ARSENIC SPECIATION IN SURFACE WATER DRAINING THE GOLDEN ZONE BRECCIA DEPOSIT IN CENTRAL ALASKA

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Background

The Golden Zone (-149.6397222, 63.2188889) is a 9,900 hectare Au–Cu-Ag mining claim located in the Chulitna mineral belt of the Valdez Creek mining district in south-central Alaska, approximately 240 km north of Anchorage. It is bordered on the north and west by the mountainous Denali Wilderness Area, which is off limits to mining and an environmentally sensitive area. The Golden Zone property lies at the northern end of the Chulitna-Yentna mineral belt, a fault-bounded block of Devonian to Triassic sediments and volcaniclastic sediments (Hedderly-Smith, 2011).

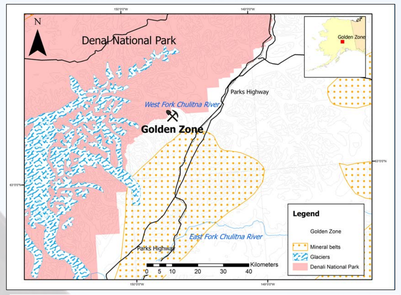


Figure 1. Location map for Golden Zone

Figure 2. Photo of the breccia pipe showing the extreme angularity of the clasts, cockade texture and copper mineralization. The lens cap is 55 mm in diameter; the hammer is 30cm long.

Several types of intrusion-related deposits exist on the property; porphyry-type, skarn and other carbonate replacements, veins, shear zones and a highly-altered hydrothermal breccia pipe, which is the main target of exploration. This breccia pipe is part of a quartz diorite porphyry-quartz intrusion of Cretaceous age (~70 Ma), (Gage & Newberry, 2003) and contains arsenopyrite, chalcopyrite, pyrrhotite and pyrite mineralization within the stock, as shown in Figure 2.

Water samples were collected from the Golden Zone site over two field trips in July and August of 2011. Sampling was focused on Bryn Mawr creek, which is a tributary of the West Fork of the Chulitna River and drains the main zone of mineralization. In-situ arsenic speciation was performed in the field using the method refined by Haque & Johannesson (2006) as described below.

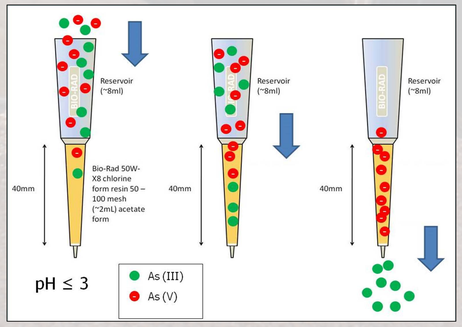


Figure 3. Arsenic species separation using chromatography resins to selectively retain As(V) species.

In-situ Arsenic Speciation

10ml 0.8 x 4cm Poly-Prep® columns were purchased from Bio-Rad Laboratories (Hercules, USA), and filled with AG® 1-X8 resin (50 - 100 mesh, chloride form). AG® 1-X8 is a strong cation exchange resin, composed of sulphonic acid functional groups attached to a styrene divinylbenzene co-polymer lattice. The resin was converted in bulk to the acetate form by washing 50g with 150ml of 1M NaOH solution (J. T. Baker), rinsing with nanopure water and repeating two times until the pH of the rinse was neutral. This was followed by washing with approximately 150ml of 1M acetic acid (BDH Aristar Ultra) and rinsing with nanopure water until neutral. In the field, a 50 ml aliquot was filtered (0.45µm), acidified with concentrated nitric acid and slowly passed through a fresh column and collected. Anionic As(V) species are absorbed by the column matrix, while neutral As(III) species pass through, allowing the quantities of both species present in the sample to be determined by comparison with total dissolved metals analysis. The efficiency of the columns was tested using standard As(III) and As(V) solutions, which were mixed to nominal concentrations of 60ppb and immediately passed through the columns. This confirmed that over 96% of As(V) was removed by the resin.

