any extraction process, as grinding the ore to the optimum size for gold liberation has a significant effect on the outcome of the rest of the procedure.

Cyanide Leach – No technique has revolutionized Au extraction so much as the development of cyanidation, which generally results in Au recoveries of about 90%.

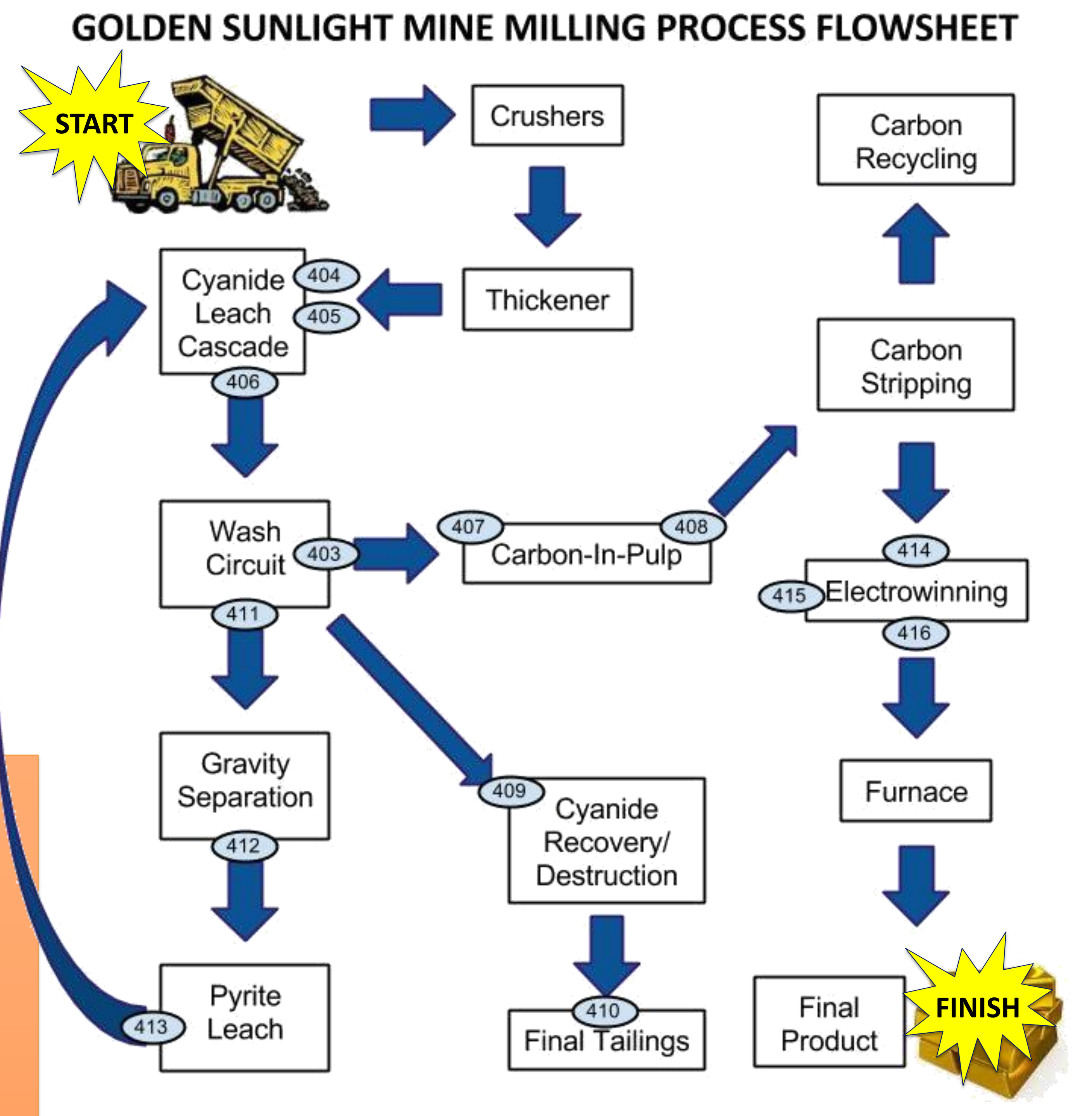
Gravity Separation – At Golden Sunlight, the gravity separation consists of a spiral apparatus where downward flow of water combined with the rotational motion of the spiral separates particles based on size.

Pyrite Leach – Non-extracted Au, refractory to the cyanidation process, can occur when Au particles are locked within other particles (one common culprit is pyrite, a sulfide mineral). These particles are liberated into solution using a pyrite leach.

Carbon-In-Pulp – Activated carbon is used to adsorb Au from a solution.

Electrowinning – Primary metal (i.e. Au) is anodically dissolved and redeposited in a purer form on a complimentary electrode.

Furnace/Production of Doré Bars – The final product of the Au extraction process, Doré, is a Au-Ag amalgam.



Results & Discussion

Sinter Method

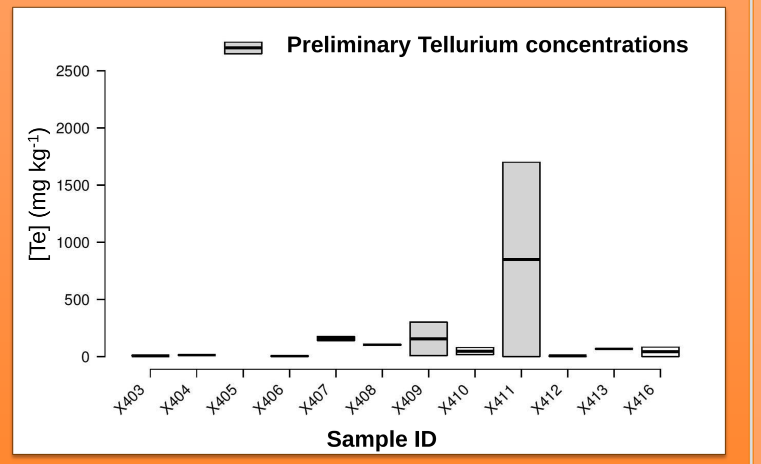
After substantial method development, the following results were achieved:

- Accurate and precise analyses of standard reference material was achieved.
- Complete dissolution was achieved for most samples.

Elemental Composition

Samples were dissolved in triplicate, of which two runs have been analyzed by ICP-MS.

- General agreement was observed in the Te concentration between runs 1 and 2 for most samples.
- Incomplete dissolutions of several samples (411 and perhaps 405 and 406) resulted in unreasonably high apparent concentrations of Te.



Mass Balance of Te

Based on preliminary data, Te concentration in the pyrite leach seems reasonable. The mass balance calculation of Te is awaiting final Te concentrations from ICP-MS.

Conclusions

- The sodium peroxide sinter method combined with ICP-MS analysis shows promise for the analysis of Golden Sunlight samples.
- Matrix effects due to the rich elemental composition of the samples made analysis more challenging than was initially anticipated.
- Preliminary data shows promising results with many of the samples, and it is believed that better results could be achieved if the sample preparations were repeated.
- Preferential dissolution of Te in partially dissolved samples

Future Directions- Finish Project

- Complete analysis of mine samples by ICP-MS
- Perform mass balance calculation and assess potential for Te recovery

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Golden Sunlight Mine Processing Facilities near Whitehall, MT (image courtesy of Barrick Gold, www.barrick.com)