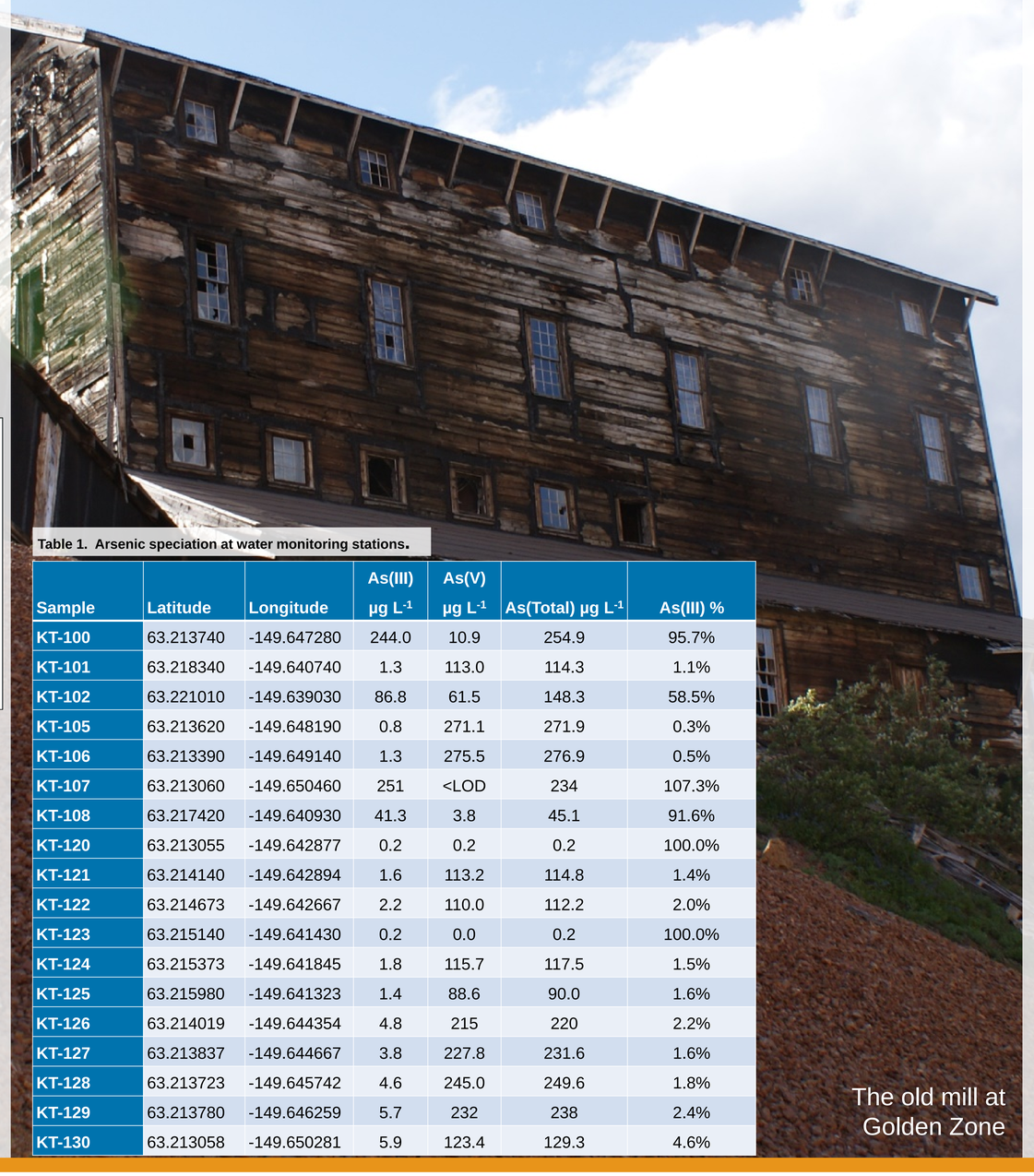
Analytical Results

pH of the stream samples ranged from 6.0 to 8.1 and can be described as circum-neutral. Total dissolved As concentrations in the study area ranged from 0.2 µg/L to 278 µg/L. The spatial variation of dissolved As (Figure 4) shows that its concentration is highest were Bryn Mawr bisects the mineralized zone and rapidly decreased downstream. As concentrations in tributaries joining Bryn Mawr were less than 1 µg/L background As levels are assumed to be low which enhances the significant As signature from the mineralized zone. There were no other anomalous metal concentrations noted; both Cu and Ag were below the level of detection of the ICP-MS (~ 0.3 µg/L).

Arsenic speciation in Bryn Mawr is dominated by As(V), which is the more oxidized form, with the exception of stations KT-100, KT-107, KT-120 & KT-123 (Figure 5). These correspond to locations where groundwater enters Bryn Mawr via adits. In the well aerated waters of the stream As(III) is rapidly oxidized to As(V).

Table 1. Arsenic speciation at water monitoring stations.

Sample	Latitude	Longitude	As(III) µg L^{-1}	As(V) µg L^{-1}	As(Total) µg L^{-1}	As(III) %
KT-100	63.213740	-149.647280	244.0	10.9	254.9	95.7%
KT-101	63.218340	-149.640740	1.3	113.0	114.3	1.1%
KT-102	63.221010	-149.639030	86.8	61.5	148.3	58.5%
KT-105	63.213620	-149.648190	0.8	271.1	271.9	0.3%
KT-106	63.213390	-149.649140	1.3	275.5	276.9	0.5%
KT-107	63.213060	-149.650460	251	<LOD	234	107.3%
KT-108	63.217420	-149.640930	41.3	3.8	45.1	91.6%
KT-120	63.213055	-149.642877	0.2	0.2	0.2	100.0%
KT-121	63.214140	-149.642894	1.6	113.2	114.8	1.4%
KT-122	63.214673	-149.642667	2.2	110.0	112.2	2.0%
KT-123	63.215140	-149.641430	0.2	0.0	0.2	100.0%
KT-124	63.215373	-149.641845	1.8	115.7	117.5	1.5%
KT-125	63.215980	-149.641323	1.4	88.6	90.0	1.6%
KT-126	63.214019	-149.644354	4.8	215	220	2.2%
KT-127	63.213837	-149.644667	3.8	227.8	231.6	1.6%
KT-128	63.213723	-149.645742	4.6	245.0	249.6	1.8%
KT-129	63.213780	-149.646259	5.7	232	238	2.4%
KT-130	63.213058	-149.650281	5.9	123.4	129.3	4.6%



The old mill at Golden Zone

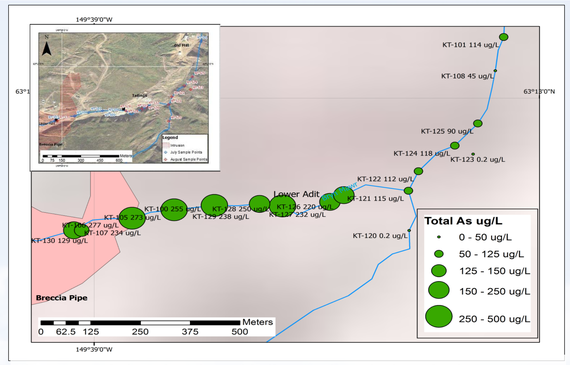


Figure 4. Variation of total As with distance from the breccia pipe.

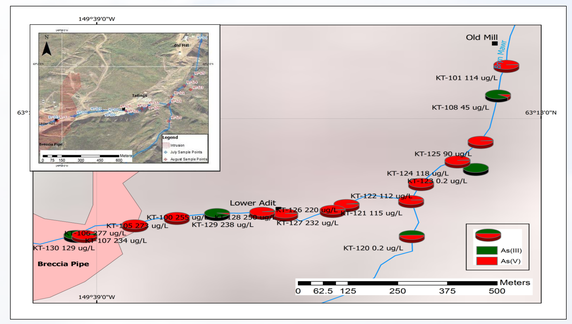


Figure 5. Spatial variation of arsenic species within the study area.

Discussion

The As signature of Golden Zone results from weathering of arsenopyrite within the mineralized zone and can be detected above background levels for approximately 750 meters down stream of the deposit. Although As speciation is dominated by As(V), seeps of groundwater into surface drainage are accompanied by As(III) which can be readily discerned using in-situ As speciation. High concentrations of As(III) may indicate previously unrecognized pathways for groundwater interaction with mineralization and compliment existing geophysical and geochemical exploration surveys.

Acknowledgments

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References

Gage, B. G. & Newberry, R. J. (2003), 'Ore Mineralogy and Mineral Compositions from Golden Zone Mine, Southcentral Alaska', *Short Notes on Alaska Geology* **Professional Reports 120**, 21 - 33.

Haque, S. & Johannesson, K. H. (2006), 'Arsenic Concentrations and Speciation along a Groundwater Flow Path: The Carrizo Sand Aquifer, Texas, USA.', *Chemical Geology* **228**, 57 - 71.

Hedderly-Smith, D. (2011), 'The Golden Zone Au-Ag-Cu Deposit - The Time is Now!'' Alaska Miners Association. 2011 Annual Convention Abstracts.'